れている可能性がある．3）本研究は横断調査の結果を用いているため，老年症候群と諸健康状態間の因果関係について言及することができなかった．今後は，縦断調査を行うことにより，老年症候群と健康状態間の因果関係について検討することが必要である．

上記より，転倒，尿失禁，うつ，低栄養のうち，どれか一つ以上を保有する者は，健康度自己評価が低く，転倒恐怖感が高く，高次生活機能が低く，筋力，バランス能力，歩行速度などの身体機能も低いことが明らかとなった．特に，男性では，健康度自己評価が悪い，血色素量が低い，通常歩行速度が遅いことが，女性では健康度自己評価が悪い，転倒恐怖感があることが老年症候群の保有と強い関連があった．高齢者が地域でより自立した健康長寿を目指すためには，転倒，尿失禁，うつ，低栄養の老年症候群を持つ高齢者に対して，その危険因子を改善することを目的とした効率の高いプログラムを実施することが重要である．

本研究は，厚生労働科学研究費補助金（長寿科学総合研究事業　H14-長寿-006「寝たきり予防を目的とした老年症候群発生予防の検診（「お達者健診」）の実施と評価に関する研究」（主任研究者：鈴木隆雄一吉田英世）による助成を受けた．

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Health status of community-dwelling elderly with geriatric syndrome

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Abstract

Objectives: This study was conducted in order to examine the prevalence of geriatric syndrome (falls, incontinence, depression, and under-nutrition) in community-dwelling elderly people, and to analyze the health status of the elderly with geriatric syndrome risk compared to those of a group not at risk.

Methods: The subjects comprised 1,784 residents (769 men and 1,015 women) aged 70 years or more living in Itabashi-ku, Tokyo, who took part in the study. For this study, we divided the subjects into two groups: those with geriatric syndrome (n = 688) and those without (n = 1,096).

Results: It was found that 33.6% of men and 42.4% of women had geriatric syndrome. Elderly with geriatric syndrome in both men and women had a significantly lower the proportion of subjects who perceived as 'healthy' in terms of the self-rated health, the higher-level functional capacity, higher prevalence of fear of falling, and decreased physical performance including handgrip strength and usual・maximal walking speed than those in the group who did not have geriatric syndrome. Logistic regression analysis showed that geriatric syndrome was associated with poor perceived self-rated health, a lower hemoglobin level and a slower usual walking speed in men, whereas in women it was associated with poor perceived self-rated health and fear of falling.

Conclusion: Elderly individuals with geriatric syndrome have significantly decreased health status and physical performance compared to those without geriatric syndrome.

Key words: *Community-dwelling elderly, Geriatric syndrome, Health status, Physical performance, Prevention of long-term care status*
(Nippon Ronen Igakkai Zasshi 2007; 44: 224–230)

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Clinical Section

Gerontology

Gerontology 2007;53:322–328
DOI: 10.1159/000103257

Received: September 19, 2006
Accepted: February 18, 2007
Published online: May 29, 2007

Concomitant Lower Serum Albumin and Vitamin D Levels Are Associated with Decreased Objective Physical Performance among Japanese Community-Dwelling Elderly

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Key Words
Serum albumin · Vitamin D · Physical performance · Community-dwelling elderly

Abstract
Background: Previous studies have shown that serum albumin or vitamin D is associated with physical performance. We hypothesized that older adults with concomitant lower serum albumin and vitamin D (25-hydroxyvitamin D, 25OHD) levels are associated with decreased physical performance compared to those with 1 or none of the 2 risk factors. ***Objective:*** To investigate the association of combined serum albumin and 25OHD levels with physical performance (muscle strength and balance capability) in community-dwelling elderly. ***Methods:*** A cross-sectional study in a community-based population in the province of Tokyo, Japan, was performed. For the study, 1,094 community-dwelling people aged 70 and older underwent an interview, anthropometric measurements, blood analysis and physical performance testing. The subjects were classified into 4 types by combining serum albumin and 25OHD levels: lower albumin only, lower vitamin D only, lower albumin and lower vitamin D, higher albumin and higher vitamin D. ***Results:*** Men with concomitant lower albumin and lower 25OHD levels had significantly decreased knee extension power, usual timed Up & Go and maximal timed Up & Go, even after adjusting for age and body mass index (BMI). In women, concomitant lower albumin and lower vitamin D was associated with significantly decreased handgrip strength and functional reach, even after adjusting for age and BMI. Subjects with combined lower albumin and lower vitamin D levels showed a significant decline in muscle strength and balance capability compared to higher albumin and higher vitamin D, even after adjusting for age, current drinking or smoking status, physical activity, history of chronic disease, basic activities of daily living, instrumental activities of daily living, BMI and bone mineral density. ***Conclusion:*** Concomitant lower serum albumin and lower vitamin D levels are associated with decreased muscle strength and balance capability in both men and women. These results suggest that serum albumin and 25OHD together may be an important target for strategies aiming to achieve a healthy life and prevent loss of independence in community-dwelling elderly.

Introduction

Many studies have reported that the serum albumin level in the elderly is significantly associated with muscle mass, muscle strength and functional capacity [1–4]. We

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have previously shown that physical performance is certainly associated with the serum albumin level and tends to decrease at low serum albumin levels [5]. Particularly, handgrip strength and knee extension power were significantly declined at low serum albumin levels compared to normal levels in elderly men.

Low vitamin D level is also significantly related to decline of muscle strength [6–9], sarcopenia [8], functional limitations and disability [6, 9]. Moreover, vitamin D deficiency is common in healthy, community-dwelling elderly as well as geriatric patients [10–12].

Deterioration in physical performance has been found to be associated with serum albumin and serum vitamin D independently. However, few studies focused on the combination of serum albumin and vitamin D in relation with physical performance in the elderly.

Concomitant low serum albumin and vitamin D is not an unusual phenomenon among community-dwelling elderly. We hypothesized that older adults with both lower serum albumin and lower vitamin D levels are associated with decreased physical performance compared with those with only 1 or none of the 2 risk factors.

This study was conducted to investigate the association of combined serum albumin and vitamin D levels with physical performance in the community-dwelling elderly.

Methods

Population

The subjects analyzed in this study consisted of 1,094 residents (456 men and 638 women) aged 70 or older living in Itabashi-ku, Tokyo, who had participated in mass health checkups for the community elderly ('Otasha-kenshin') conducted in November 2004. Otasha-kenshin, literally meaning 'health checkups for successful aging', is a comprehensive health examination for the community elderly aiming to prevent the 'geriatric syndrome' including fall and fracture, incontinence, poor oral health, mild cognitive impairment, depression and undernutrition, in order to prevent loss of independence in the late life. Details of the survey, including subject details, investigation methods and contents have been described in our previous paper [13]. None of the subjects who participated in the present study had a history of malignant disease.

