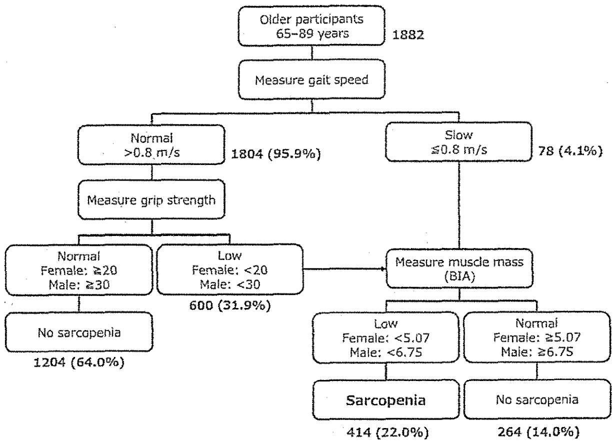

Fig. 1. The prevalence of sarcopenia, low muscle mass, poor physical performance, and low muscle strength according to the EWGSOP-suggested algorithm for sarcopenia in our study participants (n = 1882).

sarcopenia in men and women aged 65 to 89 years was 21.8% and 22.1%, respectively (Figure 1).

The prevalence of sarcopenia showed an age-dependent increase after 75 years in both genders. The prevalence of sarcopenia in men was 2.6%, 5.3%, 23.3%, 43.9%, and 75.0% and in women it was 11.5%, 11.8%, 27.1%, 35.6%, and 54.3% for those aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years, respectively (Figure 2). In those younger than 75 years, the prevalence of sarcopenia was higher in women than in men (65–69 years: OR = 4.81, 95% CI = 1.12–20.55; 70–74 years: OR = 2.41, 95% CI = 1.18–4.91). However, in those aged 85 to 89 years, the prevalence of sarcopenia was lower in women than in men (OR = 0.39, 95% CI = 0.17–0.88) (Figure 3).

The prevalence of low muscle mass also showed an age-dependent increase after age 65 years in both genders. The prevalence of low muscle mass in men aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years was 21.1%, 28.4%, 37.2%, 58.5%, and 75.0%, respectively, and 24.5%, 30.1%, 43.0%, 55.6%, and 71.4% in women of the same age groups (Table 1). The prevalence of low strength was increasingly age dependent after 75 years in both genders. The prevalence of low HGS was 13.2%, 14.7%, 40.7%, 61.0%, and 87.5% in men, and 23.0%, 19.4%, 41.1%, 62.2%, and 71.4% in women aged 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 89 years, respectively. The prevalence of low physical performance increased in those older than 80 years in both genders. In men aged 65 to 69, 70 to 74, 75 to 79, 80

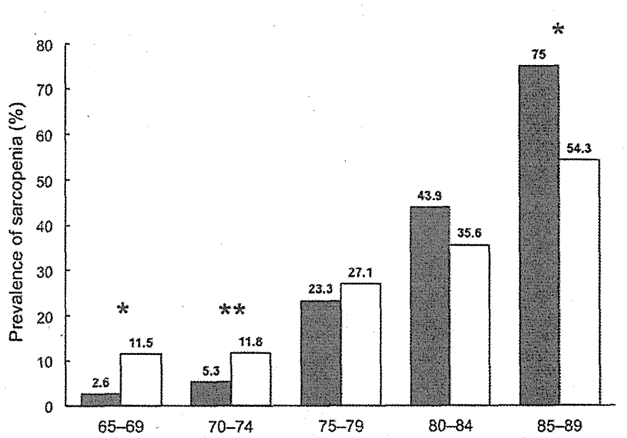

Fig. 2. The prevalence of sarcopenia is shown in each gender and each age group. Closed column: men; open column: women. *P < .05, **P < .01, men versus women.

	Univariate		
	OR	95%CI	P-value
65–69	4.81	1.12–20.55	.011
70–74	2.41	1.18–4.91	.008
75–79	1.22	0.80–1.85	.198
80–84	0.70	0.41–1.20	.125
85–89	0.39	0.17–0.88	.017
All	1.014	0.77–1.28	.480

Reference for men

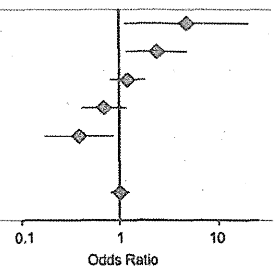

Fig. 3. Odds ratio of the prevalence of sarcopenia in men versus women in each age group.

to 84, and 85 to 89 years, the prevalence of slow walking speed was 0.0%, 1.1%, 3.5%, 9.8%, and 16.7%, respectively, and in women of the same age, it was 3.6%, 1.6%, 1.9%, 8.9%, and 20.0%, respectively.

In men, 48 (38.7%) in the sarcopenia group and 74 (16.7%) in the nonsarcopenia group experienced a fall in the previous year. The OR for falls in the sarcopenia group relative to the nonsarcopenia group was 3.16 (95% CI = 2.04–4.89). The OR for fear of falling in the sarcopenia group (67.7%) versus the nonsarcopenia group (25.2%) was 6.23 (95% CI = 4.04–9.60). In women, 94 (32.4%) in the sarcopenia group and 254 (24.8%) in the nonsarcopenia group experienced a fall in the previous year. The OR for falls in the sarcopenia group relative to the nonsarcopenia group was 1.45 (95% CI = 1.09–1.93). The OR for fear of falling in the sarcopenia group (84.1%) versus the nonsarcopenia group (50.0%) was 5.30 (95% CI 3.78–7.43) (Table 2). The sarcopenic participants showed significantly lower scores for all physical performance tests than those without sarcopenia ($P < .05$).

Discussion

The current cross-sectional study was performed to evaluate the prevalence of sarcopenia in Japanese older adults. The prevalence of sarcopenia using the EWGSOP-suggested algorithm for sarcopenia in men and women was 21.8% and 22.1%, respectively. Previous epidemiological studies of sarcopenia in several countries show a prevalence of sarcopenia of 5% to 40% in older men and 7% to 70% in older women.[14,19–32] In general, the prevalence of sarcopenia is approximately 25% in older men and 20% in older women. Our data are located around the mean of these previous studies in both genders. Therefore, we believe our study had no sampling bias or overestimation/underestimation in the measurement of BIA.

In those younger than 75 years, the prevalence of sarcopenia was higher in women than in men; however, the opposite trend was observed in those older than 85 years. This phenomenon was also found in previous studies in Caucasian and Chinese elderly.[23,29] The mechanism of this important finding is unclear. However, IGF-1 might play an important role in this phenomenon. IGF-1 is the most important mediator of muscle growth and repair. In women older than 65 years, the IGF-1 level did not show age-related changes; however, in men older than 85 years, the IGF-1 level is decreased.[33] Thus, in septuagenarians, the IGF-1 level is higher in men than in women, but in those older than 85 years, it is lower in men than in women. This trend is quite consistent with the prevalence of sarcopenia. Therefore, the gender difference in the prevalence of sarcopenia may well be dependent on the IGF-1 level.

Sarcopenic older adults showed significantly lower scores in all physical performance tests than those without sarcopenia. In addition, sarcopenic older adults had a higher incidence of falls (men, OR = 3.16; women, OR = 6.23) and greater fear of falling (men, OR = 1.45; women,

Table 1
Prevalence of Sarcopenia and Low Muscle Mass, Strength, and Physical Performance

	Men						
	Overall	65–69	70–74	75–79	80–84	85–89	*P* for Trend
	n = 568	n = 76	n = 190	n = 172	n = 82	n = 48	
Sarcopenia	124 (21.8)	2 (2.6)	10 (5.3)	40 (23.3)	36 (43.9)	36 (75.0)	<.001
Low muscle mass	218 (38.4)	16 (21.1)	54 (28.4)	64 (37.2)	48 (58.5)	36 (75.0)	<.001
Low strength	200 (35.2)	10 (13.2)	28 (14.7)	70 (40.7)	50 (61.0)	42 (87.5)	<.001
Low physical performance	24 (4.2)	0 (0.0)	2 (1.1)	6 (3.5)	8 (9.8)	8 (16.7)	<.001
	Women						
	Overall	65–69	70–74	75–79	80–84	85–89	*P* for Trend
	n = 1314	n = 278	n = 372	n = 414	n = 180	n = 170	
Sarcopenia	290 (22.1)	32 (11.5)	44 (11.8)	112 (27.1)	64 (35.6)	70 (54.3)	<.001
Low muscle mass	508 (38.7)	68 (24.5)	112 (30.1)	178 (43.0)	100 (55.6)	50 (71.4)	<.001
Low strength	468 (35.6)	64 (23.0)	72 (19.4)	170 (41.1)	112 (62.2)	50 (71.4)	<.001
Low physical performance	54 (4.1)	10 (3.6)	6 (1.6)	8 (1.9)	16 (8.9)	14 (20.0)	<.001

Values are in n (%).

OR = 5.30) than nonsarcopenic older adults. In a similar study conducted in Italy, 27.3% of participants with sarcopenia and 9.8% of participants without sarcopenia experienced falls over a 1-year period (hazard ratio = 3.45).[34] Studies have identified physical frailty as the risk factor for falls and fear of falling in older adults.[35,36] It is possible that a vicious cycle of sarcopenia can lead to lower physical performance and the resulting changes in physical ability can lead to a higher incidence of falls and greater fear of falling.

Sarcopenia is associated with adverse health outcomes. For example, Janssen et al[37] showed that the estimated direct health care cost related to sarcopenia was $18.5 billion in the United States in 2000. Furthermore, Landi et al[38] showed that 67.4% of participants with sarcopenia and 41.2% of participants without sarcopenia died during a 7-year follow-up in a study of older adults aged 80 years and older (hazard ratio = 2.95). Our study showed that sarcopenia is highly prevalent among adults aged 80 years and older. Because older adults are the greatest consumers of health care and have a high risk of death, it is very important to begin prevention of sarcopenia early, possibly before the age of 65.

There were several limitations to this study that warrant mention. First, the study design was cross-sectional and no outcome data are available. Further research with a longitudinal design is required to clarify whether sarcopenia determined by our algorithm can predict adverse health outcomes in Japanese older adults. Second, the SMI measurement was estimated using BIA, a method not recommended to assess muscle mass by the EWGSOP. However, it is not feasible to measure muscle mass in community-dwelling older adults using dual-energy x-ray absorptiometry (DEXA), so BIA is a more practical screening method to use in large samples, especially in a community setting. However, to determine the specific effect of an intervention, a more accurate measurement, such as DEXA, computed tomography, or magnetic resonance imaging, should be used in future studies. Third, serum data were not measured. Therefore, the relationship between sarcopenia and IGF-1 could not be determined. Finally, the presence of sarcopenia might not be able to predict falls in older adults, as this study was based on the participants having experienced a fall in the previous year. Further study is required to confirm our findings in participants with sarcopenia who do not experience falls.

In conclusion, the prevalence of sarcopenia using the EWGSOP-suggested algorithm for sarcopenia in men and women was 21.8% and 22.1%, respectively, and the prevalence of sarcopenia increased age dependently in those older than 75 years in both genders. The prevalence of sarcopenia in men and women showed an opposite trend in the young old and in the old old (those older than 85 years). In addition, participants with sarcopenia had an increased risk for falls and a greater fear of falling. Outcome studies are needed to determine the diagnosis of sarcopenia and the cutoff values for walking speed, HGS, and muscle mass.

