Table 3 Estimates and goodness of fit of the longitudinal final model (LONG model 2)

	Estimates	t-value
Second order factor loadings; γs		
First order factor Hand power	1.10	16.47
First order factor Walking	1.75	26.66
First order Balance	1.88	29.54
First order factor loadings; λs		
First order factor Hand power		
GRIP	1.33	14.14
TAPPING	0.98	7.70
First order factor Walking		
P-WALK	0.97	16.02
M-WALK	1.27	23.77
First order factor Balance		
O-OLS	1.00	16.68
C-OLS	0.46	7.01
Variances of exognous variables of second order factor; ζs		
ζ1	0.01	0.44
ζ2	0.26	4.70
ζ3	0.42	3.87
Variances of exognous variables of first order factor; εs		
ε1	0.78	11.27
ε2	0.88	15.84
ε3	0.48	11.33
ε4 (1992)†	0.19	2.96
ε4 (1996)†	0.04	0.59
ε5	0.25	2.07
ε6	0.83	17.13

†ε 4s of both models are not equivalent because of the release of equality constraint.
N = 463, controlled the gender and age at the time of baseline research, leaving out covariances of measuring errors between 1996 and 1996.

Discussion

Factorial structure of physical performance measures for the elderly

Statistical understandings of the factorial structure of these measures are essential due to the difference of cases of other age groups in the physical performance measures of the elderly. Longitudinal research in the study of aging is important for awareness of the substantial effects of aging. Examinations to ascertain whether the factorial structure of those tests change longitudinally are required. In our previous studies, it was clarified that the BMA model, constructed as a structural model of the physical performance tests for the elderly, fit the data well by the confirmatory factor analysis (CFA).[22] The model was a second-order covariance structure model in which *basic motor ability* was the single second-order latent variable (ξ) (see Fig. 1). It was also confirmed that this model fitted well with the cross-sectional data measured in the baseline research, which was the same as part of the data used in the present study.[23]

In this study, the goodness-of-fit of the BMA model using CFA was examined in each cross-sectional data in the physical performance tests of the baseline research in 1992 and the follow-up 4 years later in 1996 as the prestage of simultaneous analysis. The modification was added by taking the covariance in measuring errors of TAPPING and M-WALK on the basis of the analytical result. The present study also revealed that the improved BMA model (CROSS final model) fit the cross-sectional data in both years very well (Fig. 2). It was confirmed with these that the BMA model in Figure 1 fit in the factorial structure of the physical performance tests for the elderly residents in the community.

Some studies have been reported of modeling the relationship between motor ability and activities of daily living[7] or functional limitations[8] for the elderly. However, our studies are the first to examine statistically using CFA, focusing only on the factorial structure of the physical performance measures for the elderly and there has never been a report such as this one even among any questionnaires.[9,22,23] Further confirmation is required of the cross-community validity of this model in the physical performance measures for the elderly.

Factorial invariance of the BMA model over four-years

The value of the physical performance tests over 4 years between the baseline research in 1992 and the follow-up research in 1996 in measuring indicated the aging change (Table 1). Nonetheless, there are the same factors in the structure of both 1992 and 1996 and the factors' locations and arrangements were identical, indicating that the configuration was invariant statistically. No difference in the value of their factor-loading was found (Tables 2 and 3).

The rate of attenuation with advancement of age of our physical performance tests was different from the motor ability measured in the cross-sectional research.[3] Differences in the ratio of the intrasubject decline with aging by measuring items have been reported.[19,20] In the process of age-related changes of motor abilities, the same factors in the physical performance measures might cease to exist. With the change of the loading toward the factors, the factorial structure could be considered to be a change. A reason for invariance might lie in the fact that the 4-year period of the present study was too short to determine the longitudinal changes of the structure with advancing age. It may not be clear whether the 4-year period was appropriate as there were

no other reports in the past studying the longitudinal examination of the factorial structure in the physical performance tests for elderly persons. We intend that the follow-up period may be extended for further examination to clarify this matter.

Analysis of the factorial structure in the longitudinal data through simultaneous analysis

In the simultaneous analysis, Marsh[27] (also see Marsh *et al.*[28] and Marsh[29]) noted,

> Recent advances in the application of CFA provide a more rigorous comparison of the factor structures resulting multiple groups. . . . Here, the researcher is not only examining the similarity of the pattern of parameter estimates from different groups, but is testing whether the actual values of the parameters are the same across groups.

In summary, it is a tool that allows examining the invariance of the structure among the groups statistically. The data used for this study was the longitudinal data (three dimensions: time point × variables × subjects) corresponding to the baseline research and the follow-up research 4 years later. Therefore, ordinary simultaneous analysis is not applicable for this case. With the model expanded from this method, we examined whether there was any longitudinal age change in the factorial structure of the physical performance. The measuring expansion means to make the simultaneous analysis possible by taking all covariances from the errors (εs) of measuring variables corresponding in the same way as the model setting in the line of the MTMM matrix.[28,29] The expanded simultaneous analysis enabled the data of the same groups with the same measurements in this study to be examined in terms of the longitudinal factorial invariance of the structure.

Studies on elderly people by use of the simultaneous analysis of structural equation modeling have sought to establish the construct validity of the questionnaire and items.[37] As regards to the aging changes of the motor abilities with this analysis, several studies that investigated the differences in the structure of processing speed with cognitive psychological tasks between young and older adults have been reported.[38] There is a study that examined the difference in gender and age using the simultaneous analysis of CFA concerning the factorial invariance in the physical performance tests, though unfortunately, the age of the subjects ranged from nine to 15 years old.[29] No work on the structure in the performance measures of motor abilities for the elderly, such as this paper, was reported heretofore.

