older adults.[2] The maintenance of an acceptable level of functional capacity in community-living elderly currently has a high priority both with medical researchers and policy makers. In other words, decline in functioning has to be prevented if possible, or otherwise reduced to a minimum.

The conceptual framework and measures of functional capacity adopted in this study are based on a hierarchical model of competence proposed by Lawton (1972),[3] which comprises seven sublevels starting from life maintenance as the first sublevel to social role performance as the seventh sublevel. Scales for activities of daily living such as Katz's Index of ADL[4] and basic activities of daily living (B-ADL) seem to correspond to the fourth sublevel of Lawton's model; 'Physical self-maintenance'. The index of instrumental activities of daily living (I-ADL) developed by Fillenbaum[5] represents the fifth level; 'Instrumental health-maintenance'. According to Lawton's model, we developed a multidimensional 13-item index of competence, the so-called Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence (Table 1), which was devised to assess competence corresponding to higher (5th to 7th) sublevels of Lawton's model.[6,7] This multidimensional 13-item index of competence comprises three subscales; 'instrumental self-maintenance', 'intellectual activity', and 'social roles'; and has already been verified to have high reliability and validity. The TMIG-Index of Competence has been widely accepted and used in Japan. The possible range of competence score in this index is from 0 to 13 points, and a high score indicates high functional capacity.

Table 1 Item of the TMIG Index of Competence

1.	Can you use public transportation (bus or train) by yourself?
2.	Are you able to shop for daily necessities?
3.	Are you able to prepare meals by yourself?
4.	Are you able to pay bills?
5.	Can you handle your own banking?
6.	Are you able to fill out forms for your pension?
7.	Do you read newspapers?
8.	Do you read books or magazines?
9.	Are you interested in news stories or programs dealing with health?
10.	Do you visit the homes of friends?
11.	Are you sometimes called on for advice?
12.	Are you able to visit sick friends?
13.	Dot you sometimes initiate conversations with young people?

The response to each item is 'yes' (= able to do) or 'no' (= unable).
The total score is the number of items answered with 'yes'. Therefore, a higher score indicates higher functional capacity.
The items 1 to 5 are indicators of the first-order factor *Instrumental Self-Maintenance*. items 6–9 are those of *Intellectual Activity*.
and items 10 to 13 are indicators of Social Role.

The most important point to maintain functional capacity, in a sense, is to prevent functional disability that limits independence in tasks including hygienic and personal care (B-ADL) and the most relevant capacities to live in a community (I-ADL). Many previous studies[8–13] have shown that performance-based measurements of physical function in non-disabled older people predict future incidence of disability or dependence in B-ADL. Objective measurements of lower extremity functions, such as walking speed, standing balance, and repeated rising from a chair, are highly predictive of subsequent disability in older populations of various ethnicities.[9–11,13] In addition, hand-grip strength is an important predictor of disability and mortality of older people.[12–14] Also, many population-based longitudinal studies also examined the factors associated with functional decline in I-ADL with special reference to physical performance of the elderly.[14–18] Among these studies, two population-based prospective studies confirmed that hand-grip strength could predict incident disability in both B-ADL and I-ADL.[14,18]

In 1991, we launched a longitudinal interdisciplinary study on aging, in which we assessed the functional capacity by TMIG Index of Competence in representative samples of older community residents of rural areas in Japan.[19] The participants were followed up for 5 years. Using these data, we investigated the association between baseline physical performance including walking speed, muscle strength, balance as well as manual skill and decline of I-ADL over 5 years in elderly residents living in the community.

Subjects and methods

Study area and subjects

The data in this study were obtained from the Longitudinal Interdisciplinary Study on Aging conducted by the Tokyo Metropolitan Institute of Gerontology (TMIG-LISA), which is a long-term project aiming to verify predictors of longevity and outcome, and to identify factors accelerating or retarding the aging process. The TMIG-LISA comprises three major disciplines: medical, psychological, and social science. Sampling methods of subjects have been described elsewhere.[19] One of the cohorts in the medical science discipline of TMIG-LISA is from Nangai Village, a rural area in Akita Prefecture and a typical agricultural area in the northern part of Honshu Island, Japan. The total population in 1992 was 5136 people and the proportion of residents aged 65 years and older to the total population was approx-

imately 20%. The criteria for including in the cohort were ambulatory residents aged 65 and over. A preliminary survey identified 852 people as ambulatory residents; they were then asked to participate in the baseline survey.

Baseline and follow-up surveys

A baseline survey including face-to-face interview and medical examinations was carried out in the summer of 1992, and a total of 748 residents were interviewed, accounting for 87.8% of all eligible residents ($N = 852$).

After the interview, residents who were able to walk (unassisted or using a cane) were invited to participate in a series of medical examinations and physical performance tests. Over ninety-one percent (685/748) of subjects interviewed completed all the medical examinations and physical performance tests. We limited the subjects of this particular study to those who were independent in both B-ADL and I-ADL at the time of the baseline survey. Data collected at the baseline survey were used to characterize the study population for analyses in the present study.

These people have been followed by interview survey and medical examinations on a yearly basis using methods similar to the baseline survey. All the surveys have been conducted in municipal community centers in Nangai Village. In 1997, excluding 47 deceased, 10 institutionalized or hospitalized, and 4 who refused or did not participate for other reasons, 624 participants who were independent at least in B-ADLs in 1997 and underwent baseline medical examinations and physical performance tests in 1992 were analyzed in the present study (Table 2).

Assessment of functional capacity and measurements of physical performance

The interview survey employed at the baseline (1992) and follow-up (1997) surveys contained scales for assessing functional health status, lifestyles, and life satisfaction. Functional health status was assessed by questions on B-ADL and I-ADL. B-ADL was measured using five items: (1) walking, (2) feeding, (3) continence, (4) bathing, and (5) dressing. I-ADL was derived from the sublevel of competence consisting of five questions concerning 'Instrumental self-maintenance' in the TMIG Index of Competence as mentioned before.

The response to each item in I-ADL was given a score of 1 for 'yes' and 0 'no'. A total score was created by simply summing the item scores. Thus, a score of 5 represents no difficulty and 0 represents total incapability in I-ADL. We defined 'dependence in I-ADL' as a loss of independence in item of I-ADL (e.g. the decline of I-ADL was defined in practice as decrease from full mark (= 5) at baseline to below four during follow-up period). Since the primary objective of this study was to identify the predictors of decline in I-ADL during a 5-year follow-up period, we used only the data of I-ADL obtained from the 1997 follow-up survey as the outcome measure.

In the medical examinations, anthropometric measurements included body height (cm; measured to the nearest mm), body weight (kg; measured to the nearest 100 g) and dermal thickness (cm; sum of measurements at triceps and sub scapular regions). The Quetelet's index (kg/m^2) was adopted as a measure of body mass index (BMI).