Table 2
Characteristics and Physical Performance in Study Participants With or Without Sarcopenia by Gender

	Men					Women				
	Sarcopenia		Nonsarcopenia			Sarcopenia		Nonsarcopenia		
	n = 124		n = 444			n = 290		n = 1024		
	Mean	SD	Mean	SD	*P* value	Mean	SD	Mean	SD	*P* value
Demographic										
Age	81.1	4.8	74.0	4.8	<.001	77.6	5.4	73.9	5.3	<.001
Body mass index	22.2	2.7	23.4	3.0	<.001	22.3	3.3	23.0	3.2	.002
Skeletal muscle mass index	5.53	0.73	7.16	1.01	<.001	4.23	0.46	5.65	0.94	<.001
Fall related										
Fall incidents, n (%)	48 (38.7)		74 (16.7)		<.001	94 (32.4)		254 (24.8)		.006
Fear of falling, n (%)	84 (67.7)		112 (25.2)		<.001	244 (84.1)		512 (50.0)		<.001
Physical performance										
10-m walking time, s	10.0	3.3	7.7	1.8	<.001	10.0	3.1	7.8	2.0	<.001
Timed up and go test, s	10.2	3.5	6.6	1.9	<.001	9.1	3.0	7.1	1.8	<.001
Functional reach, cm	23.4	6.6	29.8	6.2	<.001	23.9	7.2	26.7	5.8	.011
One leg stand, s	9.5	9.2	20.2	18.3	<.001	12.8	17.5	19.9	15.1	<.001
Five chair stand, s	9.3	1.7	8.2	2.0	.004	9.0	2.1	8.2	2.6	.032
Handgrip strength, kg	23.0	5.4	34.0	5.7	<.001	15.9	2.7	22.9	4.6	<.001

Acknowledgments

The authors acknowledge Ms Yoko Moriguchi and Mr Takahiro Mitani for their contribution to the data collection.

References

1. Rosenberg I. Summary comments. Am J Clin Nutr 1989;50:1231–1233.
2. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412–423.
3. Morley JE. Sarcopenia in the elderly. Fam Pract 2012;29:i44–i48.
4. Wang C, Bai L. Sarcopenia in the elderly: Basic and clinical issues. Geriatr Gerontol Int 2012;12:388–396.
5. Cawthon PM, Marshall LM, Michael Y, et al. Frailty in older men: Prevalence, progression, and relationship with mortality. J Am Geriatr Soc 2007;55:1216–1223.
6. Rolland Y, Czerwinski S, Abellan Van Kan G, et al. Sarcopenia: Its assessment, etiology, pathogenesis, consequences and future perspectives. J Nutr Health Aging 2008;12:433–450.
7. Topinkova E. Aging, disability and frailty. Ann Nutr Metab 2008;52:6–11.
8. Schaap LA, Pluijm SM, Deeg DJ, et al. Higher inflammatory marker levels in older persons: Associations with 5-year change in muscle mass and muscle strength. J Gerontol A Biol Sci Med Sci 2009;64:1183–1189.
9. Sattler FR, Castaneda-Sceppa C, Binder EF, et al. Testosterone and growth hormone improve body composition and muscle performance in older men. J Clin Endocrinol Metab 2009;94:1991–2001.
10. Thomas DR. Loss of skeletal muscle mass in aging: Examining the relationship of starvation, sarcopenia and cachexia. Clin Nutr 2007;26:389–399.
11. Hida T, Ishiguro N, Shimokata H, et al. High prevalence of sarcopenia and reduced leg muscle mass in Japanese patients immediately after a hip fracture. Geriatr Gerontol Int 2013;13:413–420.
12. Gibson AL, Holmes JC, Desautels RL, et al. Ability of new octapolar bioimpedance spectroscopy analyzers to predict 4-component-model percentage body fat in Hispanic, black, and white adults. Am J Clin Nutr 2008;87:332–338.
13. Janssen I, Baumgartner RN, Ross R, et al. Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. Am J Epidemiol 2004;159:413–421.
14. Janssen I. Influence of sarcopenia on the development of physical disability: The Cardiovascular Health Study. J Am Geriatr Soc 2006;54:56–62.
15. Rolland Y, Lauwers-Cances V, Cristini C, et al. Difficulties with physical function associated with obesity, sarcopenia, and sarcopenic-obesity in community-dwelling elderly women: The EPIDOS (EPIDemiologie de l'OSteoporose). Study. Am J Clin Nutr 2009;89:1895–1900.
16. Lopopolo RB, Greco M, Sullivan D, et al. Effect of therapeutic exercise on gait speed in community-welling elderly people: A meta-analysis. Phys Ther 2006; 86:520–540.
17. Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: Towards a standardised approach. Age Ageing 2011;40:423–429.
18. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1998;319:1701–1707.
19. Kim SH, Kim TH, Hwang HJ. The relationship of physical activity (PA) and walking with sarcopenia in Korean males aged 60 years and older using the Fourth Korean National Health and Nutrition Examination Survey (KNHANES IV–2, 3), 2008–2009. Arch Gerontol Geriatr 2013;56:472–477.
20. Rolland Y, Lauwers-Cances V, Cournot M, et al. Sarcopenia, calf circumference, and physical function of elderly women: A cross-sectional study. J Am Geriatr Soc 2003;51:1120–1124.
21. Lauretani F, Russo CR, Bandinelli S, et al. Age-associated changes in skeletal muscles and their effect on mobility: An operational diagnosis of sarcopenia. J Appl Physiol 2003;95:1851–1860.
22. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc 2002;50:889–896.
23. Baumgartner RN, Koehler KM, Gallagher D, et al. Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998;147:755–763.
24. Bouchard DR, Dionne IJ, Brochu M. Sarcopenic/obesity and physical capacity in older men and women: Data from the Nutrition as a Determinant of Successful Aging (NuAge)—the Quebec Longitudinal Study. Obesity (Silver Spring) 2009; 17:2082–2088.
25. Woods JL, Iuliano-Burns S, King SJ, et al. Poor physical function in elderly women in low-level aged care is related to muscle strength rather than to measures of sarcopenia. Clin Interv Aging 2011;6:67–76.
26. Cheng Q, Zhu X, Zhang X, et al. A cross-sectional study of loss of muscle mass corresponding to sarcopenia in healthy Chinese men and women: Reference values, prevalence, and association with bone mass. J Bone Miner Metab; 2013 [Epub ahead of print].
27. Lau EM, Lynn HS, Woo JW, et al. Prevalence of and risk factors for sarcopenia in elderly Chinese men and women. J Gerontol A Biol Sci Med Sci 2005;60: 213–216.
28. Sanada K, Miyachi M, Tanimoto M, et al. A cross-sectional study of sarcopenia in Japanese men and women: Reference values and association with cardiovascular risk factors. Eur J Appl Physiol 2010;110:57–65.
29. Lin CC, Lin WY, Meng NH, et al. Sarcopenia prevalence and associated factors in an elderly Taiwanese metropolitan population. J Am Geriatr Soc 2013;61: 459–462.
30. Pongchaiyakul C, Limpawattana P, Kotruchin P, et al. Prevalence of sarcopenia and associated factors among Thai population. J Bone Miner Metab 2013;31: 346–350.
31. Lee WJ, Liu LK, Peng LN, et al. ILAS Research Group. Comparisons of sarcopenia defined by IWGS and EWGSOP criteria among older people: Results from the I-Lan Longitudinal Aging Study. J Am Med Dir Assoc 2013;14:528. e1–528.e7.
32. Ryu M, Jo J, Lee Y, et al. Association of physical activity with sarcopenia and sarcopenic obesity in community-dwelling older adults: The Fourth Korea National Health and Nutrition Examination Survey. Age Ageing; 2013 [Epub ahead of print].
33. Albani D, Batelli S, Polito L, et al. A polymorphic variant of the insulin-like growth factor 1 (IGF-1) receptor correlates with male longevity in the Italian population: A genetic study and evaluation of circulating IGF-1 from the "Treviso Longeva (TRELONG)" study. BMC Geriatr 2009;9:19.
34. Landi F, Liperoti R, Russo A, et al. Sarcopenia as a risk factor for falls in elderly individuals: Results from the ilSIRENTE study. Clin Nutr 2012;31:652–658.
35. Gillespie SM, Friedman SM. Fear of falling in new long-term care enrollees. J Am Med Dir Assoc 2007;8:307–313.
36. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guideline for the prevention of falls in older persons. J Am Geriatr Soc 2001;49:664–672.
37. Janssen I, Shepard DS, Katzmarzyk PT, et al. The healthcare costs of sarcopenia in the United States. J Am Geriatr Soc 2004;52:80–85.
38. Landi F, Cruz-Jentoft AJ, Liperoti R, et al. Sarcopenia and mortality risk in frail older persons aged 80 years and older: Results from ilSIRENTE study. Age Ageing 2013;42:203–209.

Geriatrics Gerontology International
Medline Indexed

Geriatr Gerontol Int 2014

ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Effect of physical activity on memory function in older adults with mild Alzheimer's disease and mild cognitive impairment

Takanori Tanigawa,[1] Hajime Takechi,[2] Hidenori Arai,[1] Minoru Yamada,[1] Shu Nishiguchi[1] and Tomoki Aoyama[1]

[1]*Department of Physical Therapy, Human Health Sciences, and* [2]*Department of Geriatric Medicine, Graduate School of Medicine, Kyoto University, Kyoto, Japan*

Aim: It is very important to maintain cognitive function in patients with mild cognitive disorder. The aim of the present study was to determine whether the amount of physical activity is associated with memory function in older adults with mild cognitive disorder.

Methods: A total of 47 older adults with mild cognitive disorder were studied; 30 were diagnosed with mild Alzheimer's disease and 17 with mild cognitive impairment. The global cognitive function, memory function, physical performance and amount of physical activity were measured in these patients. We divided these patients according to their walking speed (<1 m/s or >1 m/s). A total of 26 elderly patients were classified as the slow walking group, whereas 21 were classified as the normal walking group.

Results: The normal walking group was younger and had significantly better scores than the slow walking group in physical performance. Stepwise multiple linear regression analysis showed that only the daily step counts were associated with the Scenery Picture Memory Test in patients of the slow walking group ($\beta = 0.471$, $P = 0.031$), but not other variables. No variable was significantly associated with the Scenery Picture Memory Test in the normal walking group.

Conclusions: Memory function was strongly associated with the amount of physical activity in patients with mild cognitive disorder who showed slow walking speed. The results show that lower physical activities could be a risk factor for cognitive decline, and that cognitive function in the elderly whose motor function and cognitive function are declining can be improved by increasing the amount of physical activity. **Geriatr Gerontol Int 2014; ••: ••–••.**

Keywords: memory function, mild cognitive disorder, older adults, physical activity, physical performance.

Introduction

Mild cognitive impairment (MCI) is a condition of objective cognitive impairment based on neuropsychological testing in the absence of clinically overt dementia.[1] This condition is of interest for identifying the prodromal and transitional stages of Alzheimer's disease (AD)[2,3] and other types of dementia. Indeed, a study shows that more than half of MCI cases progress to dementia within 5 years.[1] However, it is reported that the cognitive function of people with MCI can recover to normal.[4,5] Indeed, one study showed that 38.5% of older adults with MCI recovered to normal within 5 years.[6] Therefore, it is very important to prevent the deterioration of MCI to dementia. Because no consensus has been established regarding pharmacological intervention for MCI, non-pharmacological intervention is expected. Accordingly, we need to establish a way to prevent deterioration or even improve cognitive function in MCI patients.

Recently, it has attracted attention that increasing the amount of physical activity can prevent the decline of cognitive function. Many studies reported that global cognitive function is associated with the amount of physical activity. Furthermore, previous reports have shown that physical frailty is associated with an increased risk of developing AD and MCI,[8,9] and can predict a future cognitive decline in older adults.[10] Additionally, people with dementia have been shown to be

Accepted for publication 20 August 2013.

Correspondence: Dr Tomoki Aoyama MD PhD, Department of Physical Therapy, Human Health Sciences, Graduate School of Medicine, Kyoto University, 53 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto 606-8507, Japan. Email: aoyama.tomoki.4e@kyoto-u.ac.jp

doi: 10.1111/ggi.12159

frail because of their poor mobility and body composition.[11,12] Thus, cognitive function and physical frailty are interrelated.

Accordingly, the cognitive decline in frail elderly patients can cause further decline of cognitive function and motor function. Therefore, it is important to maintain and improve the cognitive function of the frail elderly with mild cognitive disorder.