In the longitudinal data in the follow-up research, the factorial structure can be compared and examined in the measuring terms by analyzing the date in each time point through CFA. The construct validity can be confirmed in that case, yet the statistical examination cannot be given the difference in the arrangement of the factors and the factor-loadings. These can be proved statistically in the case of examining the longitudinal factorial invariance through simultaneous analysis. On the other hand, as they should be measured with the same method, it would become difficult for the follow-up research along with the difficulty of keeping the high rate of participation. Since intersubject variability generally tends to increase with aging,[19] the longitudinal changes should be confirmed in order to recognize the true effects of aging. Regarding the physical performance tests for the elderly, it is necessary to examine the longitudinal changes in the structure of those in population-based studies, which is not found elsewhere.

The results in this study indicated the applicability of the simultaneous analysis of CFA as a method of examining statistically the longitudinal factorial invariance of measurements of the same groups with the same procedure. The present study suggests that the analysis can be applicable for a longitudinal study and may be extended for use for various measures, such as before and after intervention study, hospital admission, and discharge, as well as at the start and end of medical treatment of clinic cases. It is a feasible tool for the examination of factorial invariance with time and comparison of various factors. In gerontology, for which this method can be applied as a tool, and in understanding and clarifying the factorial structure in various cases, it is hoped that it will make a meaningful contribution, even if so slightly.

Acknowledgments

This study was part of a research project, Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (TMIG-LISA): Medical Sciences.

References

1 Guralnik JM, Branch LG, Cumming SR, David Curb J. Physical performance measures in aging research. *J Gerontrol* 1989; **44**: M141–M146.
2 Reuben DB, Siu AL. An objective measure of physical function of elderly outpatients: The physical performance test. *J Am Geriatr Soc* 1990; **38**: 1105–1112.
3 Kinugasa T, Nagasaki H, Itoh H, Hashizume K, Furuna T, Maruyama H. Effect of Aging on motor ability in men Aged 18–83 years. *Jpn J Phys Fitness Sports Med* 1994; **43**: 343–351. (In Japanese.)
4 Guralnik JM, Seeman TE, Tinetti ME, Nevitt MC, Berkman LF. Validation and use of performance measures of functioning in a non-disabled older population: MacArthur studies of successful aging. *Aging Clin Exp Res* 1994; **6**: 410–419.
5 Nagi SZ. An epidemiology of disability among adults in the United States. *Milbank Mem Fund Q Health Soc* 1976; **54**: 439–467.

6 Verbrugge LM, Jette AM. The disablement process. *Soc Sci Med* 1994; **38**: 1–14.
7 Morey MC, Pieper CF, Cornoni-Huntley J. Physical fitness and functional limitations in community-dwelling older adults. *Med Sci Sports Exerc* 1998; **30**: 715–723.
8 Laukkanen P, Era P, Heikkinen R-L, Suutama T, Kauppinen M, Heikkinen E. Factors related to carrying out everyday activities among elderly people aged 80. *Aging Clin Exp Res* 1994; **6**: 433–443.
9 Kinugasa T, Nagasaki H, Furuna T, Itoh H. Physical performance measures for characterizing high functioning older persons. *J Aging Phys Act* 1996; **4**: 338–348.
10 Seeman TE, Charpentier PA, Berkman LF *et al.* Predicting changes in physical performance in a high-functioning elderly cohort: MacArthur studies of successful aging. *J Gerontol Med Sci* 1994; **49**: M97–M108.
11 Guralnik JM, Simonsick EM, Ferrucci L *et al.* A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontrol Med Sci* 1994; **9**: M85–M94.
12 Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *New Eng J Med* 1995; **332**: 556–561.
13 Guralnik JM, Ferrucci L, Pieper CE *et al.* Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol Med Sci* 2000; **55A**: M221–M231.
14 Judge JÖ, Schechtman K, Cress E, FICSIT Group. The relationship between physical performance measures and independence in instrumental activities of daily living. *J Am Geriatr Soc* 1996; **44**: 1332–1341.
15 Gill TM, Williams CS, Tinetti ME. Assessing risk for the onset of functional dependence among older adults: The role of physical performance. *J Am Geriatr Soc* 1995; **43**: 603–609.
16 Blair SN, Kohl HW, Barlow CE *et al.* Changes in physical fitness and all-caused mortality: A prospective study of healthy and unhealthy men. *JAMA* 1995; **273**: 1093–1098.
17 Laukkanen P, Heikkinen E, Kauppinen M. Muscle strength and mobility as predictors of survival in 75–84-year-old people. *Age Aging* 1995; **24**: 468–473.
18 Furuna T, Nagasaki H, Itoh H, Hashizume K, Kinugasa T, Maruyama H. Motor abilities of older adults in Japanese urban and rural communities. *Jpn J Phys Fitness Sports Med* 1995; **44**: 347–356. (In Japanese.)
19 Furuna T, Nagasaki H, Nishizawa S *et al.* Longitudinal change in the physical performance of older adults in the community. *J Jpn Phy Ther Assoc* 1998; **1**: 1–5.
20 Sugiura M, Nagasaki H, Furuna T, Okuzumi H. Walking ability older adults in the community – a four-year follow-up study. *Jpn J Phys Fitness Sports Med* 1998; **47**: 443–452. (In Japanese.)
21 Henry FM. Specificity vs. generality in learning motor skill. In: Brown RC, Kenyon GS, eds. *Classical Studies on Physical Activity*. Englewood Cliffs: Printice Hall, 1968, 328–331.
22 Nagasaki H, Itoh H, Furuna T. A physical fitness model of older adults. *Aging Clin Exp Res* 1995; 7: 392–356.
23 Nagasaki H, Itoh H, Furuna T. The structure underlying physical performance measures for older adults in the community. *Aging Clin Exp Res* 1995; 7: 451–458.
24 Fleishman EA. *The Structure and Measurement of Physical Fitness*. Englewood Cliffs, NJ: Prentice Hall, 1964.
25 Shibata H, Suzuki T, Shimoyama Y, Koyano W. Launch of a new longitudinal interdisciplinary study on aging by Tokyo Metropolitan Institute of Gerontology (TMIG-LISA). *Fact Res Gerontol* 1993; 7: 277–294.
26 Horn JL, McArdle J, Mason R. When is invariance not invariant: A practical scientist's look at the ethereal concept of factor invariance. *Southern Psychologist* 1983; **1**: 179–188.
27 Marsh HW. The factorial invariance of responses by male and female to a multidimensional self-concept instrument: Substantive and methodological issues. *Multivariate Behav Res* 1987; **22**: 457–480.
28 Marsh HW, Byrne BM, Craven R. Overcoming problems in confirmatory factor analyses of MTMM data: The correlated uniqueness model and factorial invariance. *Multivariate Behav Res* 1992; **27**: 489–507.
29 Marsh WH. The multidimensional structure of physical fitness: Invariance over gender and age. *RQES* 1993; **64**: 256–273.
30 Kenny DA, Kashy DA. Analysis of the multitrait-multimethod matrix by confirmatory factor analysis. *Psychol Bull* 1992; **112**: 165–172.
31 Bozdogan H. Model selection and Akaike's information criteria (AIC): The general theory and its analytical extension. *Psychometrica* 1987; **52**: 345–370.
32 Hoelter JM. The analysis of covariance structures; Goodness-of fit indices. *Sociol Meth Res* 1983; **11**: 325–344.
33 Tanaka T. 'How big is big enough?': Sample size and goodness of fit in structural equation models with latent variables. *Child Dev* 1987; **58**: 134–146.
34 Marsh HW, Balla JR, MacDonald RP. Goodness-of fit indices in confirmatory factor analysis: The effect of sample size. *Psychl Bull* 1988; **102**: 391–410.
35 Bentler PM. Comparative fit indices in structural models. *Psychl Bull* 1990; **107**: 238–246.
36 Byrne BM. *A Primer of LISREL. Basic Applications and Programming for Confirmatory Factor Analytic Models*. New York: Springer-Verlag, 1989.
37 Koyano W & Shibata H. Cross-validation of the TMIG index of competence: Invariability of factor structure and predictive validity. *Jpn J Gerontol* 1992; **14**: 34–42. (In Japanese.)
38 Babcock RL, Laguna KD, Roesch SC. A comparison of the structure of proceeding speed for younger and older adults: Testing the assumption of measurement equivalence across age groups. *Psychol Aging* 1997; **12**: 268–276.

