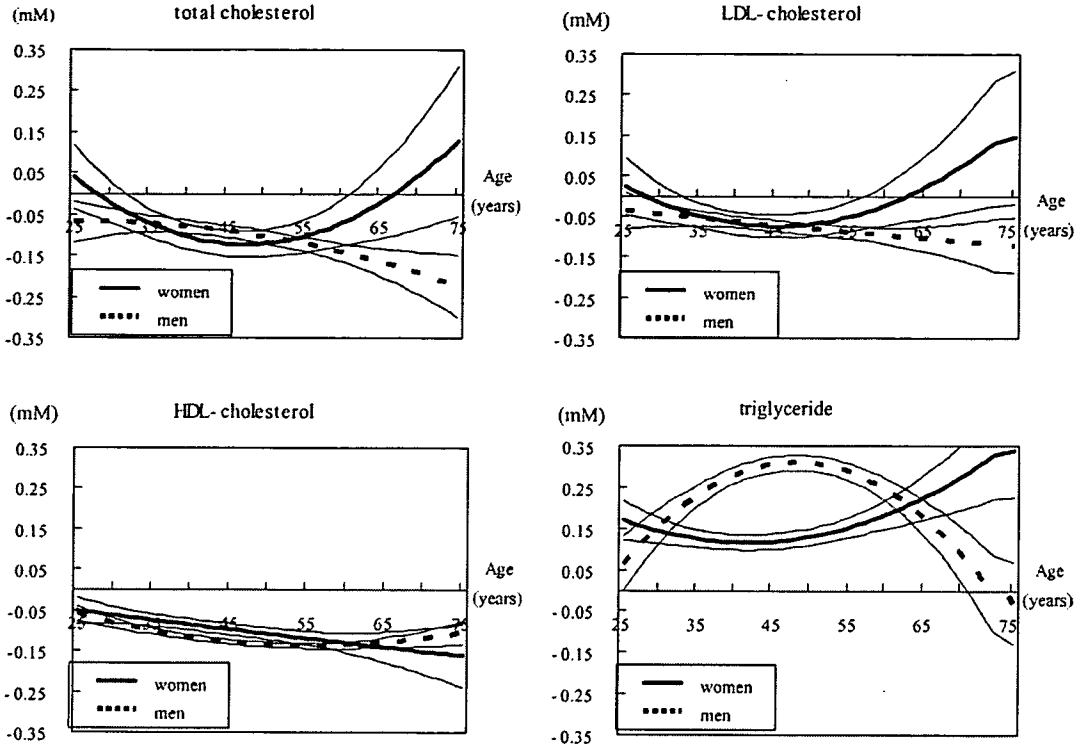

Fig. 3. The difference of estimated lipid levels (the lipid levels of smoker–those of nonsmokers) between current smokers and nonsmokers at individual age from 25 years through 75 years based on the longitudinal analysis. The curves show the average of the difference of estimated lipid levels based on the longitudinal analysis of mixed effect model between smokers and nonsmokers at each age. Thin curves indicate 95% CI.

monal changes in females after menopause might be involved in this inverted effect of smoking.

The effect of smoking on triglyceride levels also exhibits dynamic changes with age and gender difference. Based on longitudinal observation, smoking is associated with higher triglyceride levels at any age examined in both genders. In men, the strongest difference in triglyceride levels between smokers and nonsmokers is seen in middle age, and in women the stronger difference is seen after middle age. The reason for this gender difference and age-dependent effect of smoking on triglyceride levels remains unknown.

It seems that plasma enzymes involved in the metabolism of triglycerides and HDL cholesterol are potentially affected by smoking. However, there are conflicting observations. Some laboratories demonstrated that hepatic lipase is increased in smokers [16], and others demonstrated no difference between smokers and nonsmokers [17], or decreased hepatic lipase in smokers [18]. The hepatic lipase has been shown to be activated in smokers, and lectin:cholesterol acyl transferase activity has been shown to be unchanged [19] or decreased [17] compared with nonsmokers. Plasma cholesterol ester transfer protein activity has been shown to be marginally decreased in smokers in one study [17] and increased in another [19]. Plasma post-heparin lipoprotein lipase activity has been shown not to differ between smokers and nonsmokers in some studies [18,20] and to be increased in smokers in another study [17]. The reasons for these conflicting results on the effect of smoking on plasma enzymes regulating serum lipids and lipoproteins levels are not clear, but it is possible that the effect of smoking on these enzymes is dependent on the gender, age, genetic background, or ethnicity of the subjects.

It should be noted that some selection bias such as healthy worker bias may exist in our study, since most of the subjects were healthy office workers. In addition, the subjects may be aware of their lipid levels, since they had received annual examinations at a health examination center. There is another limitation of this study. Previous observations suggest that the effect of smoking on serum lipid levels is dose-dependent [4,6]. In this study, the data of smoking level in individuals were not available. In addition, alcohol consumption has an effect on serum lipid levels [21]. However, in the present study, the serum lipid levels were not adjusted to account for variations of alcohol consumption.

In the present study, we observed that the effect of smoking on serum lipid levels is age-dependent and that there is a gender difference based on the cross-sectional as well as longitudinal analysis. In men, smoking is associated with lower total and LDL cholesterol at any given age between 25 and 75 years. In women younger than 60 years, smoking is associated with lower cholesterol, but after 60–65 years smoking is associated with higher cholesterol levels. HDL cholesterol levels were lower in male and female smokers than in nonsmokers at most of the age groups examined. Smoking is

associated with higher triglyceride levels in any age examined in both genders except in males above 70 years. In men, the greatest difference in triglyceride levels between smokers and nonsmokers is seen in middle age, and in women, the greatest difference is seen after middle age.

Acknowledgments

This work was supported by a Grant-in Aid for the Comprehensive Research on Aging and Health from the Ministry of Health, Labor, and Welfare of Japan.