Several studies have shown the relationship between cognitive decline that can be observed at the early stage of dementia and the amount of physical activity. However, no study has addressed whether the association between cognitive function and the amount of physical activity depends on the level of motor function in MCI or mild AD patients.

Therefore, the aim of the present study was to determine whether there is an association between memory function and the amount of physical activity in older adults with mild cognitive disorder, stratified by their motor function.

Methods

Participants

We recruited patients from the memory clinic of the Department of Geriatric Medicine in Kyoto University Hospital, Kyoto, Japan. The diagnosis of AD or MCI was made according to the following criteria: AD, *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, and the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association;[13,14] and MCI, Petersen's criteria.[15] Of the 47 patients with cognitive disorder, 30 were classified as mild AD and 17 as MCI by the criteria. In the present study, we did not set the upper and lower limits of the Mini-Mental State Examination (MMSE) for the diagnosis of MCI. The exclusion criteria used in the present study were vascular dementia, dementia with Lewy bodies, lacunar infarcts, Fazekas grade 3 periventricular hyperintensity/deep white-matter hyperintensity,[16] severe cardiac, pulmonary or musculoskeletal disorders, or the presence of comorbidities associated with an increased risk of falls, such as Parkinson's disease and stroke.

Written informed consent for the trial was obtained from each participant or his/her family members in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 1975.

Walking speed

Comfortable 10-m walking time (walking time) is a simple test developed to screen basic mobility performance in frail older adults. It has been reported that the elderly with a walking score greater than 10.0 s can suffer an increased risk of falling.

Therefore, we divided the participants into two groups according to their walking speed (cut-off: 1 m/s); 26 of the older adults were classified as the normal walking group, whereas 21 of the older adults were classified as the slow walking group.

Cognitive function measures

Cognitive function was assessed by the MMSE and the Scenery Picture Memory Test (SPMT). MMSE is a global cognitive test that can be used to systematically and thoroughly assess mental status. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The maximum score is 30. A score of 23 or lower is indicative of cognitive impairment. SPMT is a short and simple memory test assessing the visual memory encoded as scenery, combined with verbal answers. Briefly, it uses a line drawing scenery picture of a living room in a house where 23 objects commonly observed in daily life are drawn on an A4 piece of paper. The examinee is instructed to look at the picture for 1 min and remember the items. After this encoding period, we distracted participants by asking them to carry out a brief digits forward test. Participants were then asked to recall the objects in the picture without time limitation. This recall time usually takes less than 1 min. The number of items recalled is the score for SPMT. Higher scores indicate better cognitive function. We have previously shown that SPMT is a quick and effective screen for MCI.[17]

Physical performance measures

The participants were asked to carry out the three motor function tests that are widely used to identify the frail elderly. For each performance task, the participants carried out two trials, and the better performance of the two was used for the analysis. Physical performance assessments, such as walking time,[18] the Timed Up & Go (TUG) test,[19] the Functional Reach test,[20] the one-leg stand (OLS) test,[21] and the five chair stand test (5CS)[22] were carried out as previously described.

Physical activity measures

In physical activity, a valid, accurate and reliable pedometer, the Yamax Power walker EX-510, was used to measure the free-living step counts.[23] The participants were instructed to wear the pedometer in their pocket on the side of their dominant leg for 14 consecutive days except when bathing, sleeping or carrying out water-based activities. This pedometer has a 30-day data storage capacity. We calculated the averages of their daily step counts for 2 weeks.

Table 1 Comparison of demographic characteristics and measurements with the overall group, normal walking group, and slow walking group

	All (= 47)	Normal walking (= 26)	Slow walking (= 21)	*P*-value
Age (years)	76.9 ± 7.0	74.7 ± 7.2	79.6 ± 5.9	0.016*
Female sex, *n* (%)	28 (59.6%)	17 (65.4%)	11 (52.4%)	0.38
BMI	21.7 ± 3.7	22.1 ± 3.7	21.1 ± 3.8	0.36
Loneliness	5 (10.6%)	2 (7.7%)	3 (14.3%)	0.64
Donepezil treatment	41 (87.2%)	24 (92.3%)	17 (81.0%)	0.39
MMSE	23.4 ± 3.6	23.0 ± 3.1	24.0 ± 4.2	0.37
SPMT	6.5 ± 4.7	6.7 ± 5.1	6.1 ± 4.4	0.68
Physical activity	4371.9 ± 3605.9	5264.0 ± 3476.9	3267.4 ± 3532.5	0.06
10 m walking time	9.9 ± 2.3	8.2 ± 1.0	12.3 ± 1.6	<0.001***
TUG time	9.5 ± 2.7	7.9 ± 1.4	11.4 ± 2.6	<0.001***
OLS	11.9 ± 15.8	16.9 ± 19.3	5.8 ± 6.1	0.01*
5CS	11.1 ± 3.5	10.0 ± 2.2	12.4 ± 4.2	0.016*

5CS, five chair stand test; BMI, body mass index; MMSE, Mini-Mental State examination; OLS, one leg standing; SPMT, Scenery Picture Memory Test; TUG, Timed Up & Go test. $*P < 0.05$ $***P < 0.001$.

Statistical analysis

The *t*-test and χ^2-test were used to compare the data between the normal and slow walking groups. Multiple linear regression analysis using a stepwise method was carried out to investigate whether physical activity, age, sex, body mass index, TUG, OLS and 5CS were independently associated with SPMT. The data were analyzed using SPSS software Windows version 20.0 (SPSS, Chicago, IL, USA). A *P*-value <0.05 was considered statistically significant for all analyses.

Results

The demographic characteristics of the overall, normal and slow walking groups are summarized in Table 1. A total of 26 patients were classified as the normal walking group, and 21 patients as the slow walking group. There were no significant differences in sex, body mass index, loneliness, donepezil treatment, SPMT or physical activity between the two groups ($P > 0.05$). The normal walking group was younger (normal walking group 74.7 ± 7.2, slow walking group 79.6 ± 5.9, $P = 0.016$), and had significantly better scores than the slow walking group in TUG (normal walking group 7.9 ± 1.4 s, slow walking group 11.4 ± 2.6 s, $P < 0.001$), OLS (normal walking group 24.3 ± 24.3 s, slow walking group 5.8 ± 6.1 s, $P = 0.006$), 5CS (normal walking group 10.0 ± 2.2 s, slow walking group 12.4 ± 4.2 s, $P = 0.016$; Table 1). In the slow walking group, physical activity was significantly correlated with SPMT ($r = 0.471$, $P = 0.031$), as shown in Figure 1, but this correlation was absent in the normal walking group. In addition, there was a correlation between SPMT and physical activity after adjusted by age and sex in the slow walking group ($r = 0.493$, $P = 0.032$).

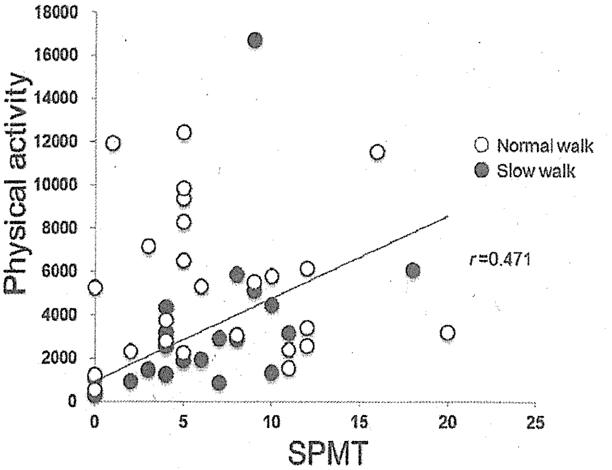

Figure 1 Relationship between physical activity and the Scenery Picture Memory Test (SPMT) in the normal walking and slow walking groups. In the slow walking group, physical activity was correlated significantly with SPMT ($r = 0.471$, $P = 0.031$).

Stepwise multiple linear regression analysis showed that no item was significantly associated with SPMT in the normal walking group, whereas only physical activity ($\beta = 0.471$, $P = 0.031$) was significantly associated with SPMT in the slow walking group (Table 2).

Discussion

The present study showed that memory function is strongly associated with the amount of physical activity

Table 2 Stepwise multiple regression analysis for Scenery Picture Memory Test

	Normal walking		Slow walking	
	β estimates	*P*-value	β estimates	*P*-value
Daily step counts	–	–	0.471	0.031*
Age	–	–	–	–
Sex	–	–	–	–
BMI	–	–	–	–
TUG time	–	–	–	–
OLS	–	–	–	–
5CS	–	–	–	–

Note: 5CS, five chair stand test; BMI, body mass index; OLS, one leg standing; TUG, Timed Up & Go test. *$P < 0.05$.

only in the slow walking group with mild cognitive disorder. The present results show that lower physical activity could be a risk factor for cognitive decline in the elderly, and would strengthen the evidence to show the relationship between the amount of physical activity and cognitive function, as previously reported.[24] Additionally, the present study might show that the cognitive function of the elderly whose motor function and cognitive function are declining can be improved by increasing the amount of physical activity.

Physical activity might have an impact on cognitive function. The reasons why the SPMT, not MMSE, showed a correlation with physical activity might be explained as following. First, SPMT has been developed to screen mild cognitive disorder, whereas the MMSE is usually used for a broad range of cognitive impairment from normal to severe dementia. Because we only included patients with mild cognitive disorder, SPMT might be better to detect small correlated changes with other functions than MMSE. Second, SPMT shows good correlation not only with memory tests, but also with frontal function tests including word fluency test (Takechi *et al.* unpubl. observation). We speculate that efficient reminding of many objects from the scene requires the frontal function. Third, SPMT uses a line drawing scenery picture of a living room familiar to the elderly. It has been reported that aerobic exercise induces beneficial changes in brain structure and function that are correlated with improvements in cognition,[25,26] even in AD patients.[27,28] Physical activity, such as walking in and out of doors, might concomitantly give the patients visual stimulation. Because SPMT uses a picture of a living room familiar to the elderly, the degree of visual stimulation in daily living might have affected the results of SPMT. Thus, physical activity and the capacity to remember a visual scene might have shown a correlation. We suggest that increasing the amount of physical activity might result in beneficial biological changes to the brain structure and function or in beneficial physical changes to mobility and body composition. Therefore, increasing the step counts in a day could help to maintain and improve the cognitive function of older adults with mild cognitive disorder.

In the normal walking group with mild cognitive disorder, we found no significant association between memory function and the other variables. Other studies also show a lack of association of cognitive function with the amount of physical activity in older adults with similar ages to those in the present study.[7,29] Therefore, we need to consider effective strategies for patients with higher physical function.

There were several limitations of the present study. First, our limited sample size might introduce some error of inference, reduce the power of the analysis and limit generalization. Second, the present study was a cross-sectional study. Therefore, the relationship between the memory function and physical activity needs further investigation, such as an increase in physical activity levels for a certain period can improve the scores of SPMT, MMSE and other cognitive tests. Third, the definition of the normal walking group depended only on walking time in the present study. We might have to measure a frailty index, such as the Edmonton frail scale[30] or the Fried frailty assessment,[31] if we can extend our results to the frail elderly. Fourth, we used the SPMT, a visual memory test, as a cognitive test. However, we did not measure other factors, such as visual function and attention, that might have affected the present results. Therefore, it might be impossible to evaluate properly the relationship between physical activity and memory function. Thus, the results of the present study should be interpreted with caution.

In conclusion, the present study shows that cognition is associated with higher levels of physical activity only in patients with mild cognitive disorder who showed a slow walking speed. Our results suggest that increasing the amount of physical activity might prevent the deterioration of cognitive function. Further investigation, such as a prospective study, is required to confirm our results.

Acknowledgments

This work was supported by Grants-in-Aid for Scientific Research from the Japan Society for the Promotion of Science, from the Ministry of Education, Culture, Sports, Science, and Technology.

Disclosure statement

None of the authors have conflicts of interest or financial disclosures.