Geriatrics and Gerontology International 2003; **3:** *S50–S54*

ORIGINAL ARTICLE

Effects of osteoporotic fractures on quality of life-related variables in the community elderly in Japan: An 8-year follow-up study in TMIG-LISA

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Background: The purpose of this study was to investigate the long-term influence of osteoporotic fractures on (1) self-rated health (SRH); (2) instrumental activity of daily living (I-ADL); and (3) state of depression, all of which are the major variables related to quality of life (QOL) in the elderly.

Methods: The subjects were 504 men and women who participated in the Longitudinal Interdisciplinary Study on Aging conducted by the Tokyo Metropolitan Institute of Gerontology (TMIG-LISA) from 1992 to 2000. Among those interviewed, 50 participants (15 males and 35 females) who sustained fractures spontaneously or by minor trauma were diagnosed as having osteoporotic fractures.
A nested case-control (1 : 1) study with sex-and age-matched controls was conducted as statistical analysis to identify the effects of osteoporotic fractures on QOL-related variables.

Results: For self-rated health, the frequency of 'poor' self-rated health increased significantly in the cases from 19.6% at baseline (1992) to 42.6% at the 8-year follow-up (2000). In the controls, there was no significant increase in frequency of 'poor' rating.
The proportion of subjects with impaired I-ADL during 8 years increased significantly in the cases from 12.0% in 1992 to 38.0% in 2000, and also in the controls from 14.0% in 1992 to 36.0% in 2000.
The prevalence of depressive status increased in the cases from 32.6% to 50.0%. There was, however, no statistically significant difference between cases and controls.

Conclusion: The results suggest that osteoporotic fractures at any site are associated with serious and remarkable decline of overall QOL-related variables among the community elderly.

Keywords: community elderly, follow-up study, osteoporotic fractures, quality of life.

Introduction

Osteoporosis characterized by reduced bone mineral density and increased susceptibility to fracture, is increasingly recognized as a major public health problem in Japan and other contemporary industrialized countries with an aging society.

Accepted for publication 2 September 2003.

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Osteoporosis and its associated fractures are also recognized as important causes of morbidity and mortality in the elderly. Fractures resulting from minor trauma are the clinical complication of osteoporosis and significant by influence the quality of life (QOL) in the elderly.

Hip fractures are well known to be the most serious osteoporotic fractures, which contribute substantially to morbidity, mortality, and health care costs. Vertebral and wrist fractures are also common. Particularly, spinal compression fractures secondary to osteoporosis cause spinal column deformity that often result in restriction of activities of daily living (ADL) and subsequent decrease in QOL, as has been reported in European and American literature.[1–4] The long-term consequence of these osteoporotic fractures can be devastating, particularly for the elderly persons who have lost self-confidence after the fractures and are trying to regain their former lifestyle. However, there is scarcely any study in Japan on the frequencies of these consequences or loss of QOL after osteoporotic fractures over the long-term.

In the present paper, the authors report the long-term influence of osteoporotic fractures on (1) self-rated health (SRH) as an indicator of physical status; (2) instrumental activity of daily living (I-ADL) as an indicator of functional status; and (3) state of depression as an indicator of emotional status, all of which are major variables related to QOL in the elderly.

Materials and methods

Study area and subjects

The data of subjects and study area 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 identify factors accelerating or retarding the aging process. The TMIG-LISA consists mainly of three disciplines: medical, psychological, and social science. Sampling methods of subjects have been described elsewhere.[5,6] One of the cohorts in the medical science discipline of TMIG-LISA is from Nangai Village, a rural area of Akita Prefecture, which is a typical agricultural area in the northern part of Honshu Island, Japan. The total population in 1992 was 5136 and the ratio of residents aged 65 years and older to the total population was approximately 20%. All ambulatory residents aged 65 and over were eligible to be included in the cohort. As a result of the preserves, 852 people were identified 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 responded to the interview, accounting for 87.8% of all eligible residents ($N = 852$).