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ARCHIVES OF GERONTOLOGY AND GERIATRICS
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Effects of cognitive function on functional decline among community-dwelling non-disabled older Japanese

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Received 6 February 2005; accepted 1 June 2005
Available online 2 August 2005

Abstract

This study examined whether cognitive impairment, falls, and urinary incontinence (UI) were independent predictors of functional decline using a 2-year observation of a non-disabled older Japanese cohort living in a community from 1999 to 2001. A total of 139 men and 214 women aged 70–94 years at the baseline who were independent in both activities of daily living (ADL) and instrumental activities of daily living (IADL) were analyzed in this study. Independent variables, such as cognitive impairment, falls, UI, and other possible factors associated with functional decline were obtained from an interview survey at the baseline. A dependent variable was functional status in ADL and IADL obtained at the time of the 2-year follow-up. During the 2-year follow-up, cognitive function was a significant predictor for both IADL dependence and ADL and/or IADL dependence. Using a group of subjects with Mini Mental State Examination (MMSE) scores of 30–27 points as a reference group, a significant correlation was identified between lower MMSE scores and an increased odds ratio for functional decline. Lower cognitive function was a significant predictor of functional decline, even among those older Japanese whose cognitive function was deemed to be within the normal range.

Keywords: Instrumental activities of daily living; Aged; Cognitive impairment; Follow-up studies; Japan

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doi:10.1016/j.archger.2005.06.001

1. Introduction

The rapid rise in the number of older Japanese in recent years means that public health policies should pay particular attention to conditions and disorders unique to the elderly. Some of the most common disorders among the elderly persons defined as "old–old (aged 75 years and older)" are jointly referred to as geriatric syndrome, which generally includes senile dementia, urinary incontinence (UI), immobility, malnutrition, pressure sores, and iatrogenic disorders (Tinetti et al., 1995; Kane et al., 1999). Geriatric syndrome is known to diminish not only the long-term quality of life, but also the physical functioning in older people (Tinetti et al., 1995). Although several studies have examined whether cognitive impairment, falls, and/or UI are independent predictors of functional decline (Stuck et al., 1999; Aguero-Torres et al., 2002), few such studies have simultaneously assessed the prevalence of these conditions among community-living older adults to address the question of whether the latter are possible predictors of functional decline (Tinetti et al., 1995). Most studies dealing with the association between geriatric syndrome and functional decline use the activities of daily living (ADL) scale instead of the instrumental activities of daily living (IADL) scale as an outcome measure (Stuck et al., 1999); the latter provides an essential basis for determining whether an elderly individual is capable of living independently in the community (Aguero-Torres et al., 2002; Sauvaget et al., 2002). Measures for preventing dependence on IADL are expected to contribute to preventing ADL dependence because IADL dependence is a predictor of ADL dependence (Spector et al., 1987; Kai et al., 1991; Strawbridge et al., 1996; Nourhashemi et al., 2001). This is because individuals with IADL limitations are more likely to regain independence than those with ADL limitations (Crimmins and Saito, 1993; Ishizaki et al., 2000a, 2004). We therefore examined whether cognitive function, UI, experience of falls affected functional decline in either IADL only or ADL and/or IADL using a 2-year observation of a non-disabled older Japanese cohort living in a community.

2. Subjects and methods

2.1. Data source and study subjects

Following approval by the Institutional Review Board of the Tokyo Metropolitan Institute of Gerontology (TMIG), the study was conducted in a village in Akita Prefecture in the northern area of Honshu, one of the four main islands in Japan. In 2000, the total population of the village was 3538. A survey was taken first in 1999 and then again 2 years later. In the autumn of 1999, a face-to-face interview survey was carried out in a community center, for subjects with difficulty reaching the center, at their homes, to obtain baseline data. Because the questions in this study contained sensitive items, including UI and cognitive function, we were careful to protect participants' privacy by using screens between interviewer–participant pairs. Of the 786 people aged 70 years and older (320 men and 466 women) living in the village in 1999, 605 (77%) participated in the survey (256 men and 349 women). The vital status of the cohort was identified in 2001, using information for the residence registration records provided by the village government. Two

years after the baseline survey, and using the same method that had been used at the baseline, the subjects were surveyed again in relation to their survival status, ADL, and IADL. We limited the subjects of this particular study to those who were independent in both ADL and IADL at the baseline survey.

2.2. Assessment of functional status

ADL questions included walking, feeding, bathing, using the toilet, and dressing. IADL questions were derived from the instrumental self-maintenance scale of the TMIG index for competence (Koyano et al., 1991), and included going out using public transportation, shopping for daily necessities, preparing meals, paying bills, and depositing or withdrawing money from a bank account. The response to each item of these indices was simply "yes" (able to do without the help of another person or special equipment) or "no" (unable to do without the help of another person or special equipment). In this study, only those subjects who were assessed as being independent in all ADL (or IADL) items listed above were regarded as being ADL (or IADL)-independent. All other subjects were defined as ADL (or IADL)-dependent. Because the objective of this study was to examine the effects of geriatric syndrome on functional decline among older people during the 2-year follow-up period, we used functional status obtained from the follow-up survey conducted in 2001 as the outcome. Each subject's degree of functional independence at the time of the 2-year follow-up was categorized into the following three levels: independent in both ADL and IADL, dependent in only IADL, and dependent in ADL. In this study, functional decline was defined a change from independent in both ADL and IADL to either dependent in only IADL or dependent in ADL.

2.3. Assessment of geriatric syndrome

We collected information about the presence of UI, cognitive impairment, or experience of falls as geriatric syndrome. The questions regarding UI were related to the presence of UI and the frequency of incontinent episodes. The first UI question asked whether the subject had ever experienced urinary leakage before reaching a toilet. Answer choices for this question were: never, occasionally, and wearing diapers at all times. All subjects who chose alternatives indicating that they experienced urinary leakage occasionally or that they wore diapers at all times were questioned about the frequency of incontinence episodes. The answer choices were: almost daily, once every 2 days, once or twice a week, 1–3 times a month, and several times a year. Those subjects indicating that they experienced urinary leakage more than once a week were defined as having UI.