During the medical examination, blood sample was collected from the antecubital vein for routine hematological and biochemical tests. Serum albumin (Alb:

Table 2 Subjects in the present study (1992–1997/TMIG-LISA)

Baseline survey in 1992		Male	Female	Total
Interviewed		300	448	748
Medical exam including phys. perform. tests		278	407	685
↓	deceased 47 institutionalized 10 others 4			
Follow-up survey in 1997		Male	Female	Total
Interviewed and Medical exam including phys. perform. tests		251	373	624

g/dL) was measured by a standard kit using the BCG method. Serum total cholesterol was determined enzymatically by an autoanalyzer (HITACHI 736). For measurements of serum cholesterol, coefficients of variation (CV) of internal quality controls ranged within 1.1%, and that of external quality controls ranged within 2.1%. Systolic and diastolic blood pressures in the sitting position were measured by a registered nurse using an automated sphygmomanometer (BP-103, Nippon Colin Ltd). The mean of duplicate measurements was used in principle. Masticatory ability was evaluated by geriatric dentists using jelly (G-1 Jelly®). The hardness of jelly was graded 1 (soft) to 3 (hard) according to the hardness of daily foods.[20]

A short physical performance battery consisting of items assessing grip strength, manual function, balance function, and walking ability, was administered to the participants.[21] The grip strength of the preferred hand was measured using a hand-held Smedley-type dynamometer. Manual function was assessed using a finger-tapping test, in which the maximum tapping rate, and constant and variable errors for tapping in time to a 4-Hz metronome were measured. The maximum tapping rate was used in the present study. Duration of standing while using the preferred leg was measured for a maximum of 60 s with eyes open, and 30 s with eyes closed. In the walking test, the participant walked along a straight walkway of 11 meters on a flat floor. The speed and number of steps were measured for the middle 5-meter portion of the walkway. The participant first took the test by walking at preferred speed, and then by walking as fast as possible. Walking at both preferred and maximum speed were repeated and the faster speed was recorded in each walking. Only the speed data of the walking test were used in this study. Good reproducibility of these walking tests has been reported previously.[21]

Statistical analysis

Descriptive statistics were generated for the subjects classified into presence and absence of declined I-ADL measured by the sublevel of TMIG Index of Competence, and stratified by sex.

We used *t*-test to compare each baseline variable between the subjects showing declined I-ADL and those not showing any decline during the follow-up period, for both sexes. The relation between baseline variables and decline of I-ADL was evaluated using stepwise multiple logistic regression models after controlling confounding variables. Decline of I-ADL (the dependent variable) was transformed into two dummy variables: one dummy variable of score 1 for the presence of decline and 0 for the absence of decline. Thus, predictors of decline of functional capacity represented by decline of I-ADL could be established.

Table 3 Frequency (%) of the elderly who had the decline of I-ADL during five-year follow-up period

Age at baseline	Male	(%)	Female	(%)
65–69	8/122	–6.5	12/160	–7.5
70–74	9/69	–13	20/118	–17
75–79	5/41	–12.2	15/54	–27.8
80+	3/19	–15.8	12/41	–29.3
Total	25/251	–10	59/373	–15.8

Results

During the five-year follow-up period, 25 men (10.0%) and 59 women (15.8%) showed decline of I-ADL as assessed by the 5-item 'Instrumental self-maintenance' scale of TMIG Index of Competence, showing a significant sex difference in the frequency of decline ($\chi^2 = 4.419$, $P = 0.036$). Table 3 shows the frequencies of the elderly who had decline of I-ADL during the 5-year follow-up period. The frequency tended to increase according to the age increase in both sexes.

Table 4 shows the differences in all baseline variables measured in 1992, by sex and by presence or absence of decline of I-ADL. In men, significant differences between subjects with and without I-ADL decline were found in six variables: grip strength, time of standing on one leg with eyes open and with eyes closed, and preferred and maximum walking speeds in physical performance tests; as well as masticatory ability. In women, significant differences were also observed between the two groups in eight variables: age, weight, dermal thickness, grip strength, time of standing on one leg with eyes open, preferred and maximum walking speeds, and masticatory ability. Thus, both sexes showed significant differences in five common baseline variables; grip strength, time of standing on one leg with eyes open, preferred and maximum walking speeds, and masticatory ability. On the other hand, there were no significant differences in systolic and diastolic blood pressures, BMI, finger tapping test, serum albumin and serum total cholesterol levels in both sexes.

Figure 1 shows the percentage of subjects (both sexes) who had I-ADL decline during the follow-up period according to quartiles of baseline maximum walking speed, grip strength, and time of standing on one leg with eyes open. The percentage with decline was greatest in the lowest quartile of these physical-performance measurements. Subjects who walked faster, had stronger handgrip, and maintained good balancing capability have lower possibility of decline in I-ADL in the future.

The effects of baseline measurements of these physical variables on the decline of I-ADL during the follow-up period were estimated with stepwise multiple logistic

Table 4 Comparison of baseline characteristics between subjects with and without decline of I-ADL during 5-year follow-up period

Baseline variables		Male			Female		
		decline (n = 25)	non-decline (n = 226)	Significance†	decline (n = 59)	non-decline (n = 314)	Significance†
Age	(year old)	72.3 ± 5.9	70.7 ± 4.9	n.s.	74.4 ± 5.4	71.1 ± 5.1	***
Systolic blood pressure	(mmHg)	139.2 ± 17.2	144.1 ± 22.9	n.s.	141.9 ± 18.1	145.2 ± 20.5	n.s.
Diastolic blood pressure	(mmHg)	77.4 ± 11.1	79.9 ± 11.4	n.s.	76.7 ± 9.1	78.8 ± 10.3	n.s.
Height	(cm)	156.5 ± 4.1	157.4 ± 5.6	n.s.	143.3 ± 5.0	144.7 ± 5.8	n.s.
Weight	(kg)	52.5 ± 7.9	54.8 ± 7.7	n.s.	46.2 ± 6.8	48.7 ± 8.6	*
BMI	(kg/m^2)	21.5 ± 3.0	22.1 ± 2.7	n.s.	22.5 ± 3.1	23.2 ± 3.5	n.s.
Dermal thickness	(cm)	20.0 ± 8.1	19.8 ± 7.4	n.s.	22.8 ± 9.1	25.9 ± 9.4	*
Hand grip strength	(kg)	26.7 ± 6.8	31.3 ± 6.5	**	17.4 ± 4.6	18.9 ± 4.8	*
One leg stand. eye open	(s)	23.4 ± 22.4	42.0 ± 22.5	***	20.8 ± 20.7	29.5 ± 23.4	**
One leg stand. eye close	(s)	2.88 ± 2.51	5.26 ± 5.15	*	3.44 ± 3.24	3.9 ± 4.32	n.s.
Preferred walking speed	(m/s)	1.06 ± 0.25	1.22 ± 0.23	**	0.97 ± 0.26	1.05 ± 0.24	*
Maximum walking speed	(m/s)	1.72 ± 0.50	1.99 ± 0.39	**	1.44 ± 0.33	1.62 ± 0.39	**
Finger-tapping test	(m/s)	183.6 ± 28.2	181.6 ± 29.4	n.s.	204.3 ± 28.8	198.3 ± 32.3	n.s.
Masticatory ability by Jelly test	(1–3)	1.47 ± 0.80	2.04 ± 1.14	**	1.71 ± 0.90	1.86 ± 1.12	*
Serum albumin	(g/dL)	4.07 ± 0.24	4.05 ± 0.24	n.s.	4.1 ± 0.3	4.15 ± 0.23	n.s.
Serum total cholesterol	(mg/dL)	172.6 ± 40.2	174.8 ± 31.8	n.s.	202.1 ± 39.1	201.8 ± 32.4	n.s.