The residents who were able to walk (unassisted or using a cane) were invited to the municipal community center in the village for the interview. We limited the subjects of this particular study to those who were independent in basic activity of daily living (B-ADL) at the time of the baseline survey.

These people have been followed by interview surveys on a yearly basis with the same questionnaire used in the baseline survey. Data collected at the baseline survey were used to characterize the study population for analyses in this study. In 2000, a total of 504 subjects (190 males and 314 females) participated in the follow-up interview survey, excluding 198 deceased, 24 institutionalized or hospitalized, and 22 who refused or did not participate due to other reasons. Among those interviewed, 50 participants (15 males and 35 females) who sustained fractures spontaneously or by minor trauma were diagnosed as having osteoporotic fracture.

Identification of fractures

Identification of osteoporotic fractures was done by interview without any roentgenological examination. The subjects were asked, 'Did you have any fractures in the last one year?' If the answer was 'yes', then they were also asked which part of the skeleton was fractured and more detailed information on the time, place, behavior, and results of the occurrence of fractures. Fractures sustained from minor traumatic energy such as falling were defined as osteoporotic fractures.

Assessment of self-rated health, functional health status (B-ADL and I-ADL), and depressive status

The interview survey employed at the baseline and follow-up surveys in TMIG-LISA contained scales for assessing self-rated health, functional health status, and state of depression status, all of which are QOL-related variables. In order to assess self-rated health, the subjects were asked, 'How do you rate your present health?' They were instructed to rate according to four categories; good, fair, poor, and very poor.[7] However, poor and very poor were combined in the analysis because the frequency of very poor was too low to be analyzed separately.

Functional health status was measured by asking questions about 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 measured by a subscale of the TMIG Index of Competence, which contained five questions concerning 'Instrumental self-maintenance'[8] (Table 1).

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 simple summing the item scores. Thus, a score of 5 represents no difficulty and 0 represents inability to perform the tasks in I-ADL. In the present study, only changes of I-ADL during the follow-up period were analyzed.

Depressive symptoms were measured by the Japanese short version of Geriatric Depression Scale (GDS). The short version GDS consists of a 15-item questionnaire to which subjects respond by indicating 'yes' or 'no' to questions about depressive symptoms. GDS-scores of 5 or higher are regarded as mild to severe depressive symptoms.[9,10]

Statistics

To identify the effects of osteoporotic fractures on the QOL-related variables, a nested case-control study (1 case to 1 control) matched for sex and age was used for statistical analysis. In addition, *t*-test and χ^2 test with the Mc Niemer test were used to compare differences, and the level of significance was $P < 0.05$.

Results

During eight years of follow-up, 15 men (7.9%) and 35 women (11.2%) were found to have the osteoporotic fractures. There was no significant sex difference in frequency ($\chi^2 = 1.40$, $p = 0.24$). There was also no difference in average age between fractured cases and non-fractured controls (70.8 ± 4.6 *vs* 70.9 ± 4.9 year. $t = 0.16$, $p = 0.87$).

The sites of fractures of the 50 subjects are shown in Table 2. The most common fracture site was spine (20.4%) followed by wrist and hand (15.3%). Hip fractures occupied approximately 10%.

Secular changes in the frequencies of three QOL-related variables during eight years follow-up were compared between cases (fractured) and controls (non-fractured).

For the variable 'self-rated health', the frequency of 'poor' self-rated health increased significantly in the cases from 19.6% at baseline (1992) to 42.6% at 8-year follow-up (2002). In the controls, there was no significant change in the frequency of 'poor' rating during 8 years (Table 3).

On the changes of status in I-ADL measured by a subscale of TMIG-Index of Competence, the proportion of subjects with impaired I-ADL during the 8 years increased significantly in the cases from 12.0% in 1992 to 38.0% in 2000, and also in the controls from 14.0% in 1992 to 36.0% in 2000 (Table 4).

A comparison of prevalence of depressive status measured by the GDS score showed considerable increase is the cases from 32.6% to 50.0%. There was, however, no statistically significant difference in both cases and controls (Table 5).

Discussion

The clinical consequence of osteoporosis is fractures and morbidity secondary to fractures. Vertebral frac-

Table 1 Influence of osteoporotic fractures on quality of life (QOL)

Measurements in the three domains of QOL
1. Self-Rated Health (good/poor)
2. Instrumental ADL (a subscale of the TMIG Index of Competence)
1.1. Using public transportation (yes/no)
1.2. Shopping for daily necessities (yes/no)
1.3. Preparing meals (yes/no)
1.4. Paying bills (yes/no)
1.5. Drawing bank account (yes/no)
3. Geriatric Depression Scale score (Short version 15 items: ≥ 5 points)

Table 2 Occurrence of fractures during follow-up

Sites of fractures	*n*	(%)
Spine	12	(20.4)
Wrist & Hand	9	(15.3)
Arm	8	(13.6)
Crus: Tibia and/or Fibula	8	(13.6)
Hip	6	(10.2)
Others	16	(27.1)

Table 3 Secular changes in Self-rated health of quality of life-related variables between cases and controls

Case

In 1992 \ In 2000	Poor	Good	Total
Poor	5	4	9 (19.1%)
Good	15	23	38 (80.9%)
Total	20 (42.6%)	27 (57.4%)	47 (100.0%)

McNemar $\chi^2 = 5.26$ ($P < 0.05$)

Control

In 1992 \ In 2000	Poor	Good	Total
Poor	4	5	9 (18.4%)
Good	13	27	40 (81.6%)
Total	17 (34.7%)	32 (65.3%)	49 (100.0%)

McNemar $\chi^2 = 2.72$ (n.s.)