The Japanese version of the Mini Mental State Examination (MMSE) (Otsuka and Homma, 1991) was modified to evaluate the cognitive function of subjects living in a community (Folstein et al., 1985). The contents of the modified Japanese MMSE differ from the original in several ways. First, while the orientation question in the original version asks about the name and floor of the hospital where a respondent receives treatment, the same question in the modified version asks about the name of the community center where the interview was carried out. Second, the serial-sevens test, wherein the respondent starts with the number 100 and proceeds downward by subtracting seven each

time, was replaced by a backward spelling of the Japanese word "*FU-JI-NO-YA-MA*" (a five-syllable Japanese word "Mt. Fuji"). This substitution was made because of difficulty encountered explaining the rules of a serial-sevens test to both interviewers and respondents. Third, a copying task (copying of a complex figure) was given before a writing task because it was expected that many of the respondents in the present survey may not have immediately understood what exactly they were expected to write when asked to write a sentence. An MMSE score of 23 points or less and a score of 19 points or less were considered to be indicative of low cognitive skills and very low cognitive skills, respectively (McDowell and Newell, 1996).

The question regarding falls asked the subjects if they had experienced any falls during the past year. All subjects who had experienced falls were then asked about the frequency of falls during that period of time.

2.4. Potential predictors of functional decline

The interview also included questions regarding potential predictors of functional decline: age, gender, educational status, presence of visual impairment, presence of hearing impairment, intellectual activity, social role, and self-rated health. In terms of educational status, the subjects in the present study were divided into those with 6 years of education or less (elementary school level), and those with 7 years of education or more. A question about visual impairment was asked "Do you have any difficulties with visual activities?" The answer choices were: No, Yes, Yes with glasses. A question about hearing impairment was asked "Do you have any difficulties with hearing capability?" The answer choices were: No, Yes, Yes with a hearing device. Subscales derived from the TMIG index for competence (Koyano et al., 1991) were used to assess the subjects' intellectual activity (four items: filling out pension forms, reading a newspaper, reading books or magazines, and being interested in news stories or programs dealing with health) and social role (four items: visiting the homes of friends, being called on for advice, being able to visit sick friends, and initiating conversations with young people). A subject's intellectual activity and social role were defined as "good" only if a subject was assessed as being independent in all subscale items, and were defined as "poor" if a subject was assessed as being dependent in any of the subscale items. A question about self-rated health was asked "How would you rate your present health?" The answer choices were: good, fair, poor, and very poor. In this particular study, the self-rated health was categorized as either 'good' (good or fair) or 'poor' (poor or very poor).

2.5. Statistical methods

Functional and cognitive status of the subjects at the baseline survey were categorized according to the level of functional independence. Possible predictors of functional decline were examined by conducting the χ^2-test and a backward-stepwise multiple logistic regression analysis using either functional decline in only IADL or functional decline in ADL and/or IADL after 2 years (reference category: remaining independent in both ADL and IADL after 2 years) as a dependent variable, and presence of UI, cognitive function and experience of falls as explanatory variables. Other explanatory variables used included age,

gender, educational status, presence of hearing impairment, presence of visual impairment, self-rated health, intellectual activity, and social role. Whereas a P-value of 0.15 was used for variable retention for the backward-stepwise procedure, gender, age, cognitive function, presence of UI, and fall experience were always used as independent variables regardless of P values. The association between functional decline and possible predictors was assessed by odds ratio (OR) and 95% confidence interval (CI). We performed the goodness-of-fit tests developed by Hosmer and Lemeshow on the final model to measure how well the model fit the data (Hosmer and Lemeshow, 1989). A sensitivity analysis was conducted to determine the effects of drop-outs on the analysis results (Heitjan, 1997). Other sensitivity analysis was performed to examine the effect of the absence of the variable regarding educational attainment on the results. All analytical procedures were performed using SPSS Version 10.0 (SPSS Inc., 1999). All reported P values were two-tailed, and the level of significance was $P < 0.05$.

3. Results

3.1. Functional and cognitive status of the followed-up subjects at the baseline

Of all the subjects who participated in the 1999 baseline survey, a total of 526 (204 men and 322 women) provided answers for all question items related to functional abilities and the presence of geriatric syndrome. Of those, 81% (425 respondents) were assessed as both ADL- and IADL-independent, 14% were assessed as IADL-dependent only, and 5% were assessed as ADL-dependent.

The mean MMSE scores of 407 subjects who were both ADL- and IADL-independent at the baseline was 26.2 points (standard deviation = 3.6, median = 27, and range = 11–30). Table 1 illustrates the distribution of the subjects' MMSE scores, the proportion of subjects who experienced UI more than once a week, and the proportion of subjects who experienced falls during the past year.

3.2. Changes in functional independence during the 2-year interval

Those subjects who were both ADL- and IADL-independent at the baseline were examined for changes in functional independence during the 2-year period (Table 2). Because 18 of 425 subjects did not have a clear educational status, the following analyses were conducted among 407 subjects. Of the 407 subjects who were initially independent in both ADL and IADL (163 men and 244 women), two had died during the interval between the two surveys and 55 (29 men and 31 women) did not participate in the follow-up survey. Although we did not have the detailed information on the reason for the lost to follow-up among the cohort, we confirmed that the reason was neither migration nor death. Although the majority of the surveyed subjects maintained functional independence over the 2-year period, a certain degree of functional decline was observed among 11% of the male and female subjects. Less than half of the female subjects who were aged 80 years and older remained functionally independent over the 2-year period.