References

1 McGough EL, Kelly VE, Logsdon RG *et al.* Associations between physical performance and executive function in older adults with mild cognitive impairment: gait speed and the Timed "Up & Go" test. *Phys Ther* 2011; **91**: 1198–1207.

2 Petersen RC, Doody R, Kurz A *et al.* Current concepts in mild cognitive impairment. *Arch Neurol* 2001; **58**: 1985–1992.

3 Winblad B, Palmer K, Kivipelto M *et al.* Mild cognitive impairment – beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. *J Intern Med* 2004; **256**: 240–246.

4 Larrieu S, Letenneur L, Orgogozo JM *et al.* Incidence and outcome to mild cognitive impairment in a population-based prospective cohort. *Neurology* 2002; **59**: 1594–1599.

5 Matthews FE, Stephane BC, McLeith IG, Bond J, Brayne C. Two-year progression from mild cognitive impairment to dementia: to what extent do different definitions agree? *J Am Geriatr Soc* 2008; **56**: 1424–1433.

6 Ishikawa T, Ikeda M, Matsumoto N, Shigenobu K, Brayne C, Tanabe H. A longitudinal study regarding conversion from mild memory impairment to dementia in a Japanese community. *Int J Geriatr Psychiatry* 2006; **21**: 134–139.

7 Winchester J, Dick MB, Gillen D *et al.* Walking stabilizes cognitive functioning in Alzheimer's disease (AD) across one year. *Arch Gerontol Geriatr* 2013; **56** (1): 96–103.

8 Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Physical frailty is associated with incident mild cognitive impairment in community-based older persons. *J Am Geriatr Soc* 2010; **58**: 248–255.

9 Deshpande N, Metter EJ, Bandinelli S, Guralnik J, Ferrucci L. Gait speed under varied challenges and cognitive decline in older persons: a prospective study. *Age Ageing* 2009; **38**: 509–514.

10 Auyeung TW, Lee JS, Kwok T, Woo J. Physical frailty predicts future cognitive decline – a four-year prospective study in 2737 cognitively normal older adults. *J Nutr Health Aging* 2011; **15**: 690–694.

11 Cronin-Stubbs D, Beckett LA, Scherr PA *et al.* Weight loss in people with Alzheimer's disease: a prospective population based analysis. *BMJ* 1997; **314**: 178–179.

12 Scarmeas N, Albert M, Brandt J *et al.* Motor signs predict poor outcomes in Alzheimer's disease. *Neurology* 2005; **64**: 1696–1703.

13 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 4th edn. Washington, DC: American Psychiatric Association, 1994.

14 McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology* 1984; **34**: 939–944.

15 Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: clinical characterization and outcome. *Arch Neurol* 1999; **56**: 303–308.

16 Fazekas F, Chawluk JB, Alavi A, Hurtig HI, Zimmerman RA. MR signal abnormalities at 1.5 T in Alzheimer's dementia and normal aging. *Am J Roentgenol* 1987; **149**: 351–356.

17 Takechi H, Dodge HH. Scenery Picture Memory Test: a new type of quick and effective screening test to detect early stage Alzheimer's disease patients. *Geriatr Gerontol Int* 2010; **10**: 183–190.

18 Lopopolo RB, Greco M, Sullivan D, Craik RL, Mangione KK. Effect of therapeutic exercise on gait speed in community-dwelling elderly people: a meta-analysis. *Phys Ther* 2006; **86**: 520–540.

19 Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991; **39**: 142–148.

20 Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol* 1990; **45**: M192–M197.

21 Vellas BJ, Wayne SJ, Romero L, Baumgartner RN, Rubenstein LZ, Garry PJ. One-leg balance is an important predictor of injurious falls in older persons. *J Am Geriatr Soc* 1997; **45**: 735–738.

22 Guralnik JM, Simonsick EM, Ferrucci L *et al.* A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 1994; **49**: M85–M94.

23 Crouter SE, Schneider PL, Karabulut M, Bassett DR Jr. Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. *Med Sci Sports Exerc* 2003; **35**: 1455–1460.

24 Abbott RD, White LR, Ross GW, Masaki KH, Curb JD, Petrovitch H. Walking and dementia in physically capable elderly men. *JAMA* 2004; **292**: 1447–1453.

25 Cotman CW, Berchtold NC. Exercise: a behavioral intervention to enhance brain healthy and plasticity. *Trends Neurosci* 2002; **25**: 295–301.

26 Nichol KE, Parachikova AI, Cotman CW. Three weeks of running wheel exposure improves cognitive performance in the aged Tg2576 mouse. *Behav Brain Res* 2007; **184**: 124–132.

27 Yu F, Kolanowski AM. Facilitating aerobic exercise training in older adults with Alzheimer's disease. *Geriatric Nursing* 2009; **30**: 250–259.

28 Yu F, Kolanowski AM, Strumpf NE, Eslinger PJ. Improving cognition and function through exercise intervention in Alzheimer's disease. *J Nurs Scholarsh* 2006; **38**: 358–365.

29 Petersen RC. Mild cognitive impairment as a diagnostic entity. *J Intern Med* 2004; **56**: 183–194.

30 Rolfson DB, Majumdar SR, Tsuyuki RT, Tahir A, Rockwood K. Validity and reliability of the Edmonton Frail Scale. *Age Ageing* 2006; **35**: 526–529.

31 Fried LP, Tangen CM, Walston J *et al.* Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; **56A**: M146–M156.

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Physiotherapy xxx (2014) xxx–xxx

Physiotherapy

Fear of falling during activities of daily living after total hip arthroplasty in Japanese women: a cross-sectional study

K. Nagai [a,*], H. Ikutomo [b], M. Yamada [c], T. Tsuboyama [c], K. Masuhara [b]

[a] *Department of Physical Therapy, Faculty of Health Science, Kyoto Tachibana University, Kyoto, Japan*
[b] *Masuhara Clinic, Osaka, Japan*
[c] *Human Health Sciences, Graduate School of Medicine, Kyoto University, Kyoto, Japan*

Abstract

Objectives To investigate the prevalence of fear of falling, and identify factors associated with fear of falling during activities of daily living after total hip arthroplasty (THA).
Design Cross-sectional study.
Setting Community.
Participants Two hundred and fourteen women who had undergone THA.
Main outcome measures Fear of falling after THA was assessed for 12 activities of daily living using a fear of falling score. The number of falls in the past year, total Oxford Hip Score (OHS), total Penn State Worry Questionnaire (PSWQ) score and walking capacity were recorded as descriptive statistics. Multiple linear regression analysis was performed, with total fear of falling score as the dependent variable and age, body mass index, time since THA, bilateral THA, total OHS, history of falling, walking capacity and total PSWQ score as the independent variables.
Results A number of participants (mean age = 64.2) experienced fear of falling while ascending and descending stairs: 45% (97/214), taking a bath: 26% (56/214), bending to pick something up off the floor: 26% (55/214), and getting up from lying on the floor: 25% (54/214). Fear of falling during activities of daily living after THA was significantly correlated with total OHS, history of falling, walking capacity, total PSWQ score and age ($P < 0.05$).
Conclusions Fear of falling develops in certain activities of daily living after THA. It is associated with poorer functional outcome, history of falling, lower walking capacity, higher anxiety level and older age.

Keywords: Fear of falling; Fall; Total hip arthroplasty; Activities of daily living; Anxiety; Walking

Introduction

Total hip arthroplasty (THA) is a widely used treatment for severe osteoarthritis of the hip. THA provides a relatively safe, effective, long-term solution to the pain, immobility and disability associated with the condition, and allows patients to perform most of their normal activities of daily living [1,2]. However, despite such improvements, lower leg strength and mobility of patients after THA are not comparable with those of the general population [3,4]. In addition, motion difficulties or biomechanical changes in some activities of daily living persist after THA [5,6].

Fear of falling is a common and potentially disabling problem among older people living in the community. The psychological state can induce a debilitating downward spiral, marked by loss of confidence, reduced activity and, consequently, loss of independence in healthy older adults [7]. Although fear of falling is a major component of the 'post-fall syndrome' [8,9], it can develop in elderly individuals who have not experienced a fall [10]. The prevalence of fear of falling has been well investigated in older people, but little is known about its prevalence after THA. Patients

* Corresponding author at: Department of Physical Therapy, Faculty of Health Science, Kyoto Tachibana University, 34, Yamada-cho, Oyake, Yamashina-ku, Kyoto 607-8175, Japan. Tel.: +81 75 571 1111; fax: +81 75 574 4314.
E-mail address: k.nagai1231@gmail.com (K. Nagai).

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http://dx.doi.org/10.1016/j.physio.2013.10.006

who have undergone THA could experience fear of falling during activities of daily living due to persistent impairments in function. Detailed information about fear of falling after THA could enable effective instruction for activities of daily living, and thus may prevent excessive fear related to activity limitation. As such, this cross-sectional study aimed to investigate the prevalence of fear of falling, and identify factors associated with fear of falling during activities of daily living after THA. It was hypothesised that, after THA, patients experience fear of falling during certain activities of daily living, and this experience is related to functional outcome.

Methods

Participants

This study had a cross-sectional design. Participants were recruited via advertising and oral announcements by staff members in the hospital. The advertisement was posted at the hospital entrance and online. The oral announcements were made by nurses or therapists for community-dwelling outpatients visiting the hospital for a regular check-up. Three hundred and eighty-one community-dwelling older Japanese people were assessed for eligibility in this study. The inclusion criterion was THA. No criteria were set regarding age or postoperative period. Patients with neurological impairment (e.g. stroke, Parkinson's disease, paresis of the lower limbs), cardiovascular disease, arthrorheumatism, visual impediment, dizziness, severe cognitive impairment or hip osteoarthritis without THA were excluded. The number of male participants was fairly small ($n = 24$); therefore, men were excluded to avoid possible confounding due to the unbalanced sex distribution. All participants gave written informed consent for participation in the study. This research was approved by the Ethical Review Board of Kyoto University Graduate School of Medicine, Kyoto, Japan (E1265).

Data collection

Demographics

A printed copy of the questionnaire was delivered to each participant at meetings for patients with THA. Medical information, including the date of operation, operated side (bilateral or unilateral), revision THA, number of medications and number of comorbidities, was collected with a self-administered questionnaire and confirmed using clinical records. For the participants who had undergone bilateral THA, the date of the latest operation was used. In all cases, THA had been performed using a posterolateral approach.

Fear of falling

The Falls Efficacy Scale [11] was modified to evaluate fear of falling in the participants. The original version consists of 10 items, nine of which were included in the modified version ('answering the telephone' was excluded because few people with fear of falling during this activity were observed); three additional items, related to movements on the floor that could be restricted after THA, were included in the modified version. As such, the modified version included 12 items. The nine activities of daily living from the original Falls Efficacy Scale were: cleaning the house; getting dressed (including putting on socks); preparing simple meals; taking a bath; simple shopping; getting in and out of a chair; walking around the neighbourhood; reaching into cabinets or closets; and going up and down stairs. The additional three items were: getting in and out of a conventional or Japanese-style bed; getting up from lying on the floor; and bending to pick something up off the floor. The scale was dichotomised to describe whether or not a person feels fear. The participants were asked to complete a questionnaire on whether they experienced fear of falling in these 12 different activities of daily living, and score their responses as 'fear' (score 1) or 'no fear' (score 0). The possible total fear of falling score ranged from 0 to 12, with lower scores indicating greater confidence.

History of falling

In the self-completed questionnaire, participants were asked how many times they had fallen in the previous year. A fall was defined as an event that resulted in the person unintentionally coming to rest on the ground, floor or other lower level [12]. Falls resulting from extraordinary environmental factors (e.g. traffic accidents, falls while riding a bicycle) were excluded from the count.