Data Collection

Interview

An interview was conducted to assess the age, living arrangements, current drinking or smoking status, physical activity, chronic disease conditions and activity limitation. Physical activity was assessed by whether the subject performed regular exercises defined as walking outdoors, running, exercises and sports at least once per week. History of chronic disease was self-reported and included hypertension, stroke, heart disease and diabetes. Heart disease included angina pectoris, acute myocardial infarction, congestive heart failure, aortic aneurysm and various arrhythmias. Activity limitation was assessed by questions on basic activities of daily living (BADL) and instrumental activities of daily living (IADL) [14]. BADL was measured using 5 items: walking, feeding, continence, bathing and dressing. IADL was assessed by 5 questions of the 'instrumental self-maintenance' sublevel in the Tokyo Metropolitan Institute of Gerontology index of competence: utilizing public transportation, shopping for daily living, preparing meals, paying bills, and managing bank deposits and savings. The response to each item in BADL and IADL was given a score of 1 for 'yes' and 0 for 'no', and the total score for 5 items was calculated. Thus, a score of 5 represents no difficulty and 0 represents total incapacity in BALD and IADL.

Anthropometrics Measurement

Body mass index (BMI) was computed as weight (in kilograms) divided by the square of height (in meters). Bone mineral density (BMD, g/cm^2) was evaluated at the forearm by dual energy X-ray absorptiometry using a DTX-200 osteometer (Osteometer MediTech, Hawthorne, Calif., USA). The measurements were performed by specially trained personnel. The osteometer was set to automatically measure BMD at a site 24 mm proximal to the position where the radius and ulna are separated by 8 mm.

Measurement of Serum Levels of Albumin and Vitamin D

Blood samples were collected in a nonfasting state, in a sitting position. The analyses were carried out centrally in one laboratory (Special Reference Laboratories Inc., Tokyo, Japan). Serum albumin level was measured by a standard kit using the biconjugate gradient method and the coefficient of variation for serum albumin was within less than 1%. Serum 25-hydroxyvitamin D (25OHD) level was used as a measure of vitamin D status [9], and was measured with an RIA2 kit (DiaSorin, Stillwater, Minn., USA). The RIA2 method is based on an antibody specific to 25OHD.

We summarized the serum albumin and 25OHD levels of these subjects into quartiles, and used the 25 percentile cutoff to classify the subjects into higher versus lower albumin and 25OHD groups. Thus, lower serum albumin was defined as 42.0 mg/dl or below for men and women. Lower serum vitamin D (25OHD) was defined as 62.5 nmol/l or below for men and 57.5 nmol/l or below for women. The subjects were classified into 4 types by combining serum albumin and vitamin D levels: lower albumin only (serum albumin $\leq$42.0 mg/dl in men and women), lower vitamin D only (serum 25OHD $\leq$62.5 nmol/l in men and $\leq$57.5 nmol/l in women), lower albumin and lower vitamin D (serum albumin $\leq$42.0 mg/dl and serum 25OHD $\leq$62.5 nmol/l in men, serum albumin $\leq$42.0 mg/dl and serum 25OHD $\leq$57.5 nmol/l in women), and higher albumin and higher vitamin D (serum albumin >42.0 mg/dl and serum 25OHD >62.5 nmol/l in men, serum albumin >42.0 mg/dl and serum 25OHD >57.5 nmol/l in women).

Physical Performance

Physical performance was assessed by muscle strength (handgrip strength and knee extension power) and balance capability (functional reach and timed Up & Go test). These assessments are routinely conducted for the community elderly as described previously [13–15]. Handgrip strength was measured by Smedley's Hand Dynamometer (Yagami, Tokyo, Japan). Knee extension power (Nm) was measured in the dominant leg, using a handheld dynamometer (Musculator GT-30; OG Giken, Tokyo, Japan). The subject was asked to sit in a chair with the knee bent at a right angle. The dynamometer was placed at the ankle joint. The muscle strength was measured as the peak force during isometric extension when the subjects were asked to extend the knee by their maximum leg power. The test was performed twice and the higher of the 2 measurements made on the dominant leg was recorded. For functional reach, the subject stood sideways against a wall in a natural position and stretched both arms to shoulder height. The positions of the fingertips were taken as the zero point. Then one arm was lowered. With the body tilted forward as far as possible, the subjects continued to stretch the arm parallel to the ground. The greatest distance of forward reach was measured. Three measurements were made, and the mean value was recorded. The timed Up & Go test measures the time (in seconds) it takes an individual to stand up, walk a standard distance of 3 meters, turn, walk back to the chair and sit down again. The timed Up & Go tests were recorded in usual and maximal speeds.

Statistical Analysis

All data were analyzed with the SPSS software for Windows, version 13.0 (SPSS Inc., Chicago, Ill., USA) and the level of significance was set at 5%. Comparisons of physical performance by combined serum albumin and vitamin D levels were conducted using ANCOVA controlled for age and BMI. To investigate the association of combined serum albumin and 25OHD levels with physical performance (muscle strength and balance capability), multiple regression analysis was conducted using 4 combined serum albumin and vitamin D groups. Similar group analysis was used in a previous report [16]. The analyses were adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD.

Table 1. Characteristics of study subjects

	Men (n = 456)	Women (n = 638)
Age, years	77.7 ± 4.0	77.8 ± 4.2
Living alone, %	9.0	39.7
Current drinkers, %	61.6	26.3
Current smokers, %	20.4	3.3
Regular exercise (every day), %	46.1	42.3
History of chronic disease, %	63.2	62.4
Hypertension, %	48.9	50.0
Stroke, %	13.6	9.1
Heart disease, %	22.8	24.6
Diabetes, %	8.8	5.8
BADL (full markers = 5)	4.99 ± 0.15	4.99 ± 0.10
IADL (full markers = 5)	4.78 ± 0.61	4.93 ± 0.36
BMI	23.0 ± 2.7	22.6 ± 3.3
BMD, g/cm^2	0.455 ± 0.081	0.291 ± 0.064
Albumin, mg/dl	43.3 ± 2.2	43.5 ± 2.0
25OHD, nmol/l	71.7 ± 13.2	65.8 ± 12.5
Combined serum albumin and vitamin D levels, %		
Low albumin only	26.5	22.7
Low vitamin D only	17.5	19.3
Low albumin and low vitamin D	9.2	6.9
High albumin and high vitamin D	46.8	51.1
Physical performance		
Handgrip strength, kg	28.4 ± 6.2	17.4 ± 4.2
Knee extension power, Nm	79.6 ± 25.8	52.6 ± 16.3
Functional reach, cm	35.3 ± 5.4	32.7 ± 5.6
Timed Up & Go (usual), s	6.3 ± 1.7	7.1 ± 2.8
Timed Up & Go (maximal), s	6.0 ± 1.6	6.7 ± 2.7

Results

The basic characteristics of the subjects – serum albumin and vitamin D concentrations, combined serum albumin and vitamin D levels, and physical performance – are shown in table 1. The mean age was 77.7 ± 4.0 years in men and 77.8 ± 4.2 years in women. The mean serum albumin concentrations were 43.3 ± 2.2 mg/dl in men and 43.5 ± 2.0 mg/dl in women. The mean vitamin D concentrations were 71.7 ± 13.2 nmol/l in men and 65.8 ± 12.5 nmol/l in women. The prevalence of lower serum albumin and vitamin D levels was 9.2% in men and 6.9% in women.