Table 1
Basic characteristics of subjects who were independent in both ADL and IADL in the baseline survey of 1999 ($n = 407$)

Basic characteristics		
Mean age (years)		74.9 (standard deviation 4.4)
Age range (years)		70–94
Age class (% ≥80)		15.5
Gender (% women)		60.0
Educational status (% 6 years or less)		88.9
Self-rated health (% poor)		20.1
Intellectual activity (% poor)		45.7
Social role (% poor)		35.1
Hearing impairment (% present)		7.9
Visual impairment (% present)		1.5
Geriatric syndrome		
Cognitive function: MMSE score (%)	30–27	51.6
	26–24	26.3
	23–20	17.4
	19–0	4.7
Presence of UI (% present)		9.3
Falls experienced during the past year (% present)		9.1

3.3. Relationship between functional decline and geriatric syndrome

Univariate analyses and a stepwise multiple logistic regression analysis were performed to compare subjects who were ADL- and IADL-independent in both 1999 and 2001 ($n = 304$) and those who were ADL- and IADL-independent in 1999 and either became IADL-dependent only in 2001 ($n = 37$) or became ADL-dependent in 2001 ($n = 9$). These analyses revealed that only MMSE score was significantly associated with functional decline after 2 years (Tables 3 and 4). As shown in Model 2 (Table 4), using a group of subjects with MMSE scores of 30–27 points as a reference group, the ORs for any functional decline after 2 years were estimated as 3.20 ($P = 0.015$), 5.66 ($P < 0.001$) and

Table 2
Functional transition over a 2-year period among Japanese elderly who were initially ADL- and IADL-independent at the baseline survey in 1999 ($n = 407$)

	Age group	Functional status in 2001				
		Independent in ADL and IADL (%)	Dependent in IADL only (%)	Dependent in ADL (%)	Dead (%)	Loss to follow-up (%)
Men	70–79 ($n = 135$)	75.6	9.6	0.7	0.0	14.1
	≥80 ($n = 28$)	60.7	10.7	3.6	0.0	25.0
	Total ($n = 163$)	73.0	9.8	1.2	0.0	16.0
Women	70–79 ($n = 209$)	82.3	3.3	2.4	1.0	11.0
	≥80 ($n = 35$)	37.1	40.0	5.7	0.0	17.1
	Total ($n = 244$)	75.8	8.6	2.9	0.8	11.9

Table 3
Results of univariate analyses that examined effects of geriatric syndrome on functional decline in IADL among Japanese elderly who were initially ADL- and IADL-independent over a 2-year period ($n = 350$)

Predictors	Category	n	Functional status in 2001			
			Independent in ADL and IADL (%)	Dependent in only IADL (%)	Dependent in ADL (%)	P-value[a]
MMSE score	30–27	185	95.1	4.9	0.0	<0.001
	26–24	91	85.7	12.1	2.2	
	23–20	61	73.8	18.0	8.2	
	19–0	13	38.5	46.2	15.4	
UI	Absent	317	87.1	10.1	2.8	0.432
	Weekly or daily	33	84.8	15.2	0.0	
Falls experienced during the past year	Absent	317	87.4	9.8	2.8	0.219
	Present	33	81.8	18.2	0.0	

[a] χ^2-test.

16.50 ($P < 0.001$) for groups of subjects with MMSE scores of 26–24 points, 23–20 points and 19–0 points, respectively (test for trend, $P < 0.001$). MMSE scores were also significantly associated with only IADL decline.

Table 4
Effect of cognitive function assessed by the MMSE on functional decline among Japanese elderly who were initially independent in both ADL and IADL during the 2-year interval, 1999–2001

Predictors	Category	Model 1[a] ($n = 341$)			Model 2[b] ($n = 350$)		
		OR	95% CI	P-value	OR	95% CI	P-value
MMSE score	30–27	1.00			1.00		
	26–24	2.65	0.99, 7.10	0.052	3.20	1.25, 8.20	0.015
	23–20	3.51	1.25, 9.86	0.017	5.66	2.19, 14.64	<0.001
	19–0	13.29	2.69, 65.79	0.002	16.50	3.68, 73.96	<0.001
			Test for trend	<0.001		Test for trend	<0.001
UI	Absent	1.00			1.00		
	Weekly or daily	1.30	0.38, 4.40	0.673	1.84	0.56, 6.07	0.317
Falls experienced during the past year	Absent	1.00			1.00		
	Present	0.48	0.16, 1.42	0.184	0.59	0.20, 1.73	0.331
Hosmer–Lemeshow test		$\chi^2 = 2.59$ ($P = 0.957$)			$\chi^2 = 3.30$ ($P = 0.914$)		

[a] Model 1: Stepwise multiple logistic regression analysis was performed to compare subjects who were ADL- and IADL-independent in both 1999 and 2001 ($n = 304$) and those who were ADL- and IADL-independent in 1999 and became dependent in only IADL in 2001 ($n = 37$). The OR was adjusted for gender, age, and educational status.

[b] Model 2: Stepwise multiple logistic regression analysis was performed to compare subjects who were ADL- and IADL-independent in both 1999 and 2001 ($n = 304$) and those who were ADL- and IADL-independent in 1999 and became dependent in IADL and/or ADL in 2001 ($n = 46$). The OR was adjusted for gender, age, educational status, and social roles.