†*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, n.s., no significance.

regression analysis (using dummy dependent variables). Table 5 shows the result of analysis with this model in χ^2 value, probability, odds ratio, and 95% confidence interval. Aging significantly increased the decline of I-ADL. On the other hand, maximum walking speed and systolic blood pressure had significant protective effects against the decline of I-ADL. Particularly, the odds ratio of maximum walking speed (0.351) implies that the odds of decline in I-ADL increased 2.85 times for every 1 m/s decrease of maximum walking speed when the effects of other confounding factors are controlled. This means that the faster the walking speed, the lower possibility is decline in I-ADL.

Although systolic blood pressure was inversely proportional to decline in I-ADL, the 95% confidence interval was almost 1.0 (0.976–0.999), implying that the effect of systolic blood pressure as a predictor would be very small.

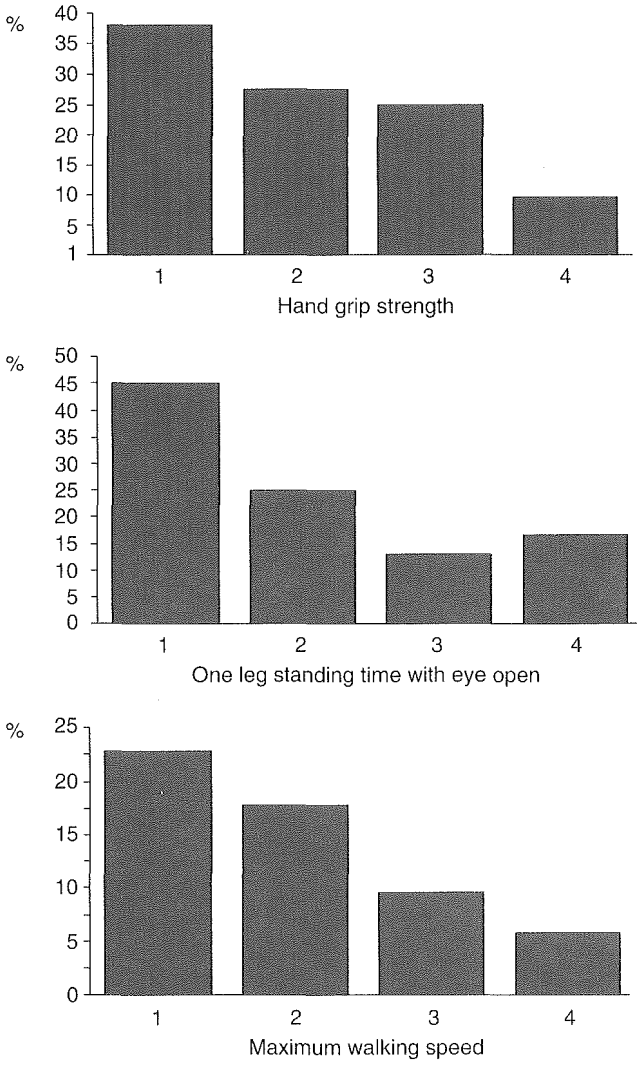

Figure 1 The percentage of the person who had decline in I-ADL during 5-year follow-up period according to a quartile (1 = low → 4 = high) of three variables at baseline (sex combined).

Discussion

Health status in the elderly is a strong predictor of subjective well-being.[22] Functional capacity is an adequate indicator of health of the elderly as noted by WHO in 1984. Most scales of functional capacity used in gerontology focus exclusively on the B-ADL. However, since B-ADL scales cannot detect the variety of competence in the elderly from disability or frailty, B-ADL is no longer a good indicator of autonomy for the elderly living in the community where the vast majority of older people have higher functional capacity. In this study, using I-ADL as an indicator of higher level functional capacity, a longitudinal observation of elderly subjects living in the community over a five-year period was conducted in order to investigate the frequency of I-ADL decline and associated risk factors measured at baseline. This study indicates that physical factors may be amenable to prevention of long-term decline of functional capacity.

Before interpreting the results and establishing a final conclusion, some limitations of our study must be considered. First of all, TMIG-Index of Competence was developed to cover the highest level of functional capacity based on Lawton's model mentioned earlier. Although this tool is a particularly appropriate measure health status for the elderly living in the community because most of them are free from disability in Japan,[23] it has not been used in other countries. Therefore, the applicability of these study findings to other populations

Table 5 Predictor of functional decline in I-ADL during 5-year follow-up among the Japanese rural-community elderly who were initially independent in I-ADL (n = 624), 1992–1997

Risk factor	Odds Ratio	95% Confidence Interval	*P* Value
Age	1.07	1.02–1.12	0.007
Systolic Blood Pressure	0.99	0.98–0.99	0.034
Maximum walking speed	0.35	0.19–0.66	0.001

Stepwise multiple logistic regression analysis was performed to compare subjects who were independent in I-ADL in both 1992 and 1997 (n = 540) and those who were initially independent but became dependent in I-ADL in 1997 (n = 84). Dependent variable was the decline of I-ADL during follow-up period (presence/absence). Independent variables are those as listed in the Table 4.

may be debatable.[24] Nevertheless, the results obtained in the present study were similar to investigations in the United States and Europe who used Lawton's I-ADL.[14,17,25]

Second, among 669 subjects examined in 1997, 45 subjects were excluded from the analyses of identifying risk factors of functional decline, because of missing data due to death, hospitalization, and other reasons. These subjects who were excluded from analyses were likely to be older and weaker than those who were analyzed using logistic regression. Therefore, the selection bias would have weakened the predictive value of each predictor for functional decline in this study.

Third, the subjects of our population-based and prospective study were older Japanese living in a rural area, who are not necessarily representative of all older Japanese. Older Japanese in Nangai Village are more likely to lead an old and traditional Japanese lifestyle. However, despite the second and third limitations, it is likely that certain physical factors can predict functional decline among all older Japanese because the biomechanical principles of functional deterioration are common, at least in Japan.

We have previously investigated predictors of functional decline in both B-ADL and I-ADL among non-disabled older people living in the community during a 3-year follow-up, analyzing 28 variables selected from demographical, physiological, psychosocial, and life-style-related domains.[18] Our conclusion was that having high-level handgrip strength, good intellectual activities and good social roles were strongly associated with maintaining independence in I-ADL for the elderly aged 65 and over. However, handgrip strength was the only physical performance variable selected in the previous study.