Table 4 Secular changes in Instrumental-activities of daily living of quality of life-related variables between cases and controls

Case

In 1992 \ In 2000	≤ 4	5	Total
≤ 4	5	1	6 (12.0%)
5	14	30	44 (88.0%)
Total	19 (38.0%)	31 (62.0%)	50 (100.0%)

McNemar χ^2 =9.60 ($P < 0.01$)

Control

In 1992 \ In 2000	≤ 4	5	Total
≤ 4	4	3	7 (14.0%)
5	14	29	43 (86.0%)
Total	18 (36.0%)	32 (64.0%)	50 (100.0%)

McNemar $\chi^2 = 5.88$ ($P < 0.05$)

Table 5 Secular changes in depressive status of quality of life-related variables between cases and controls

Case

In 1992 \ In 2000	Depr.	Non	Total
Depression	11	4	15 (32.6%)
Non	12	19	31 (67.4%)
Total	23 (50.0%)	23 (50.0%)	46 (100.0%)

McNemar $\chi^2 = 3.06$ (n.s.)

Control

In 1992 \ In 2000	Depr.	Non	Total
Depression	9	4	13 (27.7%)
Non	12	22	34 (72.3%)
Total	21 (44.7%)	26 (55.3%)	47 (100.0%)

McNemar $\chi^2 = 3.06$ (n.s.)

tures are very common in elderly Japanese women[11] and cause deformity and disability.[12,13] Hip fractures are the most serious fractures, which contribute substantially to morbidity and even mortality in Japanese elderly.[14,15] However, these osteoporotic fractures not only cause disability and morbidity, but also have important influences on mental health, self-image, and functional capacity in daily life, which cannot be captured easily using conventional clinical measurements.[16,17]

Several instruments to measure QOL have been developed over the last 15 years. These include generic and disease-specific instruments. The generic instruments grade the general state of health from both mental and physical aspects.[18,19] On the other hand, disease-specific instruments have been developed for specific diseases such as cancer, cardiovascular disease, and diabetes. Specific questionnaires for assessing QOL in patients with osteoporosis have also been developed recently in Europe,[20] America,[21] and Japan.[22]

The questionnaire used in this study is not the osteoporosis-specific QOL instrument that was developed in Japan only two years ago. In the present study, however, three variables probably constituting the essential elements of QOL in the elderly were investigated to elucidate the magnitude of osteoporotic fractures on the QOL among the rural community elderly in an eight-year follow-up study. Self-rated health is an indicator of physical status, state of depression is an indicator of emotional status, and I-ADL is an indicator of functional status, all of which are the major components of QOL in the elderly.[23]

One of the most interesting findings of this study is that occurrence of osteoporotic fractures is identified as a risk factor for decline of QOL assessed by the three QOL-related variables. Particularly, self-rated health is significantly decreased in the elderly who had osteoporotic fractures.

Self-rated health has been recognized as a useful predictor of mortality.[24,25] Our previous studies from TMIG-LISA also showed that even controlling for objective health status assessed by follow-up examinations of elderly subjects after a seven-year duration, self-rated health had a significant correlation with mortality.[26]

Previous reports of TMIG-LISA also demonstrated that self-rated health was not only a useful indicator of objective health, but was also closely related to life satisfaction and social activity.[27,28]

Osteoporosis and associated fractures, which may not manifest as significant clinical symptom, certainly deteriorate self-rated health as a latent factor for subjective well-being.

Instrumental ADL as a high-level functional capacity, which has been subsumed as a main component of QOL in the elderly, is also useful as a predictor of active life. The maintenance of functional capacity at the level of physical self-maintenance is the minimum requirement for elderly people to live an independent life.

Osteoporotic fractures, particularly those occurring in upper and lower extremities such as wrist and hip joints have very serious effects on physical self-maintenance of the elderly regardless of living conditions. In this context, prevention of osteoporotic fractures, which are responsible not only for decline of QOL but also mortality, appears to be an important issue in the aged society and requires urgent attention.

There are some limitations in this study. First, the cases of osteoporotic fractures were identified only by interview and physician's observation during the mass health examination without any roentgenological examinations. Although we were certainly able to detect almost all cases of osteoporotic fractures, some asymptomatic cases of spinal fractures that are not accompanied with clinical symptoms such as pain and dysfunction may be overlooked. In this context, there is a possibility of under-estimating the frequency of fractured cases.

The second limitation is the relationship of the fracture-site and QOL. Among the osteoporotic fractures, hip fracture is most serious and most likely to decline QOL. Spinal fractures may not have manifested any subjective symptom in some cases. Because of an inadequate number of fractured cases in this study, changes of QOL-related variables in various fracture sites were not analyzed. For the present study, however, we can conclude that osteoporotic fractures at any site are serious and remarkably decline the overall QOL-related variables among the community elderly.

Therefore, we should formulate control measures for the prevention of osteoporotic fractures among the elderly through, for example, detection and appropriate treatment of these fractures and/or fall prevention programs in the community.

References

1 Cook DJ, Guyatt GH, Adachi JD *et al.* Quality of life issues in women with vertebral fractures due to osteoporosis. *Arthritis Rheum* 1993; **36**: 750–756.

2 Leidig-Bruckner G, Minne HW, Schlaich C *et al.* Clinical grading of spinal osteoporosis: Quality of life components and spinal deformity in women with chronic low back pain and women with vertebral osteoporosis. *J Bone Miner Res* 1997; **12**: 663–675.

3 Cortet B, Houvenagel E, Puisieux F *et al.* Spinal curvatures and quality of life in women with vertebral fractures secondary to osteoporosis. *Spine* 1999; **24**: 1921–1925.

4 Adachi JD, Ioannidis G, Olszynski WP. The impact of incident vertebral and non-vertebral fractures on health related quality of life in postmenopausal women. *BMC Musculoskelet Disord* 2002; **3**: 11.

5 Shibata H, Suzuki T, Shimonaka Y, eds. *The Longitudinal Interdisciplinary Study on Aging by Tokyo Metropolitan Institute of Gerontology (TMIG-LISA). Facts, Research and Intervention in Geriatrics 1997.* Paris: Serdi, 1997.

6 Shibata H. An Overview of the Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (TMIG-LISA, 1991–2001). *J Aging Phys Act* 2000; **8**: 98–108.