The comparisons of physical performance adjusted for age and BMI in the 4 groups classified by serum albumin and vitamin D levels are shown in table 2. Men with lower albumin and lower vitamin D (serum albumin ≤42.0 mg/dl and serum 25OHD ≤62.5 nmol/l) had significantly lower mean knee extension power ($p < 0.01$) and significantly slower timed Up & Go (usual $p < 0.01$, maximal $p < 0.05$) compared to low albumin only, low vitamin D only, and high albumin and high vitamin D. In women, lower serum albumin and lower serum vitamin D (serum albumin ≤42.0 mg/dl and serum 25OHD ≤57.5 nmol/l) meant significantly declined handgrip strength ($p < 0.01$) and functional reach ($p < 0.05$) compared to low albumin only, low vitamin D only, and high albumin and high vitamin D.

Table 3 shows the associations of combined serum concentrations of albumin and 25OHD with physical performance by multivariate regression models adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD. Men with lower albumin and lower vitamin D had significantly lower knee extension power ($p < 0.05$) and significantly slower timed Up & Go (usual $p < 0.001$, maximal $p < 0.05$) compared to higher albumin and higher vitamin D. In women, lower albumin and lower

Table 2. Relation between combined serum albumin and vitamin D levels and physical performance for men and women

	Low albumin only	Low vitamin D only	Low albumin and low vitamin D	High albumin and high vitamin D	p value[a]	p value[b]
Men						
Handgrip strength, kg	27.8 ± 6.0	28.4 ± 6.0	27.1 ± 6.6	29.1 ± 6.2	0.529	0.388
Knee extension power, Nm	74.9 ± 23.4	81.7 ± 27.6	67.1 ± 23.4	83.9 ± 25.6	0.005	0.002
Functional reach, cm	35.2 ± 5.5	34.5 ± 5.2	33.5 ± 6.4	36.0 ± 5.1	0.061	0.080
Timed Up & Go (usual), s	6.2 ± 1.5	6.3 ± 1.6	7.4 ± 2.9	6.0 ± 1.5	0.003	0.001
Timed Up & Go (maximal), s	6.0 ± 1.3	6.1 ± 1.5	6.8 ± 2.3	5.9 ± 1.6	0.044	0.018
Women						
Handgrip strength, kg	17.0 ± 4.0	17.3 ± 4.0	14.1 ± 4.7	18.1 ± 4.1	0.009	0.002
Knee extension power, Nm	50.8 ± 16.3	51.4 ± 16.4	46.3 ± 14.5	54.7 ± 16.3	0.550	0.228
Functional reach, cm	32.5 ± 5.1	31.9 ± 5.4	29.3 ± 6.2	33.5 ± 5.7	0.012	0.009
Timed Up & Go (usual), s	7.3 ± 2.4	7.1 ± 1.8	9.0 ± 4.7	6.7 ± 2.8	0.067	0.036
Timed Up & Go (maximal), s	6.9 ± 2.0	6.8 ± 1.8	8.3 ± 4.3	6.5 ± 2.9	0.270	0.199

[a] ANCOVA adjusted for age and BMI among 4 groups.
[b] ANCOVA adjusted for age and BMI between low albumin + low vitamin D and high albumin + high vitamin D.

Table 3. Associations of combined serum albumin and vitamin D levels with physical performance for men and women

	Handgrip strength			Knee extension power			Functional reach			Timed Up & Go (usual)			Timed Up & Go (maximal)		
	B	SE	p value	B	SE	p value	B	SE	p value	B	SE	p value	B	SE	p value
Men															
Low albumin only	–0.06	0.68	0.194	–0.12	2.80	0.017	–0.04	0.59	0.468	0.06	0.19	0.249	0.03	0.18	0.576
Low vitamin D only	–0.02	0.79	0.635	–0.01	3.27	0.933	–0.06	0.68	0.184	0.02	0.20	0.698	0.02	0.21	0.750
Low albumin and low vitamin D	–0.05	1.04	0.353	–0.12	4.28	0.010	–0.06	0.89	0.250	0.17	0.29	<0.001	0.12	0.28	0.016
Women															
Low albumin only	–0.05	0.39	0.255	–0.03	1.58	0.423	–0.12	0.53	0.635	0.01	0.24	0.892	–0.01	0.24	0.885
Low vitamin D only	–0.02	0.41	0.708	–0.02	1.66	0.666	–0.06	0.56	0.110	–0.02	0.26	0.590	–0.02	0.26	0.629
Low albumin and low vitamin D	–0.12	0.66	0.003	–0.03	2.66	0.430	–0.09	0.88	0.022	0.09	0.41	0.022	0.06	0.41	0.135

Values are adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD. p values are derived from multiple regression analysis. B = Regression coefficient; SE = standard error.

25OHD meant significantly declined handgrip strength ($p < 0.001$), functional reach ($p < 0.05$) and timed Up & Go (usual $p < 0.05$) compared to higher albumin and higher vitamin D.

Discussion

The maintenance of physical performance in old age is an important factor for a healthy and independent life in the community. It has been reported that physical performance of the elderly living in the community is associated with serum albumin [1–5] and vitamin D levels [6–10] separately. Since our previous study has demonstrated a significant relationship between serum albumin and physical performance of the elderly [5], the present study further examined the association by adding serum vitamin D. Through this study, we found that elderly persons with lower albumin and lower vitamin D levels at the same time had decreased muscle strength and balance capability not only when compared to higher albumin and higher vitamin D but also when compared to lower albumin only and lower vitamin D only. It has been suggested that concomitant lower serum albumin and lower vitamin D levels contribute synergistically to decreased muscle strength and balance capability. To our knowledge, we are the first to report a combined effect of serum albumin and vitamin D levels on physical performance in an older population.

In general, a serum albumin level of 38.0 mg/dl is frequently used as the cutoff point for lower serum albumin [1]. On the other hand, some researchers have advocated that the appropriate cutoff points for serum albumin are 40.0 mg/dl for ambulatory elderly [17] and 43.0 mg/dl for community elderly living at home [16]. The subjects in this study had a mean serum albumin level of 43.3 ± 2.2 mg/dl in men and 43.5 ± 2.0 mg/dl in women, and only 1.6% had a level below 38.0 mg/dl. For vitamin D (25OHD), various optimal levels have been reported, ranging from 70.0 to 80.0 nmol/l [18] and there are no consistent criteria for low vitamin D and vitamin D insufficiency or deficiency. Furthermore, the serum vitamin D level is well known to vary depending on the season. Although the results of some Japanese studies offer suggestions, the cutoff value for elderly Japanese is still uncertain. For example, serum 25OHD concentrations of less than 30.0 [19], 40.0 [20] or 50.0 nmol/l [21] were defined as cutoff values for vitamin D insufficiency. Therefore, we summarized the serum albumin and 25OHD levels of these subjects into quartiles, and use the 25 percentile cutoff to classify the subjects into higher versus lower albumin and 25OHD groups.

Serum albumin is the main protein synthesized by the liver and the levels change with protein intake, by trauma or infection, and in chronic renal or hepatic diseases [2]. Vitamin D can be synthesized in the skin or consumed in the diet, vitamin D-fortified milk or margarine, and multivitamins [7]. After it is synthesized or consumed, vitamin D is transported to the liver where it is hydroxylated to 25OHD. Vitamin D level is affected by exposure to ultraviolet light, food intake, season [12, 19] and deterioration of creatinine clearance [22]. Serum 25OHD declines to significantly lower levels during autumn and winter [12, 23] and is strongly influenced by vitamin D intake in winter in ambulant elderly [19], but this is not observed in summer [19, 22].