In the present study, besides the basic confounding variables, six physical performance variables with proven validity and usefulness for assessing physical functions of community elderly were additionally selected as independent variables. We identified age increase, lower systolic blood pressure, and lower maximum walking speed as significant predictors of functional decline in I-ADL in a 5-year period among older Japanese who were initially independent in I-ADL. Appropriate blood pressure is important from the perspective of prevention of cardiovascular disease, particularly stroke, in this Japanese sample, and also maintenance of other physical function. However, lower (maximum) walking speed is not only most sensitive in predicting the decline of I-ADL of the community elderly, but is also a factor that can be improved for the elderly.

Walking ability of the elderly has been studied in association with disability,[26–29] self-perceived function,[30] depressive status,[31] institutionalization,[11,32] and mortality.[11,33] Summarizing these previous studies, walking speed may be an indicator of general morbidity as well as a good indicator of any level of functional capacity in the community elderly. Regarding the term 'walking speed', two kinds of walking speed are usually measured for the elderly: normal (usual, preferred, comfortable) walking speed; and maximum walking speed. According to Nagasaki *et al.*[21] maximum walking speed has the highest correlation coefficient with basic motor ability of the elderly in their structural model of physical performance of the elderly, which consists of six variables adopted also in this study. Shinkai *et al.*[13] reported that these two walking speeds have different predictive values for the onset of the disability in B-ADL among the community elderly; maximum walking speed was more sensitive in predicting the onset of functional dependence for younger (65–74 years) people, while usual walking speed was more sensitive for older (+75 years) people. Our findings also implicate that maximum walking speed is the best indicator for the maintenance of I-ADL in our cohort in which the young-old predominates.

One of the reasons for the relationship between walking speed and decline of I-ADL may be related to the fall occurrence. A considerable volume of research has been conducted on walking ability in relation to the occurrence of fall in the elderly. Increased body sway, uneven distance, or uneven timing during walking were identified as risk factors for falls.[34–36] Declining walking ability with advancing age contributes to decreasing walking speed, step length, and cadence. The authors have already reported that together with fall experience within one year preceding the baseline survey, walking speed was a highly sensitive and very important predicator for the occurrence of frequent falls during a five-year follow-up period among the elderly, using the same set of data as the present study.[37]

Muscle function or strength as the single most important component for locomotor competence[9] has been consistently identified as the main risk factor for falls and hip fracture in the elderly. The incidence of hip fracture increases exponentially with age. More than 90% of hip fractures are caused by falls, and result in heavy loss of both B-ADL and I-ADL.

Although the bone mass of Japanese women is lower than that of Caucasians even after adjusting for body size,[38,39] the incidence of hip fracture is lower among Japanese than among Caucasians.[40–42] A recent international cross-cultural study on the relationship between muscle strength and fall rates among residents of Japanese and American nursing homes revealed that the traditional Japanese lifestyle, such as squatting in toilet or sleeping on the floor, maintained quadriceps strength and resulted in fewer falls.[43] These daily activities of the traditional Japanese lifestyle may increase muscle bulk and play an important role in hip fracture prevention.[44,45] In this context, the present study con-

firmed that decreased walking speed certainly increases the risk of falls and therefore increases the decline of I-ADL either from fracture itself or post-fall syndrome in the community-dwelling elderly. For the prevention of falls and the ensuing against decline of I-ADL, walking ability should be maintained in the elderly through long-term practice, and perhaps training, of walking.

In conclusion, the findings in this study suggest that there are indeed ways by which the quality of life in the elderly can be influenced. Preventive measures should primarily be directed toward lifestyle in a broad sense and in particular to the maintenance of optimal walking ability. In addition to looking into predictors of functional capacity based on observational studies, further intervention trials are urgently needed aiming to maintain and even promote functional capacity in the community elderly in Japan as one of the leading longevity societies in the world.

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ORIGINAL ARTICLE

A prospective study of the effects of regular sports practice on mortality among the elderly in a rural community in Japan: An 8-year follow-up study

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Background: Regular exercise and sports practice are considered effective to maintain the health and quality of life of the elderly, and even to decrease mortality. The present study aimed to clarify the relation between regular sports practice and relatively long-term mortality among the community-dwelling elderly and to determine whether regular sports practice is an independent risk factor for all-cause mortality.

Methods: In a population-based prospective study, the Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (TMIG-LISA), 748 community-dwelling persons aged 65 and older who participated in the baseline survey in August 1992 were followed annually for 8 years with respect to mortality.

Results: Excluding 22 early deaths that occurred during the first two years of follow-up, a total of 158 deaths (83 males and 75 females) were confirmed during the 8-year follow-up period. Univariate analysis showed that subjects practicing sports regularly a had significantly higher score for instrumental activities of daily living (I-ADL), higher alcohol drinking rate, and faster usual walking speed ($P < 0.001$). To determine the independent risk factors for mortality, Cox proportional hazards regression analysis was conducted using sex, age, regular sports practicing habit, current smoking habit, current alcohol drinking habit, I-ADL (from the subscale of TMIG-Index of Competence), and usual walking speed. Regular sports practice did not reduce the risk of death, while sex ($P < 0.001$), age ($P < 0.001$), I-ADL ($P < 0.05$), and usual walking speed ($P < 0.001$) were identified as significant independent predictors for all-cause mortality among the elderly people living in the rural community.

Conclusion: Regular sports practice has no significant effect on mortality; however, keeping a higher walking speed in daily life is a strongly relevant capability for regular sports practice and a significant predictor of prolonged active live expectancy.

Keywords: community-dwelling elderly, mortality, prospective study, regular sports practice.

Introduction

Many studies of exercises and sports in the elderly have been conducted from the viewpoint of mortality,[1–3] and prevention of coronary heart diseases,[4–9] arteriosclerosis,[10,11] diabetes,[12,13] cancers,[14–16] and osteoporosis.[17–19] Recently, research has further extended to the maintenance of quality of life (QOL) in the elderly, and many

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issues have been discussed, such as the impact of exercises and sports on prophylaxis against degenerative changes of the musculoskeletal system, maintenance of activities of daily living (ADL), improvement of depression, prevention of seclusion, and enhancement of social participation.[20–25]

For the elderly, 'exercises' generally include physical activities in daily life, walking and light calisthenics at home, and competitive sports using tools or facilities such as tennis and swimming. These activities may overlap partially, and there are no strict distinctions among them. However, the exercise contents for the categories of 'daily living physical activities' and 'competitive sports' certainly differ to a large extent in terms of exercise intensity, subject's motivation, and physical capability necessary for implementation. They may also have different effects on the prognosis of long-term survival for the elderly.

We examined the long-term effect of regular sports practice on mortality by a population-base prospective study. In this study, we defined regular sports practice as the engagement in sports usually utilizing specialized facility or instrument, and analyzed the effect of regular sports practice on mortality of the elderly living in a rural community during a relatively long follow-up period.

Subjects and methods

Subjects

The Tokyo Metropolitan Institute of Gerontology (TMIG) has initiated a refined longitudinal interdisciplinary study on aging (TMIG-LISA) since 1991, which is a long-term project, with the objective to analyze the process of aging and to identify factors that affect aging in the elderly living in various areas with different living environments.