Table 5
Results of sensitivity analysis to examine effects of loss-to-follow-up and lack of educational information on functional decline over the 2-year period

Predictors	Category	Model 1[a] ($n = 405$)			Model 2[b] ($n = 363$)		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
MMSE score	30–27	1.00			1.00		
	26–24	1.86	1.03, 3.38	0.041	3.25	1.31, 8.08	<0.001
	23–20	2.98	1.54, 5.78	0.001	5.72	2.25, 14.51	<0.001
	19–0	8.84	2.69, 29.09	<0.001	21.44	5.13, 89.53	<0.001
			Test for trend	<0.001		Test for trend	<0.001
UI	Absent	1.00			1.00		
	Weekly or daily	1.44	0.60, 3.45	0.412	1.79	0.54, 5.87	0.339
Falls experienced during the past year	Absent	1.00			1.00		
	Present	0.86	0.37, 1.96	0.711	0.63	0.22, 1.84	0.400
Hosmer–Lemeshow test		$\chi^2 = 5.11$ ($P = 0.746$)			$\chi^2 = 7.33$ ($P = 0.501$)		

[a] Model 1: As a sensitivity analysis, subjects who were alive but did not participate in the follow-up survey were regarded as those who became dependent in IADL and/or ADL in 2001. Stepwise multiple logistic regression analysis was performed to compare subjects who were ADL- and IADL-independent in both 1999 and 2001 ($n = 304$) and those who were ADL- and IADL-independent in 1999 and either became dependent in IADL and/or ADL in 2001 ($n = 46$) or lost-to-follow-up in 2002 ($n = 55$). The OR was adjusted for gender, age, educational status, and social roles.

[b] Model 2: Other sensitivity analysis included subjects who did not have information about educational status ($n = 18$). Stepwise multiple logistic regression analysis was performed to compare subjects who were ADL- and IADL-independent in both 1999 and 2001 ($n = 315$) and those who were ADL- and IADL-independent in 1999 and either became dependent in IADL and/or ADL in 2001 ($n = 48$). The OR was adjusted for gender, age, and social roles.

3.4. Sensitivity analysis

Two kinds of sensitivity analyses (Table 5) were conducted to determine the effects of either drop-out or lack of information about educational status on the analysis results (Heitjan, 1997). First, we assumed that 55 subjects who did not participate in the follow-up survey were dependent in ADL and/or IADL and they were included in the multiple logistic regression analysis. Other sensitivity analysis was performed to examine the effect of not having information on educational attainment in the results. In both models, lower MMSE scores were significant predictors of functional decline and a statistically significant association was observed between lower MMSE scores and increased OR for functional dependence (test for trend, $P < 0.001$).

4. Discussion

This study examined whether cognitive impairment, falls, and UI were independent predictors for functional decline by means of a 2-year observation of a non-disabled older Japanese cohort living in a community from 1999 to 2001. Multivariate logistic regression

analysis revealed that cognitive function was a significant predictor for functional decline during the 2-year follow-up. Analysis also revealed that, using a group of subjects with MMSE scores of 30–27 points as a reference group, a significant association was found between lower MMSE scores and increased OR for functional decline. These results indicate that lower cognitive function was a significant predictor for functional decline even among those older non-disabled Japanese whose cognitive function was deemed to be within the normal range.

All subjects included in the analysis were both ADL- and IADL-independent at the baseline; nevertheless, lower MMSE scores were significantly associated with any decreased functional independence 2 years later. This result indicates that normal cognitive function as assessed by MMSE does not necessarily guarantee long-term functional independence, especially if the elderly concerned have lower than average MMSE scores. Several longitudinal studies point to dementia (Aguero-Torres et al., 1998; Sauvaget et al., 2002) and cognitive impairment (Moritz et al., 1995; Gill et al., 1996, 1997; Aguero-Torres et al., 1998) as predictors of decreased ADL-independence; others revealed dementia to be a predictor of decreased IADL-independence (Sauvaget et al., 2002). One study also indicated that elderly people with normal cognitive function, but lower MMSE scores, were likely to have decreased ADL independence in the future (Greiner et al., 1996). The present study is unique in that it examined whether lower cognitive function is a possible predictor for ADL and/or IADL decline and in that it indicates that elderly with normal cognitive function, but lower MMSE scores, are likely to have decreased functional independence in the future.

Several issues may need to be considered when addressing cognitive function as a possible predictor of decreased functional independence. According to Lawton's model (Lawton, 1972), IADL performance requires higher cognitive functioning than ADL performance, since IADL deals with execution of more complicated tasks. A person with low cognitive performance is considered to have limitations in performing IADL tasks, and is therefore at increased risk of impaired IADL. In our previous study, a survey carried out in another village targeted older adults who were both ADL- and IADL-independent at the baseline (Ishizaki et al., 2000b). In that study, poor intellectual activity was identified as a significant predictor for IADL decline among older ADL- and IADL-independent subjects; however, the subjects' cognitive functions were not measured. To compare the results from our previous study with the present study, cognitive function assessed by MMSE was excluded from a multiple logistic regression analysis in this study. The results indicated that poor intellectual activity was a significant predictor of IADL dependence in the follow-up 2 years, supporting the understanding that IADL requires a certain level of intellectual capacity.

In this study, the present of UI was not associated with functional decline. Most female subjects with UI who participated in this survey replied that they used a special pad for urinary leakage (data not shown). Thus, such women were able to maintain IADL despite having UI. The prevalence rate of UI in this study (10%) was lower that that of previous studies because subjects in this study were limited to those with any disability in both ADL and IADL, while previous epidemiological studies were included both non-disabled and disabled populations. When we added disabled subjects at the time of the baseline survey to the original analyzable subjects, the prevalence of UI was about 40%. In addition, when we

asked respondents about UI, we were careful to protect their privacy. Therefore, we can say that the effect of underreporting UI in this study was not significant.