The mechanism connecting serum albumin and muscle mass is not clear [2, 4]. But serum albumin concentration may be a marker of protein status of the body, with lower values indicating a diminished protein reserve, stimulating catabolic processes leading to muscle breakdown [4]. With an undernourished status, the main source of amino acids for protein synthesis may lead to muscle strength decline. Thus, low serum albumin, even within the normal range, is independently associated with weaker muscle strength and future decline in muscle strength in older men and women [3]. Oral amino acids and protein supplements improve muscle strength and ambulatory capacity [24]. The main function of vitamin D is to preserve calcium and phosphate homeostasis in order to promote skeletal mineralization [9]. In a role of vitamin D on physical performance, vitamin D supplementation has also been reported to be significantly effective in maintaining or improving physical performance and preventing falling of frail elderly persons living in the community [25].

In our study, elderly with concomitant lower albumin and lower vitamin D levels showed a significant decline in muscle strength and balance capability, even after age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD had been taken into account compared with those with 1 or none of the 2 risk factors. Some studies have reported a significant positive association between serum albumin and vitamin D concentrations [20], while other studies found no significant relation [11]. No association was found between these 2 parameters in our present study (data not shown). This means that serum albumin and vitamin D concentrations are independent factors, in our study at least. Both serum albumin and vitamin D concentrations are associated with physical performance among the community-dwelling elderly. Therefore, in order to maintain a higher level of physical performance, it is important to maintain higher serum albumin and vitamin D levels. Incidentally, fish consumption seems to play an important role in maintaining adequate vitamin D nutrition in elderly Japanese, especially in winter [19].

Before establishing a final conclusion, some limitations of our study must be considered. (1) The subjects analyzed were not selected randomly from the study population, and they were relatively healthy elderly persons who were able to travel from their homes to the health checkup venue. As a result, elderly persons with lower physical functional capacity were excluded. (2) Plasma calcium, albumin-corrected calcium, phosphate and parathyroid hormone, which would provide information on the extent of primary vitamin D deficiency [9], and creatinine clearance that may affect the metabolism of vitamin D via the kidney [22], were not assessed in this study. (3) This study was a cross-sectional study and therefore does not provide cause/effect relationships, although we demonstrated a significant correlation between physical performance and serum albumin and vitamin D (25OHD) levels. Therefore, longitudinal follow-up studies and controlled clinical trials are necessary to confirm the role of serum albumin alone, serum vitamin D alone, and combined serum albumin and vitamin D in influencing physical performance of the elderly.

While these results confirm that albumin and vitamin D are without doubt important nutritional elements directly linked to the physical performance of elderly persons, so far no study has examined the effect of a combination of serum albumin and vitamin D levels on physical performance. The present study is significant in that it examined the association of combined serum albumin and vitamin D levels with physical performance such as muscle strength and balance capability.

In conclusion, concomitant lower serum albumin and vitamin D levels were associated with decreased muscle strength and balance capability. This finding indicates that combined lower serum albumin and lower vitamin D levels were associated with low physical performance. To maintain physical performance and lead an independent life in the community, we therefore suggest that it is more important to maintain optimal serum albumin and vitamin D levels through a continuous healthy lifestyle, including dietary habit, physical activities and appropriate supplementations, before the functional status declines to a frail state. Further work is required to validate our findings and monitor the effect of concomitant serum albumin and vitamin D levels on interventional programs for the prevention of functional decline with aging.

Acknowledgments

The authors are grateful to the participants and the research members of the mass health checkups for the community elderly (Otasha-kenshin). This work was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan (16390187) and the Research Grant for Longevity Sciences (H-14-choju-006) from the Ministry of Health and Welfare of Japan.

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SECTION ON LONGITUDINAL STUDIES

A mortality comparison of participants and non-participants in a comprehensive health examination among elderly people living in an urban Japanese community

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*ABSTRACT. **Background and aims:** Recent studies have revealed that there are critical differences between participants and non-participants in health examinations. The aim of this study was to examine mortality differences between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among community-dwelling elderly people, using a three-year prospective cohort study. **Methods:** The study population included 854 adults aged 70 to 84 at baseline. The following items were all studied: the status of participation in the comprehensive health examination as an independent variable, age, gender, number of years of education, living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one year, self-rated health, body mass index, instrumental activities of daily living, and subjective well-being as covariates; and all-cause mortality during a three-year follow-up as a dependent variable. **Results:** In an adjusted Cox's proportional hazard regression model, the mortality risk for participants in the comprehensive health examination was significantly lower than that of non-participants (Risk Ratio (for participants)=0.44, 95% confidence interval=0.24 to 0.78). **Conclusions:** The present study shows that there is a large mortality difference between participants and non-participants. Our findings suggest two possible interpretations: 1) There is a bias due to self-selection for participation in the trial, which was not eliminated by adjustment for the covariates in the statistical model; 2) There is an intervention effect associated with participation in the comprehensive health examination which reduces the mortality risk.*

(Aging Clin Exp Res 2007; 19: 240-245)

INTRODUCTION

Along with the worldwide aging of populations, the maintenance of functional capacity and prevention of long-term care dependence among the elderly have become major issues in geriatrics and gerontology (1, 2). The term "geriatric syndromes", referring to a group of medically significant findings which are experienced by older - particularly frail - persons, occur intermittently rather than either continuously or as single episodes. They may be triggered by acute insults, and are often linked to subsequent functional decline (3), and include delirium, dementia, depression, dizziness, emesis, falls, gait disorders, hearing loss, insomnia, urinary incontinence, language disorders, functional dependence, lower extremity problems, oral and dental problems, malnutrition, osteoporosis, pain, pressure ulcers, silent angina pectoris, sexual dysfunction, syncope, and vision loss (4-8). These problems are major factors that result in long-term care dependence among the elderly.

Early screening for geriatric syndromes is important for the prevention of long-term care dependence among community-dwelling elderly. We have recently been attempting to design a system for early detection of geriatric syndromes and subsequent intervention strategies within the community (7, 8). A comprehensive health examination for elderly people living in the community has been

Key words: All-cause mortality, comprehensive health examination for the elderly, prevention of geriatric syndromes and long-term care dependence, self-selection bias.

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Received February 13, 2006; accepted in revised form August 8, 2006.

used in an attempt to screen for geriatric syndromes. The comprehensive health examination that we have been designing is different from the usual multiphasic health check-ups that are used for detecting lifestyle-related illnesses among middle-aged and elderly people in Japan and Western countries (9-12). While prevention of lifestyle-related diseases is undeniably important, prevention of long-term care dependence calls for a different approach. For example, the major causes of death in Japanese people over 65 years old are cancer, heart disease, and stroke (Vital Statistics in Japan, 2001). On the other hand, although stroke remains a cause of long-term care dependence, the other major causes are age-related frailty, falls and fractures, and dementia, which are included together in geriatric syndromes (National Livelihood Survey in Japan, 2001). Therefore, the prevention and management of geriatric syndromes, as well as the prevention of lifestyle-related diseases, is crucial for the prevention of long-term care dependence. The present study examined mortality differences between participants and non-participants in a comprehensive health examination for the prevention of long-term care dependence, using a population-based, prospective approach. Since we asked individuals to participate in the health examination and they took part voluntarily, there may be a bias among those who chose to participate, compared with those who did not (non-participants). It is well-known that participants who choose to undergo health examinations are healthier, both physically and psychologically, than those who do not (7, 13-18), and they are more likely to have desirable health-related behavior (18, 19); therefore, participants have a higher likelihood of longevity than non-participants (15, 16, 20, 21). We tried to eliminate any self-selection bias by using statistical controls for demographic and health status, in both participants and non-participants in the comprehensive health examination. We used demographic data and health status information from both groups, collected one year before baseline, to control for self-selection bias.