The cohort of the present study consisted of elderly subjects aged 65 years or above living in one of the TMIG-LISA study sites; a mountain village in Akita Prefecture. The baseline survey was conducted between June and August 1992. Among 852 eligible subjects who were confirmed to be ambulatory and living at home, 748 subjects (87.8%; 289 males and 448 females) received medical examination. Since the objective was to study the prognosis of long-term survival of the elderly who regularly practice competitive sports, 22 early deaths that occurred during the first two years (August 1992–1994) because of suffering from either chronic disease or physical frailty were excluded and 726 subjects (289 males and 437 females) were included in the final analysis.

Data collection

The survey methods included inviting the subjects to the municipal community center and conducting face-to-face interviews and comprehensive medical examinations including measurements of physical performance. Follow-up surveys were conducted during the same month (August) using the same methods as in the baseline survey. Interview was conducted every year and comprehensive medical examination every two years. The subjects were followed for 8 years from 1992 to 2000.

Data on 'regular sports practice' were collected by interview. The subject was asked, 'Do you practice any of the following sports regularly?' The subject was instructed to choose one or more answers from 9 items consisting of 'gate-ball', 'jogging', 'tennis', 'golf', 'hiking', 'dancing', 'swimming', 'martial art', and 'others'. To the question on the frequency of sports 'How many days in a week do you practice the sports?', the subject was requested to choose one answer from 'every day', '5–6 days/week', '2–4 days/week' and 'one day or less/week'.

In the analysis of the association between regular sports practice and prognosis of survival, the following confounding factors were considered: sex, age, smoking habit at baseline ('current smoking' was defined as smoking at the time of survey), drinking habit at baseline ('current alcohol drinking' was defined as drinking at the time of survey), instrumental-ADL (I-ADL) assessed by the subscale of TMIG Index of competence (5 items: 'shopping for daily living', 'preparing meals', 'paying bills', 'managing bank deposit and saving', and 'utilizing public transportation'), and walking capacity (usual walking speed).

Statistical analysis

Descriptive statistics were calculated for the data of regular sports practice (yes or no) and frequency of practice. Values are expressed as mean ± standard deviation. Statistical analysis was performed with student's *t*-test and χ^2 test. A *P*-value less than 0.05 was considered to indicate statistical significance. Cox proportional hazards regression model was used to analyze the association between regular sports practice and mortality during the follow-up period controlled for sex, age, smoking habit, drinking habit, I-ADL, and usual walking speed. Statistical analyses were performed using SPSS for Windows 7.5.1j.

Results

Status of 8-year follow-up

The cohort at the baseline survey in 1992 consisted of 748 subjects. As mentioned above, after excluding 22 early deaths (11 males and 11 females) during the first two years (1992–1994), 726 subjects were included in the final analysis. Table 1 shows the data of sex, age,

Table 1 Characteristics of the study population ($N = 726$) at the baseline survey in 1992

Variables	Male	Female	sex diff.
Age: years (mean ± SD)	71.40 ± 5.44	72.08 ± 5.59	ns
Sex: male/female (%)	289 (39.8)	437 (60.2)	–
Practicing sports regularly: yes (%)	62 (21.5)	60 (13.8)	**
Frequency per week (%)	62 (21.5)	60 (13.8)	
every day	8 (12.8)	13 (21.7)	
5–6 day	1 (1.6)	2 (3.3)	ns
2–4 day	29 (46.8)	27 (45.0)	
≤ 1 day	24 (38.7)	15 (25.0)	
I-ADL: full marks = 5 (mean ± SD)	4.75 ± 0.88	4.48 ± 1.13	***
Current smoking: yes (%)	104 (36.1)	13 (3.0)	***
Current alcohol drinking: yes (%)	181 (62.6)	94 (21.5)	***
Usual walking speed: m/s (mean ± SD)	1.16 ± 0.27	1.01 ± 0.26	***

ns, not significant; **p <0.05; ***p < 0.001.

Table 2 Comparison between the elderly who practiced sports regularly and those who did not at the baseline survey in 1992 (each sex)

Sex (N)	Category (practicing sports regularly)	Average Age (years)	I-ADL	Cur. smoking (%)	Cur. drinking (%)	walking speed (m/s)
Male ($N = 289$)	Yes ($N = 62$)	72.8 ± 4.3	4.9 ± 0.42	22 (35.5)	50 (80.7)	1.20 ± 0.23
		*	**	ns	**	**
	No ($N = 227$)	71.0 ± 5.7	4.7 ± 0.92	82 (36.2)	131 (57.7)	1.15 ± 0.27
Female ($N = 463$)	Yes ($N = 60$)	71.9 ± 4.6	4.8 ± 0.68	2 (3.4)	12 (20.0)	1.14 ± 0.22
		ns	**	ns	ns	***
	No ($N = 376$)	72.1 ± 5.7	4.4 ± 1.18	11 (2.9)	82 (21.8)	0.99 ± 0.26

ns, not significant; *p <0.05; **p <0.01; ***p <0.001.

Table 3 Comparison between the elderly who practiced sports regularly and those who did not at the baseline survey in 1992 (sex combined)

Category	Proportion (%)	Average Age (years)	I-ADL	Cur. smoking (%)	Cur. drinking (%)	Walking speed (m/s)
Practicing sports regularly ($N = 122$)	16.8	72.35 ± 4.48	4.86 ± 0.57	19.8	50.8	1.17 ± 0.23
		ns	***	ns	***	***
Not practicing sports regularly ($N = 603$)	83.2	71.69 ± 5.72	4.53 ± 1.11	15.5	35.3	1.05 ± 0.28

ns, not significant; ***p < 0.001.

regular sports practice (yes/no), frequency of practice, and other parameters used for adjustment in the present study. For the type of sports practiced, the response for 'gate-ball' was overwhelmingly high (male: 85.9%, female: 89.1%) while the other sports were hardly practiced, reflecting the rural nature of the community surveyed.

Sixty-two males (21.5%) and 60 females (13.8%) practiced sports regularly, and the proportion was significantly higher in males ($\chi^2 = 7.35$, $P = 0.007$). The proportion of subjects who practiced sports two or more days a week was 13.2% in males and 9.8% in females, and was also higher in males although the difference was not significant ($\chi^2 = 2.00$, $P = 0.18$). Among the variables used for adjustment, significant sex differences were observed in the mean score of I-ADL, percentage of smokers, percentage of drinkers, and usual walking speed.

Compare the characteristics of subjects practicing and not practicing sports regularly in by sex and sex

combined. In male, the subjects doing regular sports practice had higher average age, higher score of I-ADL, higher rate of alcohol drinking, and higher usual walking speed than the subjects who did not. In female, the subject doing regular sports practice had higher score of I-ADL, and higher usual walking speed (Table 2). In sex combined, the two groups did not differ significantly in age and smoking rate, but subjects who practiced sports regularly scored significantly higher in I-ADL and had a significantly higher alcohol drinking rate. In addition, they had a significantly higher usual walking speed (1.17 *vs* 1.05 m/s; t = 4.85, $P = 0.0001$), presumably strongly related to sports practice (Table 3). In addition, a significant positive correlation between regular sports practice and usual walking speed was confirmed even after controlling for sex and age.