In interpreting the study results, the following limitations must be considered. First, 10% of the participants at the baseline did not participate in the follow-up, and 10 of the followed-up subjects provided no answers to some of the key questions related to functional status and were therefore excluded from the analysis. The 55 subjects who were lost to follow-up were significantly more likely to have poor social role, to have hearing impairment, and to have visual impairment than the 350 analyzable subjects ($P < 0.05$, data not shown). Sensitivity analysis was conducted to determine the effects of drop-outs on the analysis results based on two assumptions. In all cases, lower MMSE scores were significant predictors of IADL dependence and a statistically significant association was observed between lower MMSE scores and increased OR for functional dependence ($P < 0.001$). It can therefore be concluded that the effects of drop-outs on the results of the analysis were relatively small. Second, although the MMSE score of an individual is known to vary greatly depending on his/her educational attainment, educational attainment was not included in the logistic model regardless of the sensitivity analysis. The result indicated that lower MMSE scores were still a significant predictor of functional dependence. Finally, the subjects in the present study were selected from an agricultural village in Japan, and they therefore do not represent the entire elderly population of the country. However, the elderly adults who participated in the baseline survey constituted 77% of all elderly aged 70 years and older living in the surveyed district; thus, our study represents at least the elderly population living within the village surveyed. Despite the limitations listed above, the present study reliably demonstrates that lower cognitive function is a significant predictor of increased functional dependence over a 2-year period among elderly Japanese whose cognitive function is deemed to be within the normal range and who are both ADL- and IADL-independent.

5. Conclusion

To prevent lifestyle-related diseases, such as cerebral stroke, heart attack, and cancer, among middle aged and older adults, every Japanese citizen aged 40 years and older is entitled to receive an annual health examination under the Health Care Law for the Aged (Nakahara, 1997). As the Japanese population is graying rapidly, we believe the annual health examination should also be used as a means either to detect or prevent functional decline among the elderly. In order to ensure functional independence among the elderly, health examinations for them should include regular assessment of functional and cognitive status (Rubenstein and Rubenstein, 1992; Ebrahim, 1999). If a person is both ADL- and IADL-independent, but is assessed as exhibiting relatively poor cognitive performance, such an individual should be examined more closely and followed up to ensure that both his/her functional and cognitive status are maintained or improved. We believe the findings in this study can be instrumental in promoting healthy changes and preventing functional decline among non-disabled older adults living in communities in Japan.

Acknowledgement

This study was supported in part by a Grant-in-Aid for Comprehensive Research on Aging and Health from the Ministry of Health, Labour and Welfare, Japan.

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AGE-RELATED CHANGES OF POSTURAL STABILITY AND PHYSICAL FUNCTION IN MIDDLE-AGED AND ELDERLY JAPANESE

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Japanese Journal of Physical Fitness and Sports Medicine

(Vol. 55 Suppl Oct. 2006)

Jpn. J. Phys. Fitness Sports Med. 2006. 55 Suppl. : S227～S230

AGE-RELATED CHANGES OF POSTURAL STABILITY AND PHYSICAL FUNCTION IN MIDDLE-AGED AND ELDERLY JAPANESE

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Abstract

The aim of the present study was to clarify the relationships between age-related changes of postural stability and physical function in middle-aged and elderly Japanese. The subjects were 640 males and 620 females who had participated in both the baseline and the 4-year follow-up surveys of the National Institute for Longevity Sciences-Longitudinal Study of Aging. Postural stability was measured using a force platform. Flexibility, muscle function, reaction time, balance and comfortable and maximal gait performance were also measured as physical function. Postural sway was increased in 4 years. Multiple logistic regression analysis controlled for age, sex, height, weight and history of diseases revealed significant relationships between decline of postural stability and sit-ups, flexibility, frequency and velocity at comfortable gait and leg extension power at baseline. These results suggest that not only greater abdominal muscle strength and leg power but also quick walking benefit the preservation of postural stability.

(Jpn. J. Phys. Fitness Sports Med. 2006, 55 Suppl : S227～S230)

key word : postural stability, abdominal muscle strength, gait performance, longitudinal study, middle-aged and elderly

INTRODUCTION

Postural instability was observed in elderly people[1]. However, few population-based longitudinal studies have been presented in the literature. Previous studies suggested that poor balance is one of the risk factors of falls, which is a serious problem for the elderly[2,3]. It is important to investigate the relationship between age-related changes of postural stability and other physical function such as physical fitness and gait performance in order to develop effective strategy for maintaining balance or preventing falls. The aim of the present study was to estimate the changes of postural stability in 4 years and to clarify the relationships between age-related changes of postural stability and physical function in middle-aged and elderly Japanese.

METHODS

Subjects : The data of this study were collected as part of the National Institute for Longevity Sciences-Longitudinal Study of Aging (NILS-LSA). In this project, the normal aging process has been assessed using detailed questionnaires and examinations including clinical evaluations, blood chemistries, anthropometrical measurements, physical fitness tests, nutritional analysis, and psychological examinations. Details of the study are reported elsewhere[4]. The initial survey of NILS-LSA involved 2267 males and females aged 40～79 years. They were gender- and decade age-stratified random samples living in Obu-shi and Higashiura-cho Aichi Prefecture, Japan. The subjects for this study were 640 males (mean age at baseline ; 58.0±10.3 years) and 620 females (56.8±10.2 years) who had participated in both of the baseline and the 4-year follow-up surveys. Written informed consent was obtained from all the participants. The Ethical Committee of the National Center for Geriatrics and Gerontology has already approved all procedures of the NILS-LSA (Approval number : 175).

Variables :

1) Postural stability (baseline, follow-up)

The measurements of postural stability were carried out using a force platform (GE Yokogawa Medical Systems Co., Japan) in quiet upright bipedal

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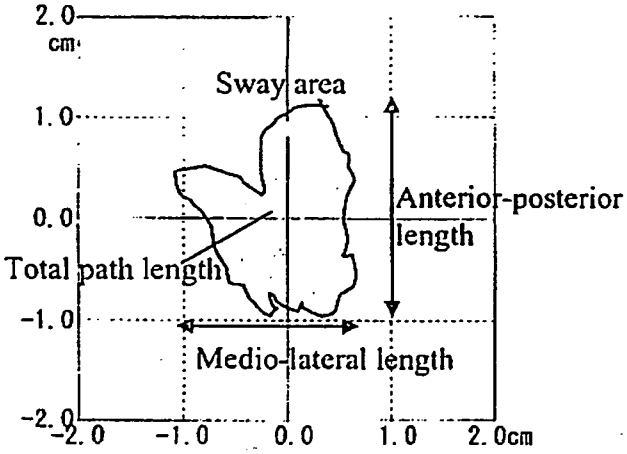

Figure 1. Examples of sway trajectory and output parameters.

stance under the eyes open and closed condition for 60 seconds. Output parameters to examine the amount of motion were the sway area, maximum anterior-posterior and medio-lateral length and total path length in both eyes conditions (Figure 1). The Romberg ratio (sway with eyes open/sway with eyes closed) was calculated in sway area and total path length.