Functional outcome

The Japanese version of the Oxford Hip Score (OHS) was used for the self-assessment of a patient's disability after THA [13,14]. The questionnaire contains the following 12 items: usual level of hip pain; trouble with washing and drying; transport difficulties; difficulty in putting on socks/stockings/tights; shopping for household items independently; walking time before severe pain; difficulty in climbing stairs; pain on standing up from sitting; limping when walking; sudden severe pain from the hip; work interference due to pain; and pain while in bed at night. Each item is scored from 1 (no symptoms or impairment) to 5 (severe symptoms or impairment). The scores are added to obtain a total value that can range from 12 to 60, with a lower score indicating less impairment or fewer symptoms.

Psychological state

The Japanese version of the Penn State Worry Questionnaire (PSWQ) was used to measure anxiety [15,16]. The validity and reliability of the Japanese version of this questionnaire have been confirmed previously [16]. The questionnaire contains 16 items which are rated on a five-point scale (from 'not at all typical of me' to 'very typical of me'). Examples of the items are: 'My worries overwhelm me', 'When I am under pressure I worry a lot', 'I am always worrying about something' and 'I worry about projects until they

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are all done'. The total PSWQ score can range from 16 to 80, with lower scores indicating less anxiety.

Ambulatory status

The participants were asked to assess their walking capacity as follows: 'How long can you walk without stopping?' [17]. The decision branch grading was set as follows: ≥60 minutes, ≥30 minutes but <60 minutes, ≥15 minutes but <30 minutes, <15 minutes and almost zero. The time frames were set for the sake of convenience according to the authors' clinical experience. The validity and reliability of this grading system have yet to be confirmed.

Statistical analysis

Data were organised as descriptive statistics. Participants with any missing data were excluded to maintain analytical accuracy by avoiding statistical imputation. Multiple regression analysis with the stepwise method was used to identify factors associated with fear of falling score after THA. Bilateral THA and number of falls in the past year were subsequently transformed into binary variables (all or nothing) to investigate the difference in fear of falling between fallers and non-fallers. The dependent variable was the total fear of falling score, and the independent variables were age, time since THA, bilateral THA, total OHS value, number of falls in the past year, walking capacity, total PSWQ score and use of multiple medications (four or more) [18]. Body mass index was included as an independent variable to control for the effect of physical attributes. Statistical Package for the Social Sciences Version 21.0 (Japan Ltd., Tokyo, Japan) was used for data analysis. Statistical significance was set at $P<0.05$.

Results

The study flow is shown in Fig. A (see online supplementary material). Twenty-two people refused to participate in this study. Questionnaires were collected from 359 people who agreed to participate; thus, the response rate was 94% (359/381). Thirty-nine participants without THA did not meet the inclusion criterion. Additionally, 37 participants who met the exclusion criteria and 24 men were excluded. Forty-five participants were also excluded because of missing data. Finally, the data for 214 participants were analysed (Table A, see online supplementary material). Of the all participants, 36% (76/214) had experienced falls in the past year. The median fear of falling score was 1 [interquartile range (IQR) 0 to 3]. A number of participants felt fear of falling when ascending and descending stairs: 45% (97/214), taking a bath: 26% (56/214), bending to pick something up off the floor: 26% (55/214), and getting up from lying on the floor: 25% (54/214) (Table 1). Nineteen percent of them (41/214) felt fear of falling while walking around the neighborhood.

Table 2 shows the results of the multiple linear regression analysis. Lower functional outcome (higher OHS value), lower walking capacity, history of falling, higher anxiety level (higher PSWQ score) and older age were significantly associated with fear of falling after THA, while the other independent variables (e.g. time since THA) were not associated with fear of falling after THA. This analysis revealed that fear of falling score after THA was significantly correlated with the total OHS value [standardised partial regression coefficient (β) 0.18; $P=0.008$], history of falling in the past year ($\beta=0.17$; $P=0.010$), walking capacity ($\beta=0.14$; $P=0.034$), total PSWQ score ($\beta=0.15$; $P=0.020$) and age ($\beta=0.14$; $P=0.036$) (Table 2). The other factors were excluded from the model.

Table 1
Fear of falling scores ($n=214$).

	No. of participants (%)[a]	Score
Activities of daily living		
Cleaning the house	28 (13)	
Getting dressed	35 (16)	
Preparing simple meals	10 (5)	
Taking a bath	56 (26)	
Simple shopping	25 (12)	
Getting in and out of a chair	19 (9)	
Walking around the neighbourhood	41 (19)	
Reaching into cabinets or closets	12 (6)	
Ascending or descending stairs	97 (45)	
Getting in and out of a conventional or Japanese-style bed	21 (10)	
Getting up from lying on the floor	54 (25)	
Bending to pick something up off the floor	55 (26)	
Total fear of falling score, median (IQR)[b]		1 (0 to 3)

IQR, interquartile range.
[a] Percentage indicates the rate of participants with fear during the activity.
[b] Total fear of falling score indicates the number of activities of daily living performed with fear.

Table 2
Multiple linear regression model ($R^2=0.173$).

Independent variable	B	SE	β	P[a]
Body mass index	0.004	0.048	0.006	0.930
Walking capacity	0.419	0.196	0.143	0.034
History of falling	0.806	0.308	0.169	0.010
Total OHS value	0.089	0.033	0.176	0.008
Total PSWQ score	0.039	0.017	0.151	0.020
Age	0.037	0.017	0.137	0.036

R^2, multiple correlation coefficient; B, partial regression coefficient; SE, standard error; β, standardised partial regression coefficient; OHS, Oxford Hip Score; PSWQ, Penn State Worry Questionnaire.
[a] $P<0.05$.

Discussion

This study had two major findings. First, the participants frequently experienced fear of falling during activities of daily living, especially while ascending or descending stairs, taking a bath, bending to pick something up off the floor,

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and getting up from lying on the floor. Second, fear of falling was associated with lower functional outcome, lower walking capacity, history of falling, higher anxiety level and older age.

Approximately half of the participants experienced fear of falling while ascending or descending stairs. This fear is well known in older people [19,20]. Lachman *et al.* reported the fear of falling during stair ascent/descent in older people using a four-point scale (0 = not at all afraid, 3 = very afraid), with an average score of 0.79 [20]. However, to the authors' knowledge, the prevalence of fear of falling after THA has not been investigated previously. Fujita *et al.* [6] reported that patients who have undergone THA have some difficulty during movement on stairs, and biomechanical analysis revealed kinetic alterations during this activity of daily living in individuals who have undergone total hip replacement compared with normal subjects [5]. Residual decreased physical function after THA may have led to these results, with the participants of the present study experiencing an increased fear of falling. Such fear during stair ascent/descent impairs stair negotiation [21], and may reduce the opportunity for using stairs after THA.

Several participants also felt fear of falling while taking a bath. McGrory *et al.* [22] reported that individuals who have undergone THA still have difficulty in taking a bath 1 year after surgery. Further, Tinetti *et al.* [23] demonstrated that self-efficacy for taking a bath or shower is the lowest among the various activities of daily living in older people. This activity, which can involve walking on a slippery surface and stepping into a bath tub, requires well-controlled balance and good range of motion in the hip joint. Lack of confidence during these movements may lead to fear of falling while taking a bath.

In the present study, one-quarter of the participants experienced fear of falling while bending to pick something up off the floor and getting up from lying on the floor. Fujita *et al.* [6] demonstrated that difficulty in bending towards the floor persists at 6 months after THA. Moreover, by investigating the relationship between the degree of difficulty in activity and range of motion in the hip joint, McGrory *et al.* [22] demonstrated that limitation in this activity of daily living is associated with the range of motion in hip flexion. A stooping movement requires muscle coordination and balance [24,25]. Limited range of motion in hip flexion, impaired muscle coordination and poor balance may have affected the experience of fear. Meanwhile, bending at the hip from an erect stance to retrieve an object on the floor can cause posterior dislocation of the femoral head [26]. Notably, 77% of dislocations occurred within 1 year of THA [27]. Therefore, anxiety about dislocation of the hip joint in the early postoperative period could have led patients to refrain from stooping, and the lack of sufficient experience with this motion could have caused fear of falling.

Getting up from the floor is often performed in the Japanese lifestyle [6]. Good lower leg function is needed to accomplish this movement [28]. Hofmeyer *et al.* [29] proposed a strategy for the elderly to rise safely from the floor, and reported a reduced degree of difficulty during the movement. Therefore, it is recommended that therapists should develop an exercise strategy for patients to acquire confidence in this activity of daily living. Recently, use of a conventional bed instead of a Japanese-style bed has been clinically recommended after THA in Japan. Therefore, the frequency of this activity of daily living may have decreased in the participants. Lack of experience in this movement may also have led to loss of confidence and induced fear of falling.

The present study revealed that fear of falling during some common activities of daily living is associated with lower functional outcome, history of falling, lower walking capacity, higher anxiety level and older age. Other researchers investigated the internal factors associated with fear of falling in healthy older people, and demonstrated the contribution of age, history of falling, anxiety trait and mobility [21,30], similar to the present findings. Meanwhile, the present study revealed that functional outcome is most strongly associated with general fear of falling after THA. This result suggests that lower functional outcome has a strong effect on fear of falling. Therefore, individuals who have undergone THA would benefit from the acquisition of good physical function to help eliminate fear of falling.

In contrast, the time since THA was not associated with fear of falling. The median postoperative period was 4 years in this study. Recovery of physical function could have plateaued by 4 years postoperatively.

In order to eliminate activity limitation due to fear of falling after THA, it is recommended that therapists should provide safety instructions and intensive rehabilitation in at least the following activities of daily living: ascending or descending stairs; taking a bath; bending to pick something up off the floor; and getting up from lying on the floor. Moreover, individuals who have undergone THA may require a long-term rehabilitation programme. Another effective approach would be to address environmental factors (e.g. by fixing a handrail) for frail patients with deteriorated function and/or advanced age. Patients with anxiety tended to experience fear of falling during activities of daily living; therefore, rehabilitation programmes that are individualised according to a patient's psychological characteristics may be effective after THA. However, the possibility that excessive confidence for avoiding falls (i.e. low perceived risk of falling in patients who are at risk of falls) may increase the number of accidents due to a lack of risk management should also be considered. As the present study does not provide sufficient information on this possibility, further prospective study is required.

The limitations of this study are as follows. The patients' actual activities of daily living were not evaluated objectively; accordingly, the detailed effect of fear of falling on activity limitation remains unclear. Objective outcomes (e.g. range of motion, muscle strength) were not evaluated; these outcomes may influence fear of falling in such patients. The types of medication that participants were prescribed were

Please cite this article in press as: Nagai K, et al. Fear of falling during activities of daily living after total hip arthroplasty in Japanese women: a cross-sectional study. Physiotherapy (2014), http://dx.doi.org/10.1016/j.physio.2013.10.006

not investigated, and thus the detailed effects of medication could not be assessed. The participants had a long postoperative period; the results might have changed if patients in the early postoperative period had been recruited. The design of this study was cross-sectional. The causal relationships between fear of falling and other factors were not clarified. Furthermore, the design of the present study is not free from possible recall bias for falls in the previous year. The fear of falling score was modified from the original Falls Efficacy Scale, and the validity and reliability of these modifications have not been confirmed. Further studies are needed to clarify the effect of fear of falling on negotiation of activities of daily living, the contribution of objective outcomes to fear, and the prevalence of fear of falling in patients during the early period after THA.

Conclusion

Patients who have undergone THA often experience fear of falling during various activities of daily living. Those patients with lower functional outcome, lower walking capacity, history of falling, higher anxiety level and older age tend to develop fear of falling. It is recommended that therapists should evaluate fear of falling in patients who have undergone THA, and institute rehabilitation programmes individually to decrease excessive fear leading to activity limitation.

Ethical approval: Ethical Review Board of Kyoto University Graduate School of Medicine, Kyoto, Japan (E1265).

Funding: Osaka Gas Group Welfare Foundation.

Conflict of interest: None declared.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.physio.2013.10.006.

References

[1] Wylde V, Blom AW, Whitehouse SL, Taylor AH, Pattison GT, Bannister GC. Patient-reported outcomes after total hip and knee arthroplasty: comparison of midterm results. J Arthroplasty 2009;24:210–6.