Association between mortality and regular sports practice

Excluding 22 early deaths recorded from 1992 to 1994, a total of 158 deaths (83 males, 28.7% and 75 females, 17.2%) occurred during the 8-year follow-up period. A significant sex difference in mortality was observed ($\chi = 13.65$, $P = 0.001$). The major cause of death was malignant tumors such as gastric cancer and lung cancer, followed by pneumonia. In the present study, the effects of regular sports practice on all-cause mortality only were examined.

Multivariate analysis on the association between mortality and regular sports practice after controlling for sex, age, I-ADL score, smoking rate, alcohol drinking rate, and usual walking speed showed that regular sports practice did not reduce the risk of death. In this analysis, while smoking, alcohol drinking, and regular sports practice were not significant variables for mortality, sex and age were identified as significant variables independently associated with death, and high I-ADL score ($P < 0.05$) and high usual walking speed ($P < 0.001$) significantly reduced the risk of mortality (Table 4).

When subjects who practiced sports at high frequencies of two or more days a week were analyzed by the same methods as above, almost identical results were obtained. Thus, no significant reduction of mortality was obtained by practicing sports at a relatively high frequency of two or more days a week.

Discussion

From the previous longitudinal studies that examined the association between prognosis of survival and lifestyle focusing on exercises and physical activities, the findings obtained from follow-up studies of elderly cohorts aged over 60 years are not necessarily consistent.

Table 4 Multivariate relative risk (RR) for deaths from all causes during 8 years according to having regular sports among the elderly in rural community (Cox proportional hazard model)

Variables	Multivariate RR[a]	(95% IC)[b]
Sex[c]	0.351***	(0.239–0.516)
Age[d]	1.064***	(1.033–1.096)
SPT[e]	1.194	(0.741–1.924)
SMK[f]	0.720	(0.467–1.111)
ALC[g]	1.245	(0.871–1.780)
I-ADL[h]	0.859*	(0.754–0.980)
NWS[i]	0.212***	(0.106–0.424)

[a]Relative risk; [b]95% Interval of confidence; [c]Sex (male = 0, female = 1); [d]Age (years old); [e]Practicing sports regularly (yes = 0, no = 1); [f]Current smoking habits (yes = 0, no = 1); [g]current alcohol consumption (yes = 0, no = 1); [h]Instrumental ADL (by subscale of TMIG-IC; 0–5); [i]Usual walking speed (m/s).
***$p < 0.001$; *$p < 0.05$.

In a cohort of 16 936 Harvard alumni (aged 35–74 years), study of the association between mortality and lifestyle centering on physical activity showed the highest mortality in the group with the lowest physical activity level (< 500 kcal/week) and a general tendency of decreased mortality with increase in physical activity.[26] A 5-year follow-up study analyzing the relationship between mortality and health practices such as physical activity, smoking, drinking, and sleeping hours identified smoking as the only health practice related to mortality in females, while no related factor was identified in males.[27] In the 10-year follow-up the first National Health and Nutrition Examination Survey (NHANES I) study on a cohort of 6109 subjects[28] low physical activity and subnormal body weight were associated with reduced survival in both men and women. The Alameda County Study that followed 6928 elderly subjects for 17 years found that mortality was associated with smoking, lack of exercise, body weight deviated from normal range, and not taking breakfast regularly.[29] The 20-year follow-up study on middle-age and elderly Finnish men also reported reduction of premature mortality by high physical activity.[30]

Recently, the association between physical activity or sports, especially jogging[31] and mortality was studied in a Copenhagen population (17 265 men and 13 375 women aged 20–93 years) for a mean follow-up period of 14.5 years, and showed that (i) mortality was decreased in the leisure-time physical activity group compared with the sedentary group, and (ii) moderate to vigorous exercise was associated with 50% risk reduction in mortality.[32] This study concluded that while light exercises have some health effect, moderate and vigorous exercises are more favorable for health.

Viewing from the above previous studies, although studies with follow-up periods less than 10 years showed an apparently weak association between mortality and health practices such as regular sports practice in the elderly, prolonged longitudinal studies for over 10 years may validate the favorable health effects of exercises and regular sport.

In the present population-base longitudinal study, we analyzed the impact of regular sports activities, presumably representing higher intensity of physical activity, on mortality in elderly subjects during a follow-up period of 8 years. However, no significant association was found between regular sports practice and mortality in multivariate analysis. One reason is that the subjects were rural elderly men and women, mostly engaging in agricultural work. Apart from sports, this cohort probably has high physical activities in their daily lives from farm work, family labor and other rural activities. In addition, gate-ball was the overwhelmingly common sport practiced for both men and women in this rural elderly population. Since gate-ball involves relatively mild activity intensity compared to other sports, this may also contribute to the lack of significant correlation.

Gate-ball is one of the most popular competitive sports among Japanese elderly. An analytical study of the health characteristics of elderly persons playing gate-ball showed that the players in general enjoyed physical and mental well-being.[33] This finding probably suggests another reason why regular sports practice (gate-ball) is not necessarily an independent determinant of mortality when other confounding factors are controlled.

The confounding factors used in the analysis of the association between sports activity and mortality have all been shown by previous studies to influence the prognosis of survival in the elderly. Among them, walking speed has been demonstrated to be a very strong predictor for maintaining daily living functions from the TMIG-LISA prospective studies[34,35]. The importance of walking speed was again substantiated in the present study; that usual walking speed is an extremely strong and independent influential factor of mortality, similar to sex and age. Our analysis showed that an increase of walking speed by 1 m/s was associated with increase of a relative risk by 0.155 in the subsequent 8 years, that means a 1/7 reduction of the risk of death.

The elderly subjects who practiced sports regularly had a significantly faster walking speed compared with subjects not practicing sports. Even when controlled for sex and age, a significant positive association between regular sports practice and walking speed was observed. In other words, the elderly who can practice sports regularly walk faster in their daily life, and they may constitute a group of individuals who are healthier and more vigorous, suggesting the presence of a strong self-selection bias for practicing regular sports.

The present findings have important implications in planning future measures to maintain or improve health status and prolong active life expectancy in the community elderly. While there is an obvious need to recommend appropriate regular sports, it is equally important to help the elderly to build basal physical strength, especially to maintain and improve walking capacity, as a prerequisite to practice sports.

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ORIGINAL ARTICLE

An intervention study to improve the nutritional status of functionally competent community-living senior citizens

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Objective: To evaluate the feasibility and effectiveness of a program to improve the dietary habits and nutritional status of functionally competent community-living senior citizens.

Design: A four-year community-based intervention.