METHODS

Participants

The source of data for the present study was the Longitudinal Interdisciplinary Study on Aging, conducted by the Tokyo Metropolitan Institute of Gerontology (22). The study was conducted in Itabashi ward, which is located in the north of Tokyo. As of 1 October 1991, of a total of 507,073 people (255,238 men, 251,835 women), 126,173 (24.9%, 58,996 men and 67,177 women) aged 50 to 74 years were registered as residents in the Itabashi ward. A sample of 4440 residents was obtained systematically from the municipal resident registration files on that date (i.e., 1 out of every 28 people were selected sequentially from the registration files). We acquired 3097 complete sets of data (for 1362 men and 1735 women) in the first round of home-visit surveys in 1991 (70.1% participation). We conducted home-visit surveys every year until 2000, with high response rates (80% to 90% participation). We obtained 1812 complete sets of data (725 men and 1087 women) in the final round of surveys in 2000.

Of the 1812 participants in the home-visit survey for 2000, 854 people aged 70 to 84, who were living in Itabashi ward on 1 October 2001, were asked, by letter, to participate in the comprehensive health examination for the elderly, conducted in October 2001. Four hundred and thirty-eight people (168 men and 270 women) took part in the examination voluntarily (51.3% participation) (7, 8). We followed the 854 adults (331 men and 523 women) as a prospective cohort and checked their mortality over a three-year follow-up period. We divided them into two groups - participants and non-participants - according to their participation in the comprehensive health examination in 2001. Non-participants included individuals who refused to participate in the comprehensive health examination and those who did not respond. Since the health examination was completed by the end of October 2001, we defined 1 November 2001 as the baseline for the follow-up period in the present study. Lastly, we carried out three-year mortality surveillance, from 1 November 2001 to 1 November 2004.

Comprehensive health examination

We carried out comprehensive health examinations for the elderly in 2001 and 2003, including medical examinations (blood pressure, history of past illnesses, bone mineral density, electrocardiogram, blood testing, and dental examination), physical fitness tests (hand-grip strength, walking ability, and balance ability tests), interviews regarding life-style and some risks of geriatric syndromes, cognitive function tests (Mini-Mental State Examination [23], digit symbol substitution test [24], verbal fluency test [25]), and a basic physician's medical check-up by interview. The complete examination took 90 min per participant (7, 8). Participants were then given summary reports of the results. In addition, those participants who were judged to be especially frail were encouraged to seek intervention via the community network, including health centers, clinics and hospitals.

Mortality follow-up

Current residence in Itabashi ward on 1 November 2004 was determined from the municipal resident registration files for Itabashi ward. Twelve people (1.4%) had moved away and were lost to follow-up. Seventy-eight (9.1%) had died. The dates on which residents moved away or died were identified from the registration files and used to calculate survival times. Certifications of all decedents and those moving away, and the relative dates were obtained from the Itabashi ward authorities.

Covariates

Data collected during the final round of the home-visit surveys in 2000 were used as covariates in analyzing for an independent association between participation in the health examination and mortality. Data for age, gender, number of years of education, living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one year, self-rated health, body mass index (BMI), instrumental activities of daily living (IADL) (measured according to the Tokyo Metropolitan Institute of Gerontology Index of Competence (2, 26), range: 0 to 13), and subjective well-being (measured according to the revised version of the Philadelphia Geriatric Center Morale Scale (27); range: 0 to 17), were used. Presence of chronic diseases was defined as having at least one disease among cancer, diabetes, heart disease, stroke, and hypertension.

Statistical analysis

All statistical procedures were performed using SAS version 9.1 software (SAS Institute Inc., Cary, NC, USA). We used a Kaplan-Meier survival curve and a Cox's proportional hazards regression model to investigate the difference in mortality between participants and non-participants in the comprehensive health examination over a three-year follow-up period, with the SAS LIFETEST and PHREG procedures, respectively.

The dependent variable in the analyses was survival time, calculated as the number of days between baseline (1 November 2001) and the date of death or censoring. Survivors were censored on 1 November 2004. Drop-outs were censored on the date of moving away from Itabashi ward.

A Kaplan-Meier survival curve was used to examine whether the survival of participants was significantly different from that of non-participants.

To assess the independent relationship between participation status in the comprehensive health examination and all-cause mortality, the above-mentioned covariates were included in the Cox's proportional hazard regression model. Before analysis, we checked relationships between independent variables in the regression model by calculating Pearson correlation coefficients and verified relatively low to mild relationships among them (range of absolute value of correlation coefficients, 0.00-0.44). Therefore, we confirmed that the likelihood of any occurrence of multi co-linearity in the regression model was relatively low.

Ethical considerations

The study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. We were given access to municipal resident registration files by the Itabashi ward authorities. The study was explained to all participants and all were advised that: 1) their participation would be entirely voluntary; 2) they could withdraw from the study at any time; and 3) if they chose not to participate or to withdraw, then they would not be disadvantaged in any way.

RESULTS

Table 1 lists the characteristics of members in the follow-up cohort (number of participants, age, proportion of women, number of years of education, proportion of living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one

Table 1 - *Demographic, health and functional status of participants and non-participants in 2000 and vital status over a 3-year follow-up period.*

	Participants (n=438)	Non-participants (n=416)	*p*-value†
Age in 2001 (years)	74.2±3.9	75.2±4.2	<0.001
Gender (% women)	61.9	60.6	0.698
Number of years of education (years)	10.5±2.7	9.9±2.9	0.002
Living alone (% living alone)	17.1	18.3	0.661
Presence of chronic diseases (% present)*	41.8	51.2	0.007
Experience of falls over one year (% present)	19.2	18.7	0.873
History of hospitalization over one year (% present)	9.1	16.3	0.002
Self-rated health (% fair/poor)	20.6	29.0	0.005
Body Mass Index (Kg/m^2)	22.5±3.0	22.2±3.4	0.120
Instrumental activities of daily living (points)	11.5±1.8	10.3±3.0	<0.001
Subjective well-being (points)	12.3±3.4	11.6±3.9	0.009
Vital status:			
Death (% present)	3.9	14.7	<0.001
Drop-out (% present)	1.3	1.4	0.888

*Presence of chronic disease was defined as having at least one disease among cancer, diabetes, heart disease, stroke, and hypertension. †*p*-value refers to *t*-test for continuous variables and χ^2 test for categorical variables, testing differences in characteristics between two groups.