[2] Schmalzried TP, Szuszczewicz ES, Northfield MR, Akizuki KH, Frankel RE, Belcher G, *et al.* Quantitative assessment of walking activity after total hip or knee replacement. J Bone Joint Surg Am 1998;80:54–9.

[3] Sicard-Rosenbaum L, Light KE, Behrman AL. Gait, lower extremity strength, and self-assessed mobility after hip arthroplasty. J Gerontol A Biol Sci Med Sci 2002;57:M47–51.

[4] Bennett D, Humphreys L, O'Brien S, Kelly C, Orr JF, Beverland DE. Gait kinematics of age-stratified hip replacement patients – a large scale, long-term follow-up study. Gait Posture 2008;28:194–200.

[5] Foucher KC, Hurwitz DE, Wimmer MA. Do gait adaptations during stair climbing result in changes in implant forces in subjects with total hip replacements compared to normal subjects? Clin Biomech (Bristol, Avon) 2008;23:754–61.

[6] Fujita K, Makimoto K, Higo T, Shigematsu M, Hotokebuchi T. Changes in the WOMAC, EuroQol and Japanese lifestyle measurements among patients undergoing total hip arthroplasty. Osteoarthritis Cartilage 2009;17:848–55.

[7] Vellas B, Cayla F, Bocquet H, de Pemille F, Albarede JL. Prospective study of restriction of activity in old people after falls. Age Ageing 1987;16:189–93.

[8] Bhala RP, O'Donnell J, Thoppil E, Ptophobia. Phobic fear of falling and its clinical management. Phys Ther 1982;62:187–90.

[9] Murphy J, Isaacs B. The post-fall syndrome. A study of 36 elderly patients. Gerontology 1982;28:265–70.

[10] Silverton R, Tideisaar R. Falling in old age: its prevention and treatment. New York: Springer; 1989.

[11] Buchner D, Hornbrook M, Kutner N, Tinetti M, Ory M, Mulrow C, *et al.* Development of the common data base for the FICSIT trials. J Am Geriatr Soc 1993;41:297–308.

[12] Koski K, Luukinen H, Laippala P, Kivela SL. Physiological factors and medications as predictors of injurious falls by elderly people: a prospective population-based study. Age Ageing 1996;25: 29–38.

[13] Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. J Bone Joint Surg Br 1996;78:185–90.

[14] Uesugi Y, Fujita K, Okumiya A. Quality of life of total hip arthroplasty patients, and reliability and validity of the Oxford Hip Score Japanese Version. J Jpn Soc Nurs Res 2006;29:81–7.

[15] Meyer TJ, Miller ML, Metzger RL, Borkovec TD. Development and validation of the Penn State Worry Questionnaire. Behav Res Ther 1990;28:487–95.

[16] Motooka H, Matsumi J, Hayashi K. The reliability and validity of a Japanese version of the Penn State Worry Questionnaire (PSWQ): a self-report inventory of 'worry'. Jpn J Couns Sci 2009;42: 247–55.

[17] Remerand F, Le Tendre C, Baud A, Couvret C, Pourrat X, Favard L, *et al.* The early and delayed analgesic effects of ketamine after total hip arthroplasty: a prospective, randomized, controlled, double-blind study. Anesth Analg 2009;109:1963–71.

[18] Hartikainen S, Lonnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. J Gerontol A Biol Sci Med Sci 2007;62:1172–81.

[19] Delbaere K, Close JC, Mikolaizak AS, Sachdev PS, Brodaty H, Lord SR. The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. Age Ageing 2010;39: 210–6.

[20] Lachman ME, Howland J, Tennstedt S, Jette A, Assmann S, Peterson EW. Fear of falling and activity restriction: the survey of activities and fear of falling in the elderly (SAFE). J Gerontol B Psychol Sci Soc Sci 1998;53:43–50.

[21] Tiedemann AC, Sherrington C, Lord SR. Physical and psychological factors associated with stair negotiation performance in older people. J Gerontol A Biol Sci Med Sci 2007;62:1259–65.

[22] McGrory BJ, Freiberg AA, Shinar AA, Harris WH. Correlation of measured range of hip motion following total hip arthroplasty and responses to a questionnaire. J Arthroplasty 1996;11:565–71.

[23] Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol 1990;45:239–43.

[24] Burgess-Limerick R, Abernethy B, Neal RJ, Kippers V. Self-selected manual lifting technique: functional consequences of the interjoint coordination. Hum Factors 1995;37:395–411.

[25] Hernandez ME, Ashton-Miller JA, Alexander NB. Age-related differences in maintenance of balance during forward reach to the floor. J Gerontol A Biol Sci Med Sci 2013;68: 960–7.

[26] Pedersen DR, Callaghan JJ, Brown TD. Activity-dependence of the 'safe zone' for impingement versus dislocation avoidance. Med Eng Phys 2005;27:323–8.
[27] Woo RY, Morrey BF. Dislocations after total hip arthroplasty. J Bone Joint Surg Am 1982;64:1295–306.
[28] Bergland A, Laake K. Concurrent and predictive validity of 'getting up from lying on the floor'. Aging Clin Exp Res 2005;17:181–5.
[29] Hofmeyer MR, Alexander NB, Nyquist LV, Medell JL, Koreishi A. Floor-rise strategy training in older adults. J Am Geriatr Soc 2002;50:1702–6.
[30] Murphy SL, Dubin JA, Gill TM. The development of fear of falling among community-living older women: predisposing factors and subsequent fall events. J Gerontol A Biol Sci Med Sci 2003;58: M943–7.

Please cite this article in press as: Nagai K, et al. Fear of falling during activities of daily living after total hip arthroplasty in Japanese women: a cross-sectional study. Physiotherapy (2014), http://dx.doi.org/10.1016/j.physio.2013.10.006

Journal of Clinical Gerontology & Geriatrics 5 (2014) 18–22

Contents lists available at ScienceDirect

Journal of Clinical Gerontology & Geriatrics

journal homepage: www.e-jcgg.com

Original article

Effect of physical activity at midlife on skeletal muscle mass in old age in community-dwelling older women: A cross-sectional study

Shu Nishiguchi, MSc [a,b,*], Minoru Yamada, PhD [a], Yuu Kajiwara, MSc [c], Takuya Sonoda, MSc [d], Kazuya Yoshimura, MSc [e], Hiroki Kayama [a], Takanori Tanigawa [a], Taiki Yukutake [a], Tomoki Aoyama, MD PhD [a]

[a] *Department of Physical Therapy, Human Health Sciences, Graduate School of Medicine, Kyoto University, Kyoto, Japan*
[b] *Japan Society for the Promotion of Science, Tokyo, Japan*
[c] *Japanese Red Cross, Fukuoka Hospital, Fukuoka, Japan*
[d] *Department of Health and Welfare, Health Affairs Policy Division, Kyoto Prefecture, Kyoto, Japan*
[e] *Possible Medical Science Co. Ltd, Osaka, Japan*

ARTICLE INFO

Article history:
Received 8 May 2013
Received in revised form
24 August 2013
Accepted 10 September 2013
Available online 12 December 2013

Keywords:
Community-dwelling older adults
Midlife physical activity
Physical performance
Skeletal muscle mass

ABSTRACT

Background/Purpose: Measures to prevent the development of muscle mass decline should be initiated from midlife. However, the impact of physical activity at midlife on muscle mass in old age remains uncertain. The aim of this cross-sectional study was to determine whether physical activity at midlife influences muscle mass and physical performance in old age.

Methods: A total of 272 Japanese women aged 65 years and older were enrolled in the study. Information about physical activity levels at midlife and in old age were collected using a retrospective questionnaire. We calculated the skeletal muscle mass index in old age and recorded the participants' walking speed and hand grip strength in old age. We then classified the participants into four groups according to their physical activity levels at midlife and in old age and conducted multiple linear regression analysis to determine whether the physical activity levels at midlife and in old age were associated with skeletal muscle mass index and physical performance in old age.

Results: The participants in the groups that were physically inactive at midlife had a significantly lower skeletal muscle mass index in old age than those who were physically active at midlife ($p < 0.01$). Participants in the groups that were physically inactive in old age also had significantly slower walking speeds at old age than those who were physically active ($p < 0.01$). These associations remained significant after adjustment for age and body mass index.

Conclusion: Physical activity at midlife may be associated with a higher muscle mass in old age and physical activity in old age may be associated with higher walking speeds in old age.

1. Introduction

Muscle mass declines at approximately 1–2% per year after the age of 50 years.[1] Longitudinal studies have shown a clear decline in muscle mass, strength, and power beginning at approximately 35 years of age.[2] The age-related loss of skeletal muscle mass induces an increased risk of falls and fractures, physical disability, mobility disorders, and mortality.[3,4] To promote healthy aging, it is therefore important to develop ways of preventing muscle mass decline.

The beneficial effect of physical activity in preventing adverse health outcomes is widely endorsed. There is growing evidence that older adults who engage in physical activity are more likely to experience better physical function and have a longer active life expectancy than sedentary older adults.[5–7] Physical activity also has a positive impact on preventing muscle mass decline.[8] Physical activity is one of the most important modifiable factors associated with the risk of chronic morbidity and high mortality in the general population.

Recent studies have shown an association between physical activity at midlife and functional and health status in old age. The level of physical activity at midlife was related to better physical

* Corresponding author. Department of Physical Therapy, Human Health Sciences, Graduate School of Medicine, Kyoto University, 53 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto 606-8507, Japan.
E-mail address: nishiguchi.shu.82s@st.kyoto-u.ac.jp (S. Nishiguchi).

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http://dx.doi.org/10.1016/j.jcgg.2013.09.002

health and functioning and lower mortality risk.[9–12] Previous studies have also investigated the effects of midlife physical activity on different components of mobility[13–15] and the risk of institutionalization.[16] The benefits of physical activity at midlife appear to result from the maintenance of muscle strength,[13] cognitive function,[17] and other functions in old age. Furthermore, muscle mass in old age also appears to benefit from physical activity at midlife. Although it is important to prevent the development of muscle mass decline in old age and midlife, the effect of physical activity at midlife on muscle mass in old age remains uncertain.

The aim of this cross-sectional observational study was to determine whether physical activity at midlife was associated with muscle mass and physical performance in old age. We hypothesized that physical activity at midlife might prevent the decrease in muscle mass in old age.

2. Methods

2.1. Participants

Participants were recruited through a local press release requesting healthy community-dwelling volunteers. A total of 272 Japanese women aged 65 years and older (mean ± SD age 73.6 ± 5.5 years) living in the city of Kyoto enrolled in the study. Participants were interviewed and excluded if they met any of the following criteria: severe cognitive impairment; severe cardiac, pulmonary, or musculoskeletal disorders; and comorbidities associated with a greater risk of falls, such as Parkinson's disease and stroke. Written informed consent was obtained from each participant in accordance with the guidelines approved by the Kyoto University Graduate School of Medicine.

2.2. Assessment of physical activity

A questionnaire[13] was used to collect retrospective information about physical activity levels during midlife and old age. In the present study, we defined midlife as the period between the ages of 40 and 65 years. The questions were: 'How much physical activity did you have during midlife?' and 'How much physical activity do you have these days?' Similar to the approach used in the previous study, there were three response categories: no regular physical activity (0); regular physical activity (1); and regular sports (2). Regular physical activity/sports were defined based on a previous study[18] as activities/sports engaged in at a frequency of more than once a week. We defined light walking or moderate exercise (equivalent to less than approximately 4.0 metabolic equivalents) as physical activity and moderate or vigorous physical activities (equivalent to more than approximately 4.0 metabolic equivalents) as sports; these definitions were based on the International Physical Activity Questionnaire.[19] For each of the midlife and old age physical activity levels, Category 0 was defined as 'inactive' and Categories 1 and 2 (combined) were defined as 'active' in the analyses.