7 Haga H, Shibata H, Suyama Y *et al.* Self-rated health as a predictor of active life in the community elderly. *J Epidemiol* 1995; **5**: 11–15.

8 Koyano W, Shibata H, Nakazato K *et al.* Measurement of competence: reliability and validity of the TMIG Index of Competence. *Arch Gerontol Geriatr* 1991; **13**: 103–116.

9 Yesavage JA, Brink TL, Rose TL. Development and validation of a geriatric depression screening scale: A preliminary report. *J Psychiatr Res* 1982–83; **17**: 37–49.

10 Niino N, Imaizumi T, Kawakami N. A Japanese translation of the Geriatric Depression Scale. *Clin Gerontol* 1991; **10**: 85–87.

11 Ross PD, Fujiwara S, Huang C *et al.* Vertebral fracture prevalence in women in Hiroshima compared to Caucasians or Japanese in the US. *Int J Epidemiol* 1995; **24**: 1171–1177.

12 Toyama Y, Nagayama N, Tanaka K. Spinal compression fracture accompanying osteoporosis and deformity of the spinal column. *Orthopedic Surg (Special Number)* 1987; **12**: 7–13. (In Japanese.)

13 Kamo Y, Takemitsu Y, Harada Y *et al.* Degenerative kyphosis middle-age senile. *Kotsu Kansetsu Jintai* 1989; **2**: 1469–1477. (In Japanese.)

14 Shichida K, Endo C, Shibazaki K *et al.* Survival rate and physical activity in elderly patients after femoral neck fracture. *Nippon Ronen Igakkai Zasshi* 1988; **25**: 563–568. (In Japanese with English summary.)

15 Suzuki T, Yoshida H, Ishizaki T. Epidemiology of osteoporosis: Incidence, prevalence, prognosis. *Nippon Rinsho* 1988; **56**: 1563–1568. (In Japanese with English summary.)

16 Fitzpatrick R, Fletcher A, Gore S *et al.* Quality of life measures in health care. I. Applications and issues in assessment. *BMJ* 1992; **305**: 1074–1077.

17 Fletcher A, Gore S, Jones D *et al.* Quality of life measures in health care. II. Design, analysis, and interpretation. *BMJ* 1992; **305**: 1145–1148.

18 Brazier JE, Harper R, Jones NM *et al.* Validating the SF-36 health survey questionnaire: New outcome measure for primary care. *BMJ* 1992; **305**: 160–164.

19 Hunt SM, McEwen J, McKenna SP. Measuring health status: a new tool for clinicians and epidemiologists. *J R Coll General Pract* 1985; **35**: 185–188.

20 Lips P, Cooper C, Agnusdei D *et al.* Quality of life as outcome in the treatment of osteoporosis: The development of a questionnaire for quality of life by the European Foundation for Osteoporosis. *Osteoporos Int* 1997; **7**: 36–38.

21 Silverman SL, Cranney A. Quality of life measurement in osteoporosis. *J Rheumatol* 1997; **24**: 1218–1221.

22 Takahashi H *et al.* Questionnaires for the evaluation of QOL in osteoporotic patients in Japan. *Osteoporosis Japan* 2000; **8**: 123–144.

23 Croog SH. Current issues in conceptualizing and measuring quality of life. Proceedings of a Workshop sponsored by the office of the Director, National Institute of Aging. Baltimore: National Institute of Aging, 1990, 11–21.

24 Kaplan G, Barell V, Lusky A. Subjective state of health and survival in elderly adults. *J Gerontol* 1988; **43**: S114–S120.

25 Jagger C, Clarke M. Mortality risks in the elderly: Five-year follow-up of a total population. *Int J Epidemiol* 1988; **17**: 111–114.

26 Haga H, Shichida K, Ueno M *et al.* Factors contributing to longitudinal changes in activities of daily living (ADL): The koganei study. *J Cross-Cult Gerontol* 1991; **6**: 91–99.

27 Haga H, Shibata H, Ueno M *et al.* Relationship of self-rated health to mortality among the community elderly. *Nippon Koshu Eisei Zasshi* 1991; **38**: 783–789. (In Japanese.)

28 Haga H, Shibata H, Nagai H *et al.* Social, psychological and physical factors correlates of self-rated health. *Social Gerontol* 1984; **20**: 15–23. (In Japanese.)

Geriatrics and Gerontology International 2003; **3:** *S55–S62*

Aging-related changes of food intake in elderly subjects living in an urban community and relation with vital prognosis: Results of an 8-year longitudinal study (TMIG-LISA)

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Purpose: We conducted an 8-year longitudinal study to investigate aging-related changes in food and nutrient intake in a cohort of elderly subjects living in an urban community, and attempted to relate food intake with vital prognosis.

Procedures: The first (baseline) nutrition survey was conducted in 1991 on 161 subjects (72 males and 89 females; aged 65–79) living in Koganei City. The second nutrition survey was conducted 8 years later in 1999. Excluding death or illness, 98 subjects (61%) were available for follow-up. Nutrition survey was conducted by a three-day dietary record method with daily home visits by dieticians. Aging-related changes in physical attributes, food intake, nutrient intake, and intake adequacy were analyzed. The relationship between nutrition intake and mortality was analyzed by Cox proportional hazard model.

Results: (i) Weight and body mass index in females decreased significantly accompanying aging. (ii) Among all food groups, consumption of fruits was significantly lowered in males and females. (iii) Significantly decreased intake of protein, fats, carbohydrate, iron, sodium was observed in females. (iv) No change in protein–fat–carbohydrate energy ratio was observed. (v) Nutrient intake was greater than the recommended dietary allowances at baseline and also eight years later. (vi) A significant correlation was observed between vegetable protein intake and vital prognosis in males.

Conclusion: In the present cohort, although nutrient and food intake changed with aging, nutrient intake was higher than the recommended dietary allowances. These results show that a 'diet for healthy longevity' is achieved by continuing to maintain the recommended dietary allowances despite age advancement.

Keywords: aging, nutrient intake, nutrition survey, recommended dietary allowance, vital prognosis.