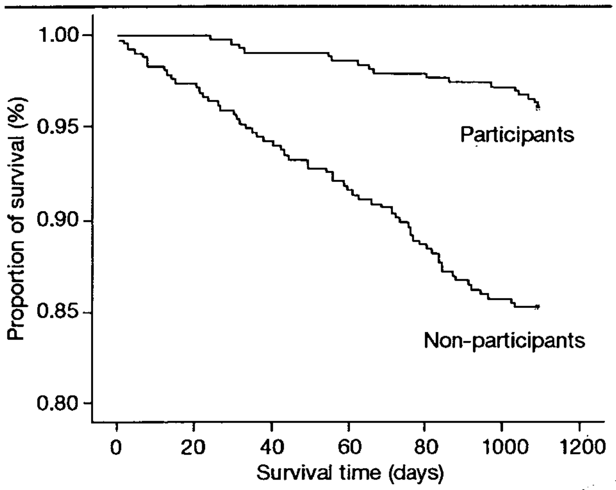

Fig. 1 - *Unadjusted Kaplan-Meier survival curves exploring difference in all-cause mortality between participants and non-participants in comprehensive health examination over a three-year follow-up period. Mortality risk was significantly lower for participants than non-participants (Log-rank test: p<0.001).*

year, self-rated health, BMI, IADL, and subjective well-being) collected from the two groups in 2000. We carried out a *t*-test for continuous measures and a χ^2 test for categorical measures, in order to clarify the difference in those characteristics between the two groups. Participants in the comprehensive health examination were younger ($p<0.001$) than non-participants, and had a higher education level ($p=0.002$), fewer chronic diseases ($p=0.007$), less hospitalization ($p=0.002$) and better self-rated health ($p=0.005$). Participants also were more likely to score better on IADL ($p<0.001$) and subjective well-being ($p=0.009$) than non-participants.

After three years, 78 of the 854 adults had died, i.e., 17 participants and 61 non-participants in the comprehensive health examination. Figure 1 shows the Kaplan-Meier survival curve ascertaining the relationship between status of participation in the health examination and all-cause mortality. The mortality risk was significantly lower for participants than for non-participants (Log-rank test: $p<0.001$).

Table 2 shows the associations between participation status in the comprehensive health examination, other factors, and all-cause mortality. In the unadjusted model, there was a significant inverse association between participation in the comprehensive health examination and all-cause mortality (RR=0.25, 95% CI= 0.14-0.42). In the adjusted model, there was a significant and independent inverse association between participation in the comprehensive health examination and all-cause mortality (RR=0.44, 95% CI= 0.24-0.78). Other factors such as age [RR= 1.08, 95% CI= 1.02-1.15], gender [RR (for women)=0.38, 95% CI= 0.23-0.64], self-rated health [RR (for fair/ poor)=1.91, 95% CI= 1.11-3.28] and IADL [RR (for a one-point increase)=0.88, 95% CI= 0.81-0.95] were also significantly and independently associated with mortality in the adjusted model.

DISCUSSION

Recent studies have revealed that there are critical differences between participants and non-participants in health examinations or health surveys for the elderly, both cross-sectionally and longitudinally (13-18, 21), and also large differences in survival between these groups (15, 16, 21). The present study examined mortality differences between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among elderly people in the community over a three-year follow-up period, using a statistical technique designed to exclude any self-selection bias.

A significant and large difference in mortality between participants and non-participants in the comprehensive health examination was also observed in the adjusted model controlling for potential confounding factors. Our findings show that the mortality risk of participants in the comprehensive health examination is lower than that of non-participants, for which we suggest two possible explanations: 1) a self-selection bias may remain even after adjustment by the covariates in the statistical model; 2)

Table 2 - *Unadjusted and adjusted risk ratio of all-cause mortality associated with participation status in comprehensive health examination, participants' demographic, health, and functional status.*

Independent variable	Unadjusted	Adjusted*
Participation in comprehensive health examination in 2001 (for participants)	0.25 (0.14-0.42)†	0.44 (0.24-0.78)†
Age in 2001 (for one year)	1.17 (1.11-1.24)†	1.08 (1.02-1.15)†
Gender (for women)	0.48 (0.30-0.74)†	0.38 (0.23-0.64)†
Number of years of education (for one year)	0.89 (0.82-0.98)†	0.92 (0.84-1.01)
Living alone (for living alone)	0.76 (0.40-1.43)	1.01 (0.51-1.99)
Presence of chronic diseases (for present)	1.80 (1.14-2.83)†	1.27 (0.77-2.10)
Experience of falls over one year (for present)	0.70 (0.37-1.32)	0.76 (0.39-1.51)
History of hospitalization over one year (for present)	2.88 (1.76-4.72)†	1.47 (0.84-2.55)
Self-rated health (for fair/poor)	2.38 (1.52-3.73)†	1.91 (1.11-3.28)†
Body mass index (for 1 Kg/m^2)	0.89 (0.83-0.96)†	0.94 (0.87-1.02)
Instrumental activities of daily living (for 1 point)	0.79 (0.75-0.84)†	0.88 (0.81-0.95)†
Subjective well-being (for 1 point)	0.96 (0.91-1.02)	1.03 (0.97-1.11)

*Obtained from multivariate Cox's proportional hazard regression model adjusted for all other variables listed above. †Significantly different from 1.

there may be an intervention effect related to participation in the comprehensive health examination that results in a reduced mortality risk among participants.

It has been reported that a self-selection bias occurs in health examinations or health surveys both cross-sectionally and longitudinally, that is, the physical and psychological health status of participants is initially superior to that of non-participants (7, 13-18), participants are more likely to have desirable health behavior (18, 19) and, therefore, their survival time is likely to be longer than that of non-participants (15, 16, 20, 21). Hebert et al. reported that participants were more cognitively intact, less disabled in functional ability, and less depressed in mood state than non-participants in a postal questionnaire survey (15). Suzuki et al. showed that participants had much better dietary habits, which included higher intake of vegetables, carotene, vitamin C and dietary fiber, and had a lower prevalence of cigarette smoking than non-participants in cancer screening programs (19). Minder et al. showed that the mortality risk for participants during a five-year follow-up period was lower after controlling for potential confounders than that for non-participants in preventive home visit programs (21). In the present study, similar tendencies were observed; participants in the comprehensive health examination were younger than non-participants, had a higher level of education, fewer chronic diseases, less history of hospitalization and better self-rated health, and were more likely to have better scores on IADL and subjective well-being, than non-participants (see Table 1). These factors may affect the association between participation status in the comprehensive health examination and mortality and, therefore, explain the large difference in mortality between the two groups.

On the other hand, in an attempt to eliminate any self-selection bias, covariates were included in the multivariate model. After this adjustment, participation in the health examination had a significant association with all-cause mortality. This also suggests that interventions undertaken in response to the findings of a comprehensive health examination may reduce mortality risk among the elderly. We recommend that individuals who are judged to be especially frail according to the examination results should receive information on interventions via the community network, including health centers, clinics and hospitals. This process may affect longevity in participants. Further studies are needed to examine whether comprehensive health examination systems for the elderly reduce mortality risk and are beneficial in terms of better independence, health and longevity. Ideally, these studies should be conducted using randomized control trials that allow biases such as self-selection bias to be eliminated.

Our findings also highlight another crucial issue: non-participants include individuals who have a higher mortality risk and they require relatively urgent interventions. Minder et al. (21) found that individuals who refused to take part in an intervention trial because they considered themselves to be healthy had mortality rates during a five-year follow-up period which were similar to those of participants. However, those who were too ill to participate in the trial had a higher mortality risk than participants. Similarly, Ives et al. (16) found that individuals who refused to participate in a health survey had a similar mortality risk to participants during a three-year follow-up period, but individuals who did not respond to an invitation via telephone or mail to participate in the survey had a higher mortality risk than participants. Therefore, we also need to introduce new strategies such as home-visit surveys and in-home intervention trials to care for these higher-risk individuals (28-30), so that early detection and intervention for geriatric syndromes can be assessed more efficiently. We have been designing this kind of program for future studies.