2.3. Skeletal muscle mass index

A bioelectrical impedance data acquisition system (Inbody 430; Biospace Co. Ltd, Seoul, Korea) was used to perform bioelectrical impedance analysis.[20] This system also uses an electrical current at multiple frequencies (5, 50, 250, 500, and 1000 kHz) to directly measure the amount of extracellular and intracellular water. The participants stood on two metallic electrodes and held metallic grip electrodes. Using segmental body composition, muscle mass was determined and used for further analysis. The skeletal muscle mass index (SMI) was calculated by dividing the muscle mass by height squared in meters (kg/m^2). This index has been used in several epidemiological studies.[4]

2.4. Measurements of physical performance

The following two measurements for the assessment of mobility and physical strength were made for each participant in the presence of experienced physiotherapists: (1) 10 m or 4 m walking test[21]; and (2) the hand grip strength (HGS) test.[22]

In the walking test, participants were asked to walk 10 m or 4 m at their normal walking speed. Walking time was calculated using a stopwatch to record the time taken to cover the central 10 m or 4 m of the walkway (2 m at the start and finish were used for acceleration and deceleration). Using the better walking time of two trials, the participants' walking speed (m/s) was calculated to obtain values for analyses.

In the HGS test, participants used a hand-held dynamometer with the arm held to the side of the body. The participants squeezed the dynamometer with maximum isometric effort. No other body movement was allowed. The HGS score was defined as the better performance of two trials.

2.5. Assessment of sarcopenia

For the present study we adopted the criteria of the European Working Group on Sarcopenia in Older People (EWGSOP).[23] The EWGSOP recommended defining sarcopenia as the presence of both low muscle function (slow walking speed equal to or less than 0.8 m/s; or low HGS equal to or less than 20 kg) and low muscle mass. For assessing low appendicular muscle mass, we divided the SMIs of the participants into quartiles and defined the first quartile as the cutoff for low appendicular muscle mass (SMI 5.55 kg/m^2).

2.6. Statistical analysis

Before analysis, we classified the participants into four groups according to physical activity levels in midlife and old age: Group I, physically inactive at both midlife and old age; Group II, physically active at midlife, but not at old age; Group III, physically inactive at midlife, but active at old age; and Group IV, physically active at both midlife and old age (Fig. 1).

Differences in the demographic variables among the four groups were examined using analysis of variance (ANOVA). When a significant effect was found, differences were determined with the Tukey–Kramer's post-hoc test. In addition, we entered four

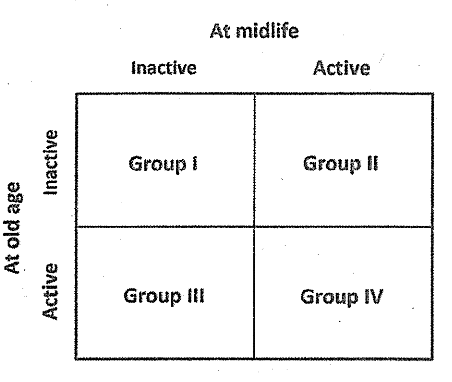

Fig. 1. Classification of participants in the four groups according to the midlife and old age physical activity levels: (Group I = physically inactive at both midlife and old age; Group II = physically active at midlife, but not at old age; Group III = physically inactive at midlife, but active at old age; Group IV = physically active at both midlife and old age).

dummy-coded groups, with Group IV as the reference group in models with independent variables; unadjusted and adjusted multiple linear regression analysis were conducted to determine whether physical activity levels in midlife and old age were associated with SMI and physical performance in old age. In the adjusted analyses, age and body mass index were entered as control variables.

Statistical analyses were carried out using the SPSS version 20.0 software package (SPSS, Chicago, IL, USA), with $p < 0.05$ accepted as significant.

3. Results

Table 1 shows the characteristics of the study population. The number (%) of participants in Groups I, II, III, and IV was 57 (21.0), 25 (9.2), 84 (30.9), and 106 (38.9), respectively. Participants in Group IV (SMI 6.35 ± 0.87 kg/m^2, walking speed 1.41 ± 0.26 m/s) (physically active at both midlife and old age) had significantly higher SMIs than those in Groups I (5.85 ± 0.92 kg/m^2, $p < 0.01$) and III (6.00 ± 1.08 kg/m^2, $p < 0.05$) (physically inactive at midlife) and faster walking speeds than those in Groups I (1.30 ± 0.25 m/s, $p < 0.05$) and II (1.27 ± 0.27 m/s, $p < 0.05$) (physically inactive at old age) (Table 1). There was no other significant difference among the four groups. A total of 38 (14.0%) participants had sarcopenia: 10 of 57 (17.5%), 3 of 25 (12.0%), 16 of 84 (16.7%), and 9 of 106 (8.5%) participants in Groups I, II, III, and IV, respectively.

In the unadjusted multiple linear regression analysis with Group IV as the reference, older adults within Groups I and III showed a significantly lower SMI ($p < 0.01$) and older adults in Groups I and II showed a significantly slower walking speed ($p < 0.01$) (Table 2). Thus participants who were physically inactive at midlife (Groups I and III) had a significantly lower SMI and participants who were physically inactive in old age (Groups I and II) had a significantly slower walking speed. These associations remained significant after adjustment for age and body mass index ($p < 0.05$) (Table 2). However, no group showed significant associations with HGS in the unadjusted and adjusted analysis.

4. Discussion

This is the first cross-sectional study to attempt to clarify the relationship between physical activity levels at midlife and skeletal muscle mass in old age. This study showed that older adults who were physically active at midlife might have a higher skeletal muscle mass in old age than those that were not physically active at midlife. A previous study reported that the rate of lean mass loss was about three times less than the rate of decline in leg strength.[24] Our results for the relationship between physical activity at midlife and skeletal muscle mass appear to be consistent with the previous study. In addition, the previous study reported that the exercise-induced increase in muscle mass was typically less than that expected for the concomitant increase in strength.[25] Therefore physical activity at midlife may be important and beneficial for preventing muscle mass decline in old age.

Muscle mass is controlled by catabolic and anabolic factors. A previous cohort study showed that regular physical activity was associated with low levels of catabolic markers such as interleukin-6.[26] In addition to its effects on catabolic factors, an increase in physical activity was associated with a high level of insulin-like growth factor-1, one of the most important factors linked to intensifying muscle mass in premenopausal women.[27] These results suggest that continuous regular physical activity prevents catabolic effects and promotes anabolic effects. However, there are no longitudinal reports that have reported an association between these factors and muscle mass from midlife to old age. On the basis of our preliminary results regarding the relationship between physical activity at midlife and skeletal muscle mass, further studies are required to confirm the benefits of physical activity from midlife for the prevention of muscle mass decline.

Our study also showed that adults physically active in old age might have a faster walking speed than those who were not physically active in old age. In addition, physical activity at midlife and in old age was not associated with grip strength in old age. Hughes et al[28] reported longitudinal changes in muscle mass, physical activity, and muscle strength and found that muscle mass decline explained only 5% of the decline in strength. Further, the changes in strength were no different between people of middle and old age who reported taking regular exercise in the past compared with those who had not exercised regularly in the past. These are the reasons why the relationship between physical activity and physical performance has different trends from that between physical activity and skeletal muscle mass. Furthermore, we observed significantly lower SMIs in Group III participants and slower walking speeds in Group II participants compared with Group IV, although there was no difference in muscle mass and physical performance between Groups II and III. These results seem to indicate that physical activity at midlife and old age may affect skeletal muscle mass and physical performance in old age. However, a previous longitudinal prospective study of the association between physical activity at midlife and walking speed[29] reported

Table 1
Demographic differences according to physical activity levels at midlife and old age.

	Total ($n = 272$)	Physical activity levels at midlife and old age					
		Group I ($n = 57$)	Group II ($n = 25$)	Group III ($n = 84$)	Group IV ($n = 106$)	*p*	*Post-hoc*
Age (y), mean ± SD	73.6 ± 5.5	74.1 ± 6.2	75.0 ± 5.2	74.0 ± 5.5	72.7 ± 4.9	0.146	—
Height (cm), mean ± SD	151.2 ± 5.4	151.1 ± 5.2	153.9 ± 5.4	150.9 ± 4.8	150.7 ± 5.9	0.088	—
Weight (kg), mean ± SD	49.7 ± 7.5	48.8 ± 6.9	51.7 ± 8.4	49.5 ± 7.6	49.9 ± 7.3	0.459	—
BMI (kg/m^2), mean ± SD	21.7 ± 2.9	21.4 ± 2.7	21.7 ± 2.8	21.7 ± 3.0	22.0 ± 2.8	0.653	—
SMI (kg/m^2), mean ± SD	6.11 ± 0.92	5.85 ± 0.92	6.14 ± 0.82	6.00 ± 1.08	6.35 ± 0.87	0.004	*,**
Walking speed (m/s), mean ± SD	1.35 ± 0.25	1.30 ± 0.25	1.27 ± 0.27	1.34 ± 0.23	1.41 ± 0.26	0.010	†,‡
HGS (kg), mean ± SD	22.1 ± 6.7	21.3 ± 3.5	21.4 ± 7.5	22.2 ± 10.2	22.5 ± 6.8	0.672	—
Sarcopenia, *n* (%)	38 (14.0)	10 (17.5)	3 (12.0)	16 (16.7)	9 (8.5)		

Group I = physically inactive at both midlife and old age; Group II = physically active at midlife, but not at old age; Group III = physically inactive at midlife, but active at old age; Group IV = physically active at both midlife and old age; BMI = body mass index; HGS = hand grip strength; SMI = skeletal muscle mass index.
*Significant difference between Group IV and Group I ($p < 0.01$).
**Significant difference between Group IV and Group III ($p < 0.05$).
†Significant difference between Group IV and Group I ($p < 0.05$).
‡Significant difference between Group IV and Group II ($p < 0.05$).

Table 2
Association of physical activity status with skeletal muscle index and physical performance in old age.

Dependent variable	Unadjusted model			Adjusted model		
	β	95% CI	Adjusted R^2 value	β	95% CI	Adjusted R^2 value
SMI			0.05			0.35
Group I	−0.22	−0.80 to −0.21**		−0.16	−0.61 to −0.11**	
Group II	−0.06	−0.62 to 0.21		−0.03	−0.48 to 0.24	
Group III	−0.18	−0.61 to −0.09**		−0.15	−0.50 to −0.07**	
Group IV	Reference			Reference		
Walking speed			0.05			0.17
Group I	−0.18	−0.19 to −0.03**		−0.17	−0.19 to −0.03**	
Group II	−0.18	−0.28 to −0.05**		−0.14	−0.24 to −0.02*	
Group III	−0.12	−0.14 to 0.01		−0.09	−0.12 to 0.02	
Group IV	Reference			Reference		
HGS			0.01			0.07
Group I	−0.08	−3.47 to 0.93		−0.06	−3.16 to 1.30	
Group II	−0.06	−4.51 to 1.66		−0.03	−3.93 to 2.30	
Group III	−0.02	−2.23 to 1.69		−0.01	−1.84 to 2.05	
Group IV	Reference			Reference		

Note: In the adjusted analysis, age and BMI were entered as control variables. Group I = physically inactive at both midlife and old age; Group II = physically active at midlife, but not at old age; Group III = physically inactive at midlife, but active at old age; Group IV = physically active at both midlife and old age; β = standard regression coefficient; CI = confidence interval; HGS = hand grip strength; SMI = skeletal muscle mass index.
*$p < 0.05$.
**$p < 0.01$.

results which were different from the present study. This may in part be because: (1) our assessment of physical activity was retrospective; (2) our questionnaire was not a particularly detailed assessment of physical activity as it did not contain items addressing the continuance and intensity of physical activity; and (3) the present study was cross-sectional. These may be the main reasons why our results differ from previous studies. In future studies, details regarding the level of physical activity at midlife and in old age must be collected to better understand how physical activity at midlife affects physical performance.