2) Physical function (baseline)

Flexibility, grip strength, one-leg balance, reaction time, leg extension power, sit-ups, knee extension strength (Takei Co., Japan), step length, step frequency, and velocity during 10 m comfortable and maximal gait (Yagami Co., Japan) were measured as physical function.

3) Covariates (baseline)

Height and weight were measured using a digital scale. Body mass index was calculated as weight divided by height squared (BMI ; kg/m^2). Body fat mass was assessed by dual X-ray absorptiometry (DXA : QDR-4500A, Hologic, USA). Medical histories such as stroke, hypertension and diabetes mellitus were determined by questionnaire and interview.

Statistical analysis : Measurements of postural stability were compared by paired-t test between baseline and follow-up. Percent changes in the postural stability variables were calculated as the (change/baseline value) × 100. Multiple logistic regression analysis was performed to assess the relationships between changes of postural stability and each physical function. Odds ratios were calculated from the change of sway area with eyes closed (case : change > = 2 s. d., control : change < 2 s. d.) per 1 s. d. increase of each physical function controlled for age, sex, height, weight and history of diseases. Significant probability levels were less than 0.05. Statistical testing was performed using Statistical Analysis System release. 8.2 (SAS Institute Inc. NC, USA).

RESULTS

The characteristics of the subjects were summarized in Table 1. Subjects who reported history of diseases such as stroke, hypertension or diabetes mellitus were 29.7% of male and 25.2% of female. Four-year changes in postural stability were showed in Table 2. Postural sway significantly increased over the follow-up period excluded medio-lateral length with eyes open and total path length in both eyes conditions ($p < 0.05$). Romberg ratio significantly decreased over follow-up period in both sway area and total path length ($p < 0.05$). Mean percent changes in postural stability were showed in Figure 2. Mean percent change in the sway area with eyes closed (20.2%) was the greatest of all parameters. Therefore, the sway area was decided as an indicator of decline in postural stability. The relationship between decline in postural stability and physical function was shown in Table 3. Multiple logistic regression analysis controlled for age, sex, height, weight and history of diseases revealed significant relationship between

Table 1. Charactaristics of subjests.

		Male (n=640)	Female (n=620)
Height	(cm)	165.0 ± 6.2	152.4 ± 5.8
Weight	(kg)	62.8 ± 8.8	53.0 ± 8.0
BMI	(kg/m^2)	23.0 ± 2.7	22.8 ± 3.1
% Body fat	(%)	21.2 ± 4.1	31.2 ± 4.9
History of deseases†	(%)	29.7	25.2

Mean ± S. D.
†: Subjects who had, stroke, hypertention or diabetes mellitus.

Table 2. Four-year changes in postural stability.

		Baseline	Follow-up	Absolute change
Eyes open				
Sway area*	(cm^2)	2.26 ± 1.17	2.34 ± 1.16	0.08 ± 1.09
Anterior-posterior length*	(cm)	2.44 ± 0.74	2.78 ± 0.82	0.34 ± 0.85
Medio-lateral length	(cm)	1.99 ± 0.60	1.98 ± 0.58	-0.01 ± 0.61
Total path length*	(cm)	78.88 ± 16.50	72.01 ± 19.69	-6.87 ± 14.53
Eyes closed				
Sway area*	(cm^2)	3.80 ± 2.37	4.20 ± 3.01	0.40 ± 2.21
Anterior-posterior length*	(cm)	2.97 ± 0.95	3.09 ± 1.05	0.12 ± 0.98
Medio-lateral length*	(cm)	2.57 ± 0.90	2.76 ± 1.00	0.19 ± 0.89
Total path length	(cm)	107.60 ± 36.67	106.83 ± 44.76	-0.74 ± 29.59
Rombelg ratio				
Sway area*	-	0.69 ± 0.34	0.66 ± 0.31	-0.02 ± 0.41
Total path length*	-	0.76 ± 0.13	0.71 ± 0.14	-0.05 ± 0.14

Mean±S.D., *$p<0.05$; paird-t test.

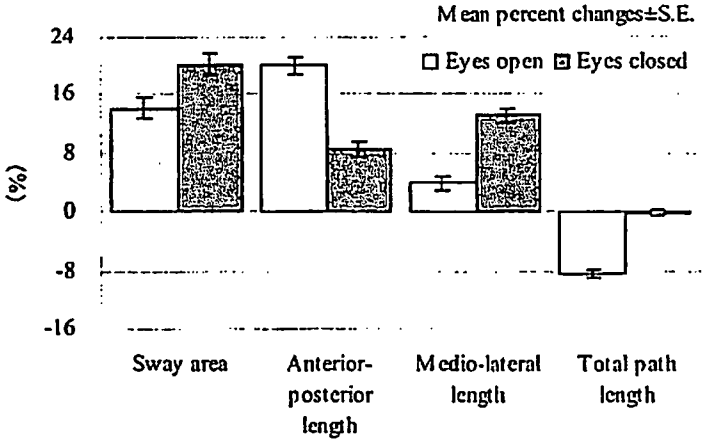

Figure 2. Mean percent changes in postural stability.

Table 3. Relationship between baseline physical function and postural stability change.