The extent to which our findings can be generalized is limited for two reasons. First, non-participants in the present study include both individuals who refused to participate in the comprehensive health examination and those who did not respond to the invitation. It has been shown that the mortality risk for non-participating subjects in intervention trials depends on the self-reported reason for refusal (21). Second, the statistical power might not have been sufficient to exclude any self-selection bias. Since we used data from the final round of home-visit surveys in 2000 as covariates, instead of the data from the baseline in 2001, some covariates may have changed in the year from 2000 to 2001. Moreover, potential confounders like smoking, alcohol consumption and physical activity, were not used as covariates in analyzing for an independent association between participation in the health examination and mortality because, for practical reasons, the variables were not collected in 2000.

CONCLUSIONS

Our results suggest that there is a large difference in survival over a three-year period between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among community-dwelling elderly people. This finding is probably caused by two factors: 1) a self-selection bias for participation in the trial, which was not eliminated by multivariate analysis; 2) an intervention effect associated with participation in the comprehensive health examination which reduces the mortality risk. Our finding also emphasizes another essential issue: non-participants include individuals who have a higher mortality risk and they require relatively urgent interventions. Therefore, we also need to introduce new strategies such as home-visit surveys and in-home intervention trials, to care for these higher-risk individuals, so that early detection and intervention for geriatric syndromes can be assessed more efficiently.

ACKNOWLEDGMENTS

The authors are grateful to Dr. Y. Gondo, Mr. H. Inagaki, and Ms. C. Kawaai for their valuable comments and study management. This study was partly supported by a Research Grant for Longevity Sciences (H14-choju-006) from the Ministry of Health, Labor and Welfare, Japan.

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ARCHIVES OF GERONTOLOGY AND GERIATRICS
Archives of Gerontology and Geriatrics 44 (2007) 163–173
www.elsevier.com/locate/archger

Effects of exercise frequency on functional fitness in older adult women

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Received 3 October 2005; received in revised form 18 April 2006; accepted 21 April 2006
Available online 30 May 2006

Abstract

This study evaluated the effects of exercise frequency on functional fitness in older women participating in a 12-week exercise program. Participants (67.8 ± 4.6 years) were divided into three different exercise groups (I, II, and III; $n = 34$) and a control group (Group C; $n = 11$). Group I participated in a 90-min exercise program once a week, for 12 weeks, while Group II attended it twice a week, and Group III attended three times a week. The exercise program consisted of a 10-min warm-up, 20 min of walking, 30 min of recreational activities, 20 min of resistance training, and a 10-min cool-down. The following items were measured before and after the program: muscular strength, muscular endurance, dynamic balance, coordination, and cardiorespiratory fitness (6-min walking distance). Comparisons of baseline and post-intervention measures showed significantly greater improvements in body weight, coordination, and cardiorespiratory fitness for Group III compared to the other groups ($p < 0.05$). In addition, the greatest improvements in body fat, muscular endurance, and dynamic balance were also observed in Group III ($p < 0.05$). However, no significant differences were found in muscular strength. Older women who participate in an exercise program three times a week gain greater functional fitness benefits than those who exercise less frequently. In order to improve functional fitness in older women, an exercise frequency of at least three times each week should be recommended.

Keywords: Exercise of older women; Functional fitness; Frequency of exercise

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0167-4943/$ – see front matter
doi:10.1016/j.archger.2006.04.007

1. Introduction

Advancing age is generally accompanied by a progressive decline in physical activity (Evans and Meredith, 1989). Age-related decline has been documented for functional fitness; including muscular strength, flexibility, balance, agility, gait velocity, and cardiorespiratory fitness (Raab et al., 1988; Rikli and Edwards, 1991). For years, performance decline in these areas was thought to be a normal and necessary consequence of aging. Previous studies, however, indicate that decline relates more to lifelong physical activity levels than to age. Physically active older women, for instance, were found to have performance patterns of flexibility, balance, and agility more similar to younger participants than to their older inactive pairs (Rikli and Busch, 1986). Based on these findings, interest in examining the relationship between musculoskeletal health and exercise in older adults has emerged (Vuori, 1995). Especially for women, muscle mass, muscular strength, muscular endurance, and cardiorespiratory fitness are important components of functional fitness; they are also the major causes of limited mobility and activity (Rantanen et al., 1994). Therefore, it is important for older women to exercise regularly to maintain and to recover functional fitness.

There are many reports which indicate that exercise intervention for older women produces an improvement in functional fitness. Nichols et al. (1995) have reported significant strength improvement in men and women over 60 who followed a strength training program twice a week for 12 weeks. Brown and Holloszy (1993) have reported significant differences in the flexibility of older participants who followed a training program twice a week for 12 weeks, and Wolfson et al. (1996) state that elderly individuals participating in a training program three times a week can significantly improve their dynamic balance after 12 weeks. According to these studies, exercise more than twice a week seems to improve functional fitness. However, only a few attempts have so far been made to establish how frequently older adults should exercise in order to improve their functional fitness.

Our aim was to evaluate the effects of exercise frequency on body composition and functional fitness in older women participating in a 12-week exercise program, to identify the minimum frequency per week required to produce significant results for the selected items.

2. Subjects and methods

2.1. Participants

Participants in this study were 45 healthy sedentary women (67.8 $\pm$ 4.6 years of age) living independently. Participants were permanent residents in Ibaraki prefecture who had not been involved in any physical activity for at least 6 months before the exercise program began. The study was approved by the Institutional Review Board of University of Tsukuba. All patients signed the informed consent form. According to their place of residence, they were divided into three different exercise groups (Group I; n = 10, Group II;

$n = 10$, and Group III; $n = 14$) and a control group (Group C; $n = 11$). Group I participated in a 90-min exercise program once a week, for 12 weeks, while Group II attended the program twice a week, and Group III attended three times a week.

2.2. Anthropometry and body composition

Body height was measured to the nearest 0.1 cm. Weight was assessed to the nearest 0.1 kg using a beam scale. Body fat was determined using bioelectrical impedance (SS-103) (Sekisui Chemical Co., Ltd.). Body mass index (BMI) was calculated by dividing weight (kg) by height (m) squared (kg/m^2).