Many research groups have recently defined sarcopenia as the coexistence of low muscle mass and low physical performance.[23,30,31] The evidence-based clinical effect of physical activity on the prevention of sarcopenia has also been reported from multiple points of view.[8] The present study showed the relationship between physical activity at midlife and skeletal muscle mass as well as between physical activity in old age and physical performance, and suggested that continued physical activity from midlife to old age might be one of the important factors for the prevention of sarcopenia in old age. The benefits of constant physical activity for various health improvements are well known. Additional studies are required to determine the benefits of physical activity over the life course, not only in terms of various health improvements, but also for the prevention of sarcopenia.

There were several limitations to the present study. Firstly, this study was cross-sectional and we included no information on the effect of continuous regular physical activity from midlife to old age in the questionnaire. A longitudinal prospective study is therefore needed to confirm these results and extend the present study. Secondly, our assessment of physical activity at midlife and old age was conducted using a very simple questionnaire and was based on the participants' ability to recall information. Thirdly, the findings in the present study should be considered as preliminary due to the relatively small sample size, which may introduce some error of inference, reduce the power of the analysis, and limit generalization. Finally, we did not collect any information about comorbidity or current treatment with drugs for our participants.

In conclusion, the results of our study suggest that physical activity at midlife may be associated with high muscle mass in old age and that physical activity in old age may be associated with a fast walking speed in old age. The present study seems to be a fundamental study to determine the benefits of physical activity over the life course for the prevention of sarcopenia.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

We thank the students of Human Health Sciences at Kyoto University for their help with data collection.

References

1. von Haehling S, Morley JE, Anker SD. An overview of sarcopenia: facts and numbers on prevalence and clinical impact. *J Cachexia Sarcopenia Muscle* 2010;**1**:129–33.
2. Frontera WR, Hughes VA, Fielding RA, Fiatarone MA, Evans WJ, Roubenoff R. Aging of skeletal muscle: a 12-yr longitudinal study. *J Appl Physiol* 2000;**88**: 1321–6.
3. Rolland Y, Czerwinski S, Abellan Van Kan G, Morley JE, Cesari M, Onder G, et al. Sarcopenia: its assessment, etiology, pathogenesis, consequences and future perspectives. *J Nutr Health Aging* 2008;**12**:433–50.
4. Janssen I, Baumgartner RN, Ross R, Rosenberg IH, Roubenoff R. Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. *Am J Epidemiol* 2004;**159**:413–21.
5. Keysor JJ. Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence. *Am J Prev Med* 2003;**25**:129–36.
6. Leveille SG, Guralnik JM, Ferrucci L, Langlois JA. Aging successfully until death in old age: opportunities for increasing active life expectancy. *Am J Epidemiol* 1999;**149**:654–64.
7. Ferrucci L, Izmirlian G, Leveille S, Phillips CL, Corti MC, Brock DB, et al. Smoking, physical activity, and active life expectancy. *Am J Epidemiol* 1999;**149**:645–53.
8. Pillard F, Laoudj-Chenivesse D, Carnac G, Mercier J, Rami J, Riviere D, et al. Physical activity and sarcopenia. *Clin Geriatr Med* 2011;**27**:449–70.
9. Balboa-Castillo T, Guallar-Castillon P, Leon-Munoz LM, Graciani A, Lopez-Garcia E, Rodriguez-Artalejo F. Physical activity and mortality related to obesity and functional status in older adults in Spain. *Am J Prev Med* 2011;**40**:39–46.

10. Sun Q, Townsend MK, Okereke OI, Franco OH, Hu FB, Grodstein F. Physical activity at midlife in relation to successful survival in women at age 70 years or older. *Arch Intern Med* 2010;**170**:194–201.
11. Bäckmand HM, Kaprio J, Kujala UM, Sarna S. Physical activity, mood and the functioning of daily living. A longitudinal study among former elite athletes and referents in middle and old age. *Arch Gerontol Geriatr* 2009;**48**:1–9.
12. Willis BL, Gao A, Leonard D, Defina LF, Berry JD. Midlife fitness and the development of chronic conditions in later life. *Arch Intern Med* 2012;**172**:1333–40.
13. Tikkanen P, Nykänen I, Lönnroos E, Sipilä S, Sulkava R, Hartikainen S. Physical activity at age of 20–64 years and mobility and muscle strength in old age: a community-based study. *J Gerontol A Biol Sci Med Sci* 2012;**67**:905–10.
14. Patel KV, Coppin AK, Manini TM, Lauretani F, Bandinelli S, Ferrucci L, et al. Midlife physical activity and mobility in older age: The InCHIANTI study. *Am J Prev Med* 2006;**31**:217–24.
15. Willcox BJ, He Q, Chen R, Yano K, Masaki KH, Grove JS, et al. Midlife risk factors and healthy survival in men. *JAMA* 2006;**296**:2343–50.
16. von Bonsdorff MB, Rantanen T, Leinonen R, Kujala UM, Törmäkangas T, Mänty M, et al. Physical activity history and end-of-life hospital and long-term care. *J Gerontol A Biol Sci Med Sci* 2009;**64**:778–84.
17. Middleton LE, Barnes DE, Lui LY, Yaffe K. Physical activity over the life course and its association with cognitive performance and impairment in old age. *J Am Geriatr Soc* 2010;**58**:1322–6.
18. Abe T, Kawakami Y, Bemben MG, Fukunaga T. Comparison of age-related, site-specific muscle loss between young and old active and inactive Japanese women. *J Geriatr Phys Ther* 2011;**34**:168–73.
19. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;**35**:1381–95.
20. Gibson AL, Holmes JC, Desautels RL, Edmonds LB, Nuudi L. Ability of new octapolar bioimpedance spectroscopy analyzers to predict 4-component-model percentage body fat in Hispanic, black, and white adults. *Am J Clin Nutr* 2008;**87**:332–8.
21. Lopopolo RB, Greco M, Sullivan D, Craik RL, Mangione KK. Effect of therapeutic exercise on gait speed in community-dwelling elderly people: a meta-analysis. *Phys Ther* 2006;**86**:520–40.
22. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing* 2011;**40**:423–9.
23. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010;**39**:412–23.
24. Goodpaster BH, Park SW, Harris TB, Kritchevsky SB, Nevitt M, Schwartz AV, et al. The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. *J Gerontol A Biol Sci Med Sc* 2006;**61**:1059–64.
25. Frontera WR, Meredith CN, O'Reilly KP, Knuttgen HG, Evans WJ. Strength conditioning in older men: skeletal muscle hypertrophy and improved function. *J Appl Physiol* 1988;**64**:1038–44.
26. Hamer M, Sabia S, Batty GD, Shipley MJ, Tabák AG, Singh-Manoux A, et al. Physical activity and inflammatory markers over 10 years: follow-up in men and women from the Whitehall II cohort study. *Circulation* 2012;**126**:928–33.
27. Ardawi MS, Rouzi AA, Qari MH. Physical activity in relation to serum sclerostin, insulin-like growth factor-1, and bone turnover markers in healthy premenopausal women: a cross-sectional and a longitudinal study. *J Clin Endocrinol Metab* 2012;**97**:3691–9.
28. Hughes VA, Frontera WR, Wood M, Evans WJ, Dallal GE, Roubenoff R, et al. Longitudinal muscle strength changes in older adults: influence of muscle mass, physical activity, and health. *J Gerontol A Biol Sci Med Sci* 2001;**56**:B209–17.
29. Brach JS, FitzGerald S, Newman AB, Kelsey S, Kuller L, VanSwearingen JM, et al. Physical activity and functional status in community-dwelling older women: a 14-year prospective study. *Arch Intern Med* 2003;**163**:2565–71.
30. Morley JE, Abbatecola AM, Argiles JM, Baracos V, Bauer J, Bhasin S, et al. Sarcopenia with limited mobility: an international consensus. *J Am Med Dir Assoc* 2011;**12**:403–9.
31. Fielding RA, Vellas B, Evans WJ, Bhasin S, Morley JE, Newman AB, et al. Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology, and consequences. International Working Group on Sarcopenia. *J Am Med Dir Assoc* 2011;**12**:249–56.

Geriatr Gerontol Int 2013

ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Validation and translation of the Kihon Checklist (frailty index) into Brazilian Portuguese

Priscila Yukari Sewo Sampaio, Ricardo Aurélio Carvalho Sampaio, Minoru Yamada, Mihoko Ogita and Hidenori Arai

Department of Human Health Sciences, Kyoto University Graduate School of Medicine, Kyoto, Japan

Aim: To translate the Japanese Kihon Checklist (frailty index) into the Portuguese language, and to validate the use of the checklist for the assessment of the elderly Brazilian population.

Methods: A semantic analysis was carried out, along with pretesting of bilingual participants. The checklist was validated against the Edmonton Frail Scale.

Results: A total of 188 Brazilian older adults (mean age 69.5 ± 7.47 years) participated in the present study. In the semantic analysis, six elderly participants reported no difficulty with responding to the Portuguese version of the Kihon Checklist. During pretesting with 21 bilingual participants, we found a strong correlation between the total scores of the original version of the Kihon Checklist in Japanese and the translated version in Portuguese ($r = 0.764$, $P < 0.001$). According to the validation process, which involved 161 participants, there was a significant correlation between the total scores of the Kihon Checklist and the Edmonton Frail Scale ($r = 0.535$, $P < 0.001$), and between each domain of the checklist with the total score of Edmonton Frail Scale (lifestyle $\tau = 0.429$, $P < 0.001$; physical strength $\tau = 0.367$, $P < 0.001$; nutrition $\tau = 0.211$, $P = 0.002$; eating $\tau = 0.213$, $P = 0.001$; socialization $\tau = 0.269$, $P < 0.001$; memory $\tau = 0.285$, $P < 0.001$; and mood $\tau = 0.359$, $P < 0.001$). Furthermore, the Portuguese version of the Kihon Checklist showed satisfactory internal consistency (Cronbach's α coefficient: 0.787).

Conclusions: The Portuguese language version of the Kihon Checklist presented good internal consistency and validity. Therefore, we encourage its application in the elderly Brazilian population with an aim of monitoring their frailty to prevent or delay the functional dependence and any other adverse health outcomes. [Correction added on 14 January 2013, after first online publication: the phrase 'loss of' has been deleted from the preceding statement.] **Geriatr Gerontol Int 2013; ••: ••–••.**

Keywords: community-dwelling older people, Edmonton Frail Scale, frailty, Kihon Checklist, validation.

Introduction

The rapid increase in the number of frail older adults is considered a major healthcare challenge.[1,2] In recent years, the term "frailty" has been repeatedly discussed in the research literature, and several definitions have been proposed.[3] However, there is insufficient evidence to accept a single definition of frailty, and no single definition is currently considered to be a gold standard.[4] In general, there are two predominant approaches to defining frailty: (i) frailty is treated as a count of health impairments;[5,6] and (ii) the frailty phenotype is identified to detect people who find themselves between the independent and the dependent life stages.[7]

Independent of the adopted approach, valid and low-cost frailty assessment tools are required for both research and clinical purposes.[8] Therefore, the Japanese Ministry of Health, Labor and Welfare proposed a frailty index named the "Kihon Checklist" (KCL) that identifies vulnerable older adults as those with a higher risk of becoming dependent.[9,10] The KCL is used for screening frail older adults and is based on the needs of the Japanese long-term care insurance system.[11] The KCL has 25 yes/no questions divided into domains: lifestyle, physical strength, nutrition, eating, socialization, memory and mood (Table 1). A subject is identified as showing frailty if they score 10 points or more in the lifestyle domain. In addition, the results of the KCL can be analyzed separately by each domain. Scoring three

Accepted for publication 8 July 2013.

Correspondence: Professor Hidenori Arai MD PhD, Department of Human Health Sciences, Kyoto University Graduate School of Medicine, 53 Kawahara-cho, Shogoin, Sakyo-ku, Kyoto 606–8507, Japan. Email: harai@kuhp.kyoto-u.ac.jp

doi: 10.1111/ggi.12134