Setting and methods: The study population was a representative sample of functionally competent seniors aged ≥ 65 years (229 men, 357 women, mean age: 71.0 years) living in a rural area (Nangai village, Northern Japan). Formal services (lectures and practice sessions, focusing mainly on improvement of dietary habits and other aspects of lifestyle) were provided to the community over a 4-year period (1996–2000). Food frequency questionnaires assessed changes in consumption of the seven main food groups for the region (meat, fish and shellfish, eggs, milk, dark-colored vegetables, fruit, and fats and oils). Serum albumin and hemoglobin concentrations were measured immediately before and after the intervention. Changes over the intervention period were contrasted with those in an age- and gender-matched population of 179 men and 293 women from the same community who had been observed during the previous four years (1992–1996).

Results: The frequency of consumption of meat, dark-colored vegetables, and fats and oils increased significantly in the intervention population, in contrast to the observational population, where the frequency of consumption of meat, fish and shellfish, fats and oils decreased. In apparent consequence, the intervention population showed a significant increase of serum albumin (men and women) and of hemoglobin (women only), whereas the observational population showed decreases in serum albumin and hemoglobin in both men and women.

Conclusions: These services provided were feasible and effective in improving dietary habits, and enhancing the nutritional status of functionally competent community-living senior citizens.

Keywords: dietary habits, food frequency, hemoglobin, intervention study, serum albumin.

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Introduction

Several previous studies have examined relationships between nutrition and health status in senior citizens.[1–5] Serum albumin is well accepted as an indicator of

nutritional status in the elderly[6–10] and among community-living Japanese aged 69–70 years, the 10-year survival rate is greater in those with a high level of serum albumin.[6] Likewise, Shibata *et al.*[11,12] noted an association between a high intake of fats and oils and longer survival of community-living seniors. A 7-year follow-up study revealed that a frequent intake of plant foods independently reduced the risk of all-cause mortality in subjects aged 65 years and over.[13] Furthermore, a community-based longitudinal study of senior citizens[14] demonstrated that a frequent intake of animal foods (meat and milk) and fats and oils was associated with a slower decline in functional abilities. It appears that the aging process is accelerated by poor nutrition, and that the introduction of measures to ensure adequate nutrition should help both to maintain functional capacity and to extend life expectancy.

Participants in previous studies aimed at improving nutritional status were frail, elderly persons suffering from malnutrition.[15–17] One study sought to improve the nutritional status of functionally competent residents of a Japanese retirement home.[18] A series of 82 lectures and practice sessions focused mainly on improving dietary habits and other aspects of personal lifestyle over a 2-year period. The intervention group showed significant increases in the frequency of eating meat, fruit, and fats and oils, with associated increases in serum albumin, whereas serum albumin concentrations decreased in the control group. These results suggested that the intervention was effective in improving dietary habits and preventing malnutrition among undernourished but functionally competent seniors. Nevertheless, most community-dwelling seniors remain functionally independent and without evidence of clinical malnutrition. Therefore, it is important to evaluate how far a lifestyle intervention could enhance the nutritional status of such individuals.

The purpose of the present study was thus to evaluate the feasibility and effectiveness of a program designed to improve dietary habits and prevent malnutrition in functionally competent community-living senior citizens.

Subjects

The study formed part of the Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (TMIG-LISA), as previously described.[19] The subjects were elderly residents of Nangai village (Akita Prefecture, in north-eastern Japan). The intervention sample comprised all residents aged ≥65 years as determined from municipal resident registration records for 1996 (Table 1). The intervention covered a four year period from June 1996 to June 2000. Immediately before and following the intervention subjects completed a medical examination and an interview that assessed dietary habits, nutritional status, and other lifestyle variables. Of 1166 potential participants, 1105 individuals completed informed consent forms approved by the TMIG Research Ethics Committee. Of the 1105 subjects initially recruited, 882 individuals (357 men, 525 women) underwent the postintervention examination. Concentrations of serum albumin (by using BCG method) and hemoglobin (by using SLSHb method) were measured before and after the intervention. Techniques for the two measurements remained unchanged over the study period, and the coefficients of variation for both items were within the accepted range (less than 1.0% and 0.7%, respectively). Changes in dietary habits over the intervention period were assessed by a food frequency questionnaire that covered the seven main food groups found in Japanese dishes (meat, fish and shellfish, eggs, milk, dark-colored vegetables,

Table 1 The number of subjects recruited for the intervention study (1996–2000), and the number of participants in the intervention health examination

Sex		Men	Women	Total	Participation rate (%)
Subjects		471	695	1166	–
Health examination					
Pre-intervention	Participants	448	657	1105	94.8
Post-intervention	Participants	357	525	882	79.8
	Hospitalization	14	19	33	–
	Died	71	82	153	–
	Refused	4	22	26	–
	Absent	1	6	7	–
	Unknown	1	3	4	–
Subjects available for analysis		229	357	586	–

Table 2 The number of subjects recruited for the observational study (1992–1996), and number available for the follow-up health examination

Sex		Men	Women	Total	Participation rate (%)
Subjects		375	559	934	–
Health examination					
Baseline	Participants	300	448	748	80.0
Follow-up	Participants	248	391	639	85.4
	Hospitalization	10	15	25	–
	Died	40	39	79	–
	Refused	0	0	0	–
	Absent	0	3	3	–
	Unknown	2	0	2	–
Subjects available for analysis		179	293	472	–

fruit, and fats and oils). Data were analyzed using the SPSS statistical package. Paired *t*-tests examined the significance of changes in serum albumin and hemoglobin concentrations over the intervention period. The significance of changes in food frequencies was evaluated by the Wilcoxon's rank sum test.

Assessment of intervention effects

The dietary and nutritional effects of the intervention were assessed by contrasting 1996–2000 data with changes seen in people of the same age group and same community between 1992 and 1996 (the observational population, Table 2). In 1992, an analogous initial procedure registered 934 senior citizens aged ≥ 65-years; of these, 748 participated in the baseline examination, and 639 in the follow-up examination. Because our purpose was to examine responses in functionally competent elders, those with functional limitations were excluded from our analyses; resultant subject numbers were 586 and 472 in the intervention and observational populations, respectively.