2.3. Functional fitness test items

Items were selected to address comprehensively each area of the instrumental activities of daily living (IADL) for older adults (Osness, 1989; Duncan et al., 1990; Kim and Tanaka, 1995; Shigematsu and Tanaka, 2000). IADL are related to complex physical abilities, such as light house-cleaning activities, preparing dinner, making beds, washing and ironing clothes, shopping, and walking (Spirduso, 1995). In this study, we selected six items, which are high in relation to IADL. The six functional fitness test items, the physical elements, and the methods used are as follows:

(i) Hand gripping (muscular strength): the subject was instructed to hold a hand-grip dynamometer (Takei Industrial, Grip-D) in the dominant hand, and to try gripping it with maximum effort while keeping the dominant hand away from the body. Performance was recorded in units of 0.1 kg.
(ii) Arm curl (muscular endurance): the subject was instructed to sit on a chair and then use the dominant hand to bring a weight (2.0 kg) up and down (flex and extend the biceps) as many times as possible in 30 s. Performance was assessed on the frequency of repetitions.
(iii) Sit-and-stand (muscular endurance): the subject was instructed to sit on a chair, back straight, feet shoulder-width apart and flat on the floor, and arms crossed at the wrists and held against the chest. On the signal, the subject rises to a full stand and then returns to a fully seated position. The subject is encouraged to complete as many full stands as possible within 30 s.
(iv) Reaching arms forward in a standing position (functional reach) (dynamic balance): the subject was asked to stand and then raise both arms to shoulder level. Performance was assessed on the maximal distance the subject could reach forward beyond her own arm's length, while the heels remained touching the ground.
(v) Walking around two cones (coordination): the subject was asked to sit in a chair located between two cones, which were placed 1.8 m on either side of and 1.5 m behind the chair. On the signal, the subject rose from the chair, walked to her right going to the inside and around the back of the cone (counterclockwise), returned to a fully seated position on the chair, walked around the other cone (clockwise), and returned to a fully seated position. One trial consisted of two complete circuits. Performance time was recorded in units of 0.1 s.

(vi) Six-minute walk distance (cardiorespiratory fitness): the test involves assessing the maximum distance that can be walked in 6 min along a 50 m course marked out in 5 m segments. The subject is instructed to walk as fast as possible (without running) around the course as many times as she can in 6 min. The score is the total number of meters walked in 6 min, to the nearest 5 m. Test administrator records the nearest 5 m mark.

The tests were all checked for reliability and validity during fitness demonstration with the elderly (Shigematsu et al., 1998; Jones et al., 1999; Enright, 2003).

2.4. The exercise program

The three experimental groups participated in the 12-week intervention program once, twice, or three times a week (Groups I, II, and III, respectively). Each exercise session lasted approximately 90 min. The exercise program consisted of a 10-min warm-up, 20 min of walking, 30 min of recreational activities, 20 min of resistance training, and a 10-min cool-down. The intensity of the walking session was approximately 13 of the rating of perceived exertion (RPE) during the session. In recreational activities, we demonstrated elements of balance, agility, and coordination using a rubber ball (diameter 10–20 cm), a Slomo® Ball (diameter 20–40 cm), a soft valley ball (diameter 30–50 cm), and a Gymnic® ball (diameter 60–80 cm). In resistance training, we demonstrated push ups, leg squats, sit ups, and back extensions using self-weight or a Thera-Band® tube. During the resistance training sessions, the participants performed three sets of 10 repetitions with a 30-s rest between sets. The control group (Group C) did not follow any exercise program.

2.5. Statistical analysis

Statistical analyses of the data began with calculations of the arithmetic means and standard deviations (±S.D.). The effects of training were assessed using the two-way analysis of variance (ANOVA) with repeated measures. If the significance of the interaction of group by time in ANOVA with repeated measures had a $p < 0.05$, we analyzed the differences between the groups at the baseline and the change rate before and after intervention using the one-way ANOVA. If there was a difference in change rate between groups on specific parameters at the baseline, the parameter was used as a covariate in the analysis. Post-hoc tests were carried out using the Bonferroni correction. $p < 0.05$ are considered to indicate statistical significance. Statistical analysis was performed with the Scientific Package of Sciences (SPSS) Version 11.0J for Windows PC.

3. Results

The physical activity levels of the subjects at the baseline are presented in Table 1. Significant differences were found in body fat between Groups III and C, and between Groups I and C. There was no significant difference in other baseline values of physical characteristics among the groups.

Table 1
Baseline physical characteristics of the study subjects

Variable	Group C (n = 11)	Group I (n = 10)	Group II (n = 10)	Group III (n = 14)	p-value
Age (year)	69.0 ± 4.9	65.1 ± 4.3	67.5 ± 3.6	69.1 ± 4.9	0.156
Height (cm)	148.1 ± 5.2	151.0 ± 4.4	150.4 ± 4.4	147.8 ± 5.2	0.292
Body weight (kg)	58.7 ± 8.2	56.8 ± 6.6	56.5 ± 4.7	52.2 ± 9.0	0.185
Body fat (%)	35.8 ± 3.2	31.9 ± 3.1	34.0 ± 2.6	32.2 ± 4.3	0.040[a]
BMI (kg m^{-2})	26.7 ± 2.6	24.9 ± 2.4	25.0 ± 1.6	23.9 ± 3.7	0.118

Values are presented as mean ± S.D.
[a] Significant difference between Group III and Group C ($p < 0.05$), and between Group I and Group C ($p < 0.05$).

Interaction of group by time was found for body weight, body fat, and BMI. There was a significant difference in the effect of time in body fat between Group III and Group C ($p < 0.05$). There was a significant difference in the effect of time in BMI between Group III and Group C ($p < 0.05$) (Table 2). The mean percentage changes in body weight and BMI in Groups C, I, II, and III were +1.1%, +0.4%, +0.1%, and −2.8%, respectively. The mean percentage changes in body fat were +2.0%, +0.5%, −0.3%, and −2.4% (Fig. 1).

Interaction of group by time was found for grip strength, arm curl, sit-and-stand, functional reach, walking around two cones and 6-min walk distance. There was a significant difference in the effect of time between Group II and Group C ($p < 0.05$), and Group I and Group C ($p < 0.05$). There was a significant difference in the effect of time between Group III and Group II ($p < 0.05$), and Group I ($p < 0.05$), and between Group II and Group C ($p < 0.05$), and between Group I and Group C ($p < 0.05$) (Table 3).

The mean percentage changes in grip strength in Groups C, I, II, and III were −1.1%, −1.4%, −2.1%, and +1.4%, respectively. The mean percentage changes in arm curl were −0.2%, −3.9%, −0.9%, and +7.5%. The mean percentage changes in sit-and-stand were −6.0%, −1.5%, −2.5%, and +4.4%. The mean percentage changes in functional reach were −1.9%, −3.0%, −4.5%, and +9.6%. The mean percentage changes in walking around

Table 2
Physical characteristics of the study groups before and after 12-week intervention

Variable	Group C (n = 11)	Group I (n = 10)	Group II (n = 10)	Group III (n = 14)	Two-way ANOVA			Post-hoc test
					Group	Time	Interaction	
Body weight (kg)								
Baseline	58.7 ± 8.2	56.8 ± 6.6	56.5 ± 4.7	52.2 ± 9.0	0.07	0.32	$p < 0.05$	ns
12 weeks	59.4 ± 8.4	57.0 ± 6.4	56.6 ± 4.8	50.5 ± 7.4				
Body fat (%)								
Baseline	35.8 ± 3.2	31.9 ± 3.1	34.0 ± 2.6	32.2 ± 4.3	$p < 0.05$	0.94	$p < 0.05$	C < III
12 weeks	36.5 ± 3.3	32.1 ± 3.0	34.0 ± 2.7	31.5 ± 4.7				
BMI (kg m^{-2})								
Baseline	27.0 ± 2.8	24.9 ± 2.4	25.0 ± 1.6	23.9 ± 3.7	$p < 0.05$	0.34	$p < 0.05$	C < III
12 weeks	26.7 ± 2.6	25.0 ± 2.3	25.0 ± 1.6	23.1 ± 3.1				

Values are presented as mean ± S.D.