		Odds ratio†	95% CI	p-value
Flexibility		1.048	1.008 - 1.090	<0.05
Grip strength		1.002	0.938 - 1.069	
One-leg balance with eyes closed		0.972	0.933 - 1.013	
Reaction time		1.440	0.049 - 42.022	
Leg extensor power		0.997	0.994 - 1.000	<0.05
Sit-ups		0.921	0.850 - 0.998	<0.05
Knee extensor strength		0.962	0.918 - 1.008	
Comfortable gait	step length	0.987	0.944 - 1.032	
	step frequency	0.967	0.940 - 0.995	<0.05
	velocity	0.965	0.936 - 0.995	<0.05
Maximum gait	step length	0.975	0.934 - 1.018	
	step frequency	1.004	0.981 - 1.027	
	velocity	0.986	0.960 - 1.012	

†: Odds ratios of remakable change of away area with eyes closed (case : change>=2 s.d., control : change<2 s.d.) per 1 s.d. increase of each physical function controlled for age, sex, height, weight and history of diseases (stroke, hypertension or diabetes mellitus).

increased postural sway and sit-ups (Odds ratio per 1 s.d. = 0.921, 95% confidence interval = 0.850-0.998), flexibility (1.048, 1.008-1.090), step frequency (0.967, 0.940-0.995) and velocity (0.965, 0.936-0.995) at comfortable gait and leg extension power (0.997, 0.994-1.000).

DISCUSSION

The present study estimated the changes of postural stability in 4 years and the relationship between age-related changes of postural stability and physical function, corrected for age, sex, height, weight and history of diseases, based on a random sample of the middle-aged and elderly Japanese.

Previous cross-sectional studies suggested that the decline in postural stability associated with aging[1,5-7]. However, little is known about the contribution of age on postural stability in a population-based longitudinal study. In one follow-up study, Baloh et al suggested that static sway test was relatively insensitive for identifying age-related increased in sway than dynamic tests[6]. However, our results revealed that postural sway, excluding sway length was increased in 4 years. Age-associated impairment of postural control on static condition was demonstrated in the study.

The sway under the eyes closed condition was increased remarkably. The proprioceptive system or vestibular system may deteriorate with aging. Gill et al suggested that eye closure reduces the availability of visual information and shifts postural mechanisms towards vestibular and proprioceptive control, which may be unfavorable to the postural control in elderly subjects[7]. Our result is supported by previous studies[2,3,7].

In the logistic regression analysis, increased sway was negatively associated with sit-ups, leg extensor power and comfortable gait, and was positively associated with flexibility. Although Load et al indicated that increased body sway on the foam was associated with reduced quadriceps and ankle dorsiflexion strength[8], there were few studies to assess the relationship between components of physical fitness and postural stability. Our results suggest that not only greater abdominal muscle strength and leg power but also quick walking and lower trunk flexibility may benefit the preservation of postural stability.

In conclusion, the findings indicate that postural sway increased with aging in community dwelling middle-aged and elderly. Greater abdominal and lower extremity muscle strength and quick walking were associated with the preservation of postural stability.

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Original Article

Dietary Supplement Use by Community-living Population in Japan: Data from the National Institute for Longevity Sciences Longitudinal Study of Aging (NILS-LSA)

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BACKGROUND: There are few studies about dietary supplement use and nutrient intake from these products in Japan. The purpose of this study was to clarify (1) the prevalence of dietary supplement use, (2) the characteristics of dietary supplement users, (3) nutrient intake from dietary supplements, and (4) the existence of dietary supplement users who took excessive nutrients from these products.
METHODS: To collect the information on dietary supplement use in the previous year and nutrient intake from these products, we conducted a self-administered dietary supplement frequency questionnaire. The subjects were 2,259 people aged 40-82 years. Dietary supplements were grouped into 8 major categories. A dietary supplement database was developed to estimate nutrient intake from these products. Excess users were defined as people who consumed more nutrient than the tolerable upper intake level of the Dietary Reference Intakes for Japanese.
RESULTS: In the previous year, 55 % of males and 61 % of females consumed dietary supplements. Dietary supplement use was especially prevalent in females, subjects who felt unhealthy, and subjects who were more careful of maintaining an appropriate weight, though the association was affected by the frequency of dietary supplement use. The most common dietary supplements were drink type in males and vitamins in females. Some nutrient values obtained from dietary supplements were higher than those from food. Excess users were found for intake of vitamin A, B_6, K, niacin, iron, and magnesium.
CONCLUSIONS: It is important to clarify dietary supplement use and to estimate nutrient intake from these products.
J Epidemiol 2006; 16:249-260.

Key words: Dietary Supplements, Nutrition Surveys, Cohort Studies, Minerals, Vitamins.

Because sales of dietary supplements have increased in Japan,[1] it is conceivable that striking growth in the use of dietary supplements will occur in Japan, as it has in the USA and other developed countries. Assessing nutrient intake from dietary supplements, especially micronutrient intake, is very important. Because the levels of some micronutrients contained in these products are much higher than those contained in food,[2-4] people can easily consume such nutrients at toxic levels.[5-9] To monitor nutrient intake from dietary supplements is an important issue for public health. Furthermore, to assess nutrient intake from dietary supplements is essential for the development of nutritional epidemiologic studies. Lack of inclusion of dietary supplements in nutrient intake could possibly cause misclassification of individuals with regard to their total nutrient intake.[2-4,10,11] However, there have been very few studies on dietary supplement use in Japan. There is still uncertainty about the prevalence of dietary supplement use, nutrient intake from these products, and existence of users who consume extremely high levels of nutrients. One reason for the delay in the study of dietary supplement use in Japan might be due to the lack of a dietary supplement database. An extensive database that includes nutrient contents of dietary supplements is necessary for evaluating nutrient intake from these products; how-

Received April 19, 2006, and accepted July 6, 2006.
This study was supported by a Grant-in-Aid for Comprehensive Research on Aging and Health from the Ministry of Health, Labour and Welfare of Japan.
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