Introduction

Accompanying the arrival of an aging society in Japan, the promotion of national policies aiming at healthy longevity has become an important issue.[1] The health promotion campaign for the 21st century (Healthy Japan 21) is moving ahead with the aim to prolong a healthy lifespan, and recommendation of safe and adequate daily dietary intake have been published.[1] However, since implementation of these policies has only just started, there are very few reports of nutrition survey/research or actual dietary habit survey in elderly subjects living in the community with the main theme of healthy longevity. As a result, the

Accepted for publication 27 October 2003.

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implementation at individual level has not been reached. The purpose of the present study was to provide basic data for planning the policy 'dietary habit for a long and healthy life' aiming at a healthy longevity. We surveyed elderly subjects who led an independent life in the urban community, and examined the aging-related changes in food intake during eight years. Furthermore, using the mortality by all causes as an indicator of health, we attempted to relate the status of food intake with lifespan or vital prognosis.

Methods

Subjects

This study was conducted as a part of the Tokyo Metropolitan Institute of Gerontology – Longitudinal Interdisciplinary Study on Aging (TMIG-LISA).[2] The TMIG-LISA was reviewed and approved by the Tokyo Metropolitan Institute of Gerontology Ethical Review Committee. Informed consent was obtained from all subjects before participation in the study. Confidentiality of subjects has been protected.

The target area was Koganei City in the suburb of Tokyo. The first (baseline) nutrition survey was conducted in 1991. From 996 persons representing a one-tenth random sample of residents aged 65–84 years who were living in Koganei City as of June 1 1991, 814 subjects who responded to an interview were included as potential subjects. Among the 814 subjects, 405 attended the Comprehensive Health Check for the Elderly. Of 405 subjects, 170 were requested to participate in a nutrition survey. Nine subjects were excluded (5 subjects were on a trip or went out and 4 refused to be surveyed), and the remaining 161 subjects (72 males and 89 females; aged 65–79 years) were recruited in the first survey.

The second nutrition survey was conducted 8 years after the first survey, from July to September 1999. During this period, survey of vital outcome confirmed 25 deaths (18 males [25%], 7 females [8%]). An additional 22 subjects were hospitalized or sick and 16 subjects rejected being surveyed or had moved. Therefore, of the 161 subjects who participated in the first survey, 98 subjects were surveyed the second time, with an overall follow-up rate of 61%. Excluding those who died or were hospitalized or under medical treatment, the follow-up rate was 86%.

The analysis on longitudinal changes in two nutrition surveys was conducted on 98 subjects who could be surveyed in both the first and the second nutrition surveys. Analysis of survival was conducted on all 161 subjects who participated in the first survey, and subsequent survival or date of death of these subjects was confirmed.

Nutrition survey

Nutrition survey was conducted according to the three-day dietary record method, which was based on the recollection method coupled with direct interview. This method is a survey of individuals, and a dietary record form was handed to the subject in person before the survey. The subject was asked to write down on the form the contents of the food and the approximate amounts taken on specified days. The authors and other dieticians conducted home visits to each of the subjects once a day for three consecutive days. Food intake was monitored by confirming the contents of the record with the subject him/herself, spouse or family using photographs taken during interviews, scales, spoons and other instruments. The dietary record form was checked for omissions or mistakes. The quantities of intake were estimated from the approximate volume of food, or the approximate weight per slice, plate, or piece.

Dieticians conducted individual home visits on three consecutive days to confirm the dietary records. The subjects in the dietary survey were individuals who were capable of reading and writing by themselves, and furthermore capable of recording food eaten on three consecutive days. At the same time, despite being at an advanced age, these subjects led an active and busy life, and had volunteered to participate in the present study based on a trust relationship that they had developed with our Institute. With this background, we conducted a baseline dietary habit survey on these subjects in 1991, and then the same survey eight years later to observe the aging-related changes in this cohort.

The nutritional value was calculated using the Program Library EIPAC at the Tokyo University Large-scale Computer Center. The two surveys were conducted during the same period by the same method, and analyzed using the same tables of food compositions[3] and programs for calculating nutritional values. From these calculations, the quantities of nutrient intake and quantities of food intake by food group were obtained. Nutrient energy ratio was expressed as the energy ratio for the respective nutrient, such as protein energy ratio (P energy ratio), fat energy ratio (F energy ratio) and carbohydrate energy ratio (C energy ratio).

The adequacy of nutrient intake was expressed as a percentage of the nutrient intake for the individual to the recommended dietary allowance for Japanese.[4] However, the adequacy of energy intake was calculated as the percentage of energy intake for the individual to the recommended energy allowance according to the height, weight, and physical activity of the subject.[5]

Statistical analyses

The items of analysis were height, weight, body mass index (BMI) (weight in kg/height in m),[2] quantity of food intake by food group, and quantity of nutrient

intake. Aging-related changes in physical measurements, quantity of food intake by food group, and quantity of nutrient intake were analyzed using paired *t*-test.

To examine the association between nutritional factors and vital prognosis indicated by mortality by all causes, Cox proportional hazard model was used including mortality by all causes and other confounding factors in the analysis. We chose Cox proportional hazard method because this model deals with continuous values, and would sensitively detect differences in mortality, which is a continuous value. The independent variable was mortality by all causes. The dependent variables consisted of quantities of nutrient intake for energy, total protein, total fat, vegetable protein, animal protein, vegetable fat, animal fat, and carbohydrate; as well as the physical factor of BMI. These factors were used as continuous variables and were adjusted for age. Then the hazard ratio for each factor was calculated. Statistical calculations were performed using SPSS 11.0 for Windows.

Results

Physical measurements

Table 1 shows the basic attributes of these subjects. For the family structure, there were only a few subjects living alone, and 59% were living in extended families of two or three generations. For the final academic achievement, no subject had 'no schooling', and 9.6% were university graduates. As for physical items, 92% were mobile and capable of travelling far utilizing bicycles, cars, or buses. Moreover, chewing ability was good in the majority of the subjects.