Intervention

The intervention was provided as a formal service in Nangai village. Those involved included paramedical and medical professionals (nutritionists, public health nurses, physicians, dentists, etc.), instructors for exercise and leisure time activities, representatives of local senior's clubs, administrative officers, and representatives of women's community volunteer organizations. Comprehensive programs comprised both lectures and practice sessions, focusing mainly on the improvement of dietary habits and other lifestyle variables. The periodic interventions were made through seniors' clubs, volunteer activities to enhance nutrition, activities at the community citizen's hall, and health consultations provided to individual local communities. Table 3 summa-

Table 3 The number of events and participants in formal interventions in the Nangai village during the period (1996–2000)

Activities	Times	participants
Seniors' club activities	70	3157
Volunteer activities to improve nutrition	260	6906
Activities at citizen hall	15	729
Health consultations	36	2072

Table 4 Dietary guidelines to prevent malnutrition in senior citizens

Keep a balance in your daily meals, and avoid skipping a meal
Eat adequate amounts of various fats and oils
Eat adequate amounts of animal protein
Eat equal amounts of meat and fish and shellfish daily
Use various types of meat in your daily cooking
Drink a cup of milk (200 mL) daily
Use various types of vegetables during cooking
Master a means of food cooking and preservation
When you have a poor appetite , priority should be given to a main dish rather than staple food
Use seasonings after tasting a dish
Prepare various meals such as Japanese, Chinese, and Western-style foods
Take a meal together with a companion
Have your dentures checked periodically, to maintain your chewing power
Have an interest in obtaining health information

The dietary guidelines were quoted from the article 'Kumagai S *et al.* An intervention trial to postpone aging in competent elderly. Trial of nutritional improvement in the retirement home.'[18]

Table 5 Baseline characteristics of subjects in the intervention and observational populations

Population	Intervention		Observational	
Sex	Men	Women	Men	Women
Characteristics/				
Current smokers[a] (%)	34.1	1.4	36.9	1.4
Current drinkers[a] (%)	67.7	17.6	66.5	20.1
Exercise habit[b] (%)	21	12.9	22.3	16
Living alone (%)	10.9	51.3	10.6	54.6
Level of education (more than 9-year; %)	10.0	11.8	9.0	7.1
Body mass index (weight; kg/hight; m^2)	22.5	23.4	22.1	23.1
Age (mean ± standard deviation; years)	70.8 ± 5.2	71.1 ± 5.2	70.3 ± 4.4	71.0 ± 4.8

[a]Smoking and drinking habits were assessed by self-report and participants were classified as never, former, and current groups.
[b]Taking exercise more than once a week.

Table 6 Percentage of seven main food group at least once every two day at beginning and end of intervention or observational period.

Population	Intervention		Observational	
	1996	2000	1992	1996
Food group				
Meat	56.1	64.2**	63.1	54.1**
Eggs	85.5	79.7	82.9	86.0
Milk	73.7	71.5	68.9	75.2**
Fish and shellfish	95.8	95.2	94.0	93.0*
Fruit	79.4	75.4*	77.0	75.1
Dark colored vegetable	92.4	96.1**	91.7	91.5
Fats and oils	72.8	82.1**	77.3	73.3*

*$P < 0.05$; **$P < 0.01$. by Wilcoxon rank sum test.

rizes the numbers of events and participants in the various activities. Activities to enhance nutrition were based on dietary guidelines for seniors[18] (Table 4), showing how to improve nutritional status, prevent malnutrition, and prepare an ideal daily meal. Details of the intervention programs were also distributed to each household as a monthly 'health letter'.

Results

There were no substantial differences of baseline characteristics between the intervention and observational populations (Table 5). Reported food frequencies for meat, dark colored vegetables and fats and oils increased significantly in the intervention population over the four years, whereas the frequency of eating fruit decreased (Table 6). In contrast, food frequencies for meat, fish and shellfish, and fats and oils decreased significantly in the observational population over the period 1992–1996.

Serum albumin concentrations increased significantly in both men and women over the intervention (Table 7). The female members of the intervention population also showed a significant increase in hemoglobin level. In contrast, the control population showed a significant decline in both serum albumin and hemoglobin concentration over four years of observation.

Discussion

Unfortunately, we did not find it possible to establish a control population matched in terms of environmental, socioeconomic, physical, and nutritional status over the same time period as the intervention. Effects of the intervention between 1996 and 2000 were thus evaluated relative to the changes seen in an age and gender matched observational sample drawn from the same community, and followed between 1992 and 1996.

The reported frequencies of eating meat, dark colored vegetables, fats and oils increased significantly in the intervention population from 1996 to 2000. In contrast, the observational population reported decreased food frequencies for meat, fish and shellfish, and fats and oils, although their frequency of milk consumption increased. The annual reports of the National Nutrition Survey for Japan for the period 1992–1999 have documented unchanged intakes of meat, fish and shellfish, and fats and oils, with an increased intake of dark colored vegetables.[20–27] Milk intake increased from 1992 to 1995, but thereafter tended to plateau. Thus, the reported increases in food frequency for meat and fats and oils seem attributable mainly to the intervention, rather than to secular trends within the community. A secular change may have contributed to the increased food frequency for dark colored vegetables, but in our view the intervention played a greater role than secular trends in augmenting the consumption of meats, dark colored vegetables, and fats and oils between 1996 and 2000. In the observational population, the decrease in reported food frequencies for meat, fish and shellfish,

Table 7 Serum albumin and hemoglobin concentrations over the intervention or observational period

Nutritional variables	Serum albumin (g/dL)		Hemoglobin (g/dL)	
	Initial	Final	Initial	Final
Intervention population				
Men	4.04 ± 0.20	4.19 ± 0.23**	13.4 ± 1.2	13.5 ± 1.3
Women	4.16 ± 0.19	4.32 ± 0.23**	12.2 ± 1.0	12.3 ± 1.1**
Observational population				
Men	4.07 ± 0.24	4.03 ± 0.21*	13.5 ± 1.4	13.3 ± 1.4**
Women	4.14 ± 0.24	4.12 ± 0.22*	12.2 ± 1.1	11.9 ± 1.2**

Mean ± standard deviation.
*$P < 0.05$, **$P < 0.01$ by paired t-test.

and fats and oils seems attributable to advancing age, but the increased consumption of milk is probably a secular trend.

Serum albumin and hemoglobin are valuable measures of nutritional status[28] and a previous study revealed a significant correlation between hemoglobin concentration and serum albumin in older people.[28] Both parameters decrease spontaneously as age advances[29–31]. In contrast to this anticipated trend, the intervention population showed increased concentrations of serum albumin (men and women) and of hemoglobin (women only). Nation-wide, hemoglobin levels for those aged ≥ 70 years remained constant from 1996 to 1999.[24–27] It is thus reasonable to attribute the increases of serum albumin and hemoglobin to the improved diet induced by our intervention. In contrast, advancing age was considered to be the main cause of the decreases in serum albumin and hemoglobin in the observational population.

Inverse relationships have been reported between serum albumin level and deaths from cardiovascular disease, cancer, other causes, and all causes.[32,33] Corti *et al.*[9] demonstrated that a low serum albumin was an independent risk factor for all-cause mortality in subjects aged ≥ 71 years. Jensen *et al.*[34] further reported that a low serum albumin concentration was a significant predictor of both functional limitation and health care charges over a 2-year follow-up of community-dwelling senior citizens. Serum albumin seems to indicate not only nutritional status but also aging per se.[6,9,32–34] The fact that serum albumin and hemoglobin increased in the intervention population may thus suggest that the intervention slowed the inherent rate of aging of the participants.

We conclude that the pattern of formal intervention adopted here is both feasible and effective in preventing malnutrition and enhancing the nutritional status of community-living senior citizens. Further, it may serve to limit functional losses.[14,35] In the future, effects of the formal intervention on active life and life expectancies should be observed in the intervention group. Our observations merit confirmation by a fully controlled, randomized study. Further analyses are also needed to explore effects of the intervention upon physical and psychological status, and resulting functional abilities.

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