Table 2 shows the aging-related changes in height, weight, and BMI of the same individuals during 8 years.

Table 1 Basic attributes of subjects

Item	No. of subjects	%
Sex		
Male	72	44.7
Female	89	55.3
Age		
65–69 years	64	39.8
70–74	58	36.0
75–79	39	24.2
Family structure		
Living alone	17	10.6
Couple	48	30.0
Extended family (2 or 3 generations)	95	59.4
Education		
Primary school (old system)	43	26.8
Junior/Senior high school (old system)	98	63.8
University (old system/modern)	15	9.6
Using public transportation		
Can move inside home or in neighbourhood, Cannot travel far	13	8.1
Can travel far by bicycle, car or bus	147	91.9
Chewing ability		
Do not chew much	5	3.1
Can chew most thing	72	45.0
Can chew anything	83	51.9

Table 2 Aging-related changes in physical measurements

	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Height (cm)	163.0 ± 5.1	162.8 ± 5.1	NS	148.6 ± 5.9	148.2 ± 5.8	NS
Body weight (kg)	55.9 ± 8.8	54.9 ± 9.3	NS	51.6 ± 8.7	50.2 ± 9.5	*
Body mass index (kg/m^2)	21.0 ± 3.0	20.5 ± 3.1	NS	23.4 ± 3.8	22.8 ± 4.0	*

Paired *t*-test; NS, not significant; *$P < 0.05$.

In females, the mean weight decreased significantly from 51.6 to 50.2 kg and the mean BMI also decreased significantly from 23.4 to 22.8. In comparison, no significant changes were observed in males.

Amounts of food intake by food group

At baseline, the intake amounts of green and yellow vegetables, fruits, and milk or milk products were high (Table 3). Especially the intake of milk or milk products was higher than the national average. As for the changes during 8 years, significant decreases were observed in fruits for both sexes, and fats and oils for females, while a tendency of decrease was observed for most of the other food groups. However, a tendency of slight increase in the intake of beans (soybeans and other processed products), green and yellow vegetables, and meat was seen in males.

Nutrient intake

Table 4 shows the changes in nutrient intake with aging. Significant decreases common to males and females were observed for carbohydrate and sodium. In females, significant decreases were also found in energy, total protein, animal protein, total fats, vegetable fat, iron, and vitamin B_2. In males, a tendency of decrease was observed in these nutrients.

There were no changes in nutrient energy ratio (protein–fat–carbohydrate energy ratio [PFC energy ratio]), P energy ratio, and F energy ratio with aging.

The aging-related changes in nutrient intake adequacy rates are shown in Fig. 1. Except calcium in males, the intake of all nutrients was above the recommended dietary allowance both at baseline and also after 8 years.

Relationship between nutrition intake and vital prognosis

The relationship between nutrition intake and vital prognosis was analyzed by the Cox proportional hazards model. Mortality by all causes was used as the dependent variable, and parameters nutrient intake was used as independent variables. To extract variables for use in the model, simple correlation analysis was conducted on all the nutrient factors. Factors showing strong correlation were eliminated to extract the representative variables. A total of eight variables were extracted. Thus, the independent variables consisted of continuous values of energy, vegetable protein, animal protein, vegetable fat, animal fat, and carbohydrate intake; as well as the physical factor of BMI and age. Males and females were analyzed separately because we observed differences between males and females in the amount of nutrient intake, the amount of food intake according to food group, body weight, absolute values of BMI, and age-related changes in nutrient uptake.

After adjusting for age, the hazard ratios of these variables were calculated (Table 5). In males, the hazard ratio of mortality by all causes was significantly decreased for vegetable protein intake.

Discussion

Representative methods of nutrition surveys used in epidemiological studies include the weighing method,[6] and recollection method.[7] While the former method

Table 3 Aging-related changes in food intake according to food group

Food group (g/day)	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Vegetable foods						
Rice	339.0 ± 132.1	313.6 ± 171.6	NS	241.7 ± 85.6	221.4 ± 88.9	NS
Soybean, processed product	52.1 ± 34.7	52.5 ± 47.1	NS	66.0 ± 39.4	60.6 ± 43.6	NS
Green and yellow vegetables	102.8 ± 59.0	113.4 ± 71.4	NS	118.4 ± 63.6	112.9 ± 69.3	NS
Light colored vegetables	134.2 ± 72.9	113.5 ± 61.9	NS	150.6 ± 73.1	135.3 ± 63.4	NS
Fruits	162.5 ± 109.3	91.6 ± 76.9	***	202.6 ± 129.4	127.0 ± 78.5	***
Animal foods						
Milk/milk products	138.4 ± 103.6	118.6 ± 104.4	NS	206.9 ± 163.6	185.7 ± 124.3	NS
Eggs	45.9 ± 24.0	43.0 ± 25.2	NS	38.2 ± 21.1	34.9 ± 24.6	NS
Meats	48.3 ± 24.4	51.4 ± 37.7	NS	45.4 ± 31.8	38.9 ± 31.8	NS
Fish and shellfish	95.3 ± 47.7	77.9 ± 39.1	NS	81.3 ± 40.1	71.7 ± 38.0	NS
Preference foods						
Fats and oils	18.4 ± 10.6	15.9 ± 8.8	NS	18.2 ± 10.4	12.7 ± 8.3	**
Sweets	32.0 ± 31.6	27.0 ± 31.7	NS	38.8 ± 33.1	39.6 ± 33.7	NS

Paired t-test; NS, not significant; **$P < 0.01$; ***$P < 0.001$.

Table 4 Aging-related changes in nutrient intake

Nutrient (mean of 3 days)	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Energy (kcal)	1960 ± 295	1836 ± 445	NS	1760 ± 392	1553 ± 341	***
Protein (total) (g)	74.0 ± 14.1	71.3 ± 16.0	NS	70.2 ± 16.8	64.1 ± 14.6	**
Vegetable (g)	35.8 ± 5.8	35.4 ± 9.3	NS	32.8 ± 7.4	31.0 ± 7.4	NS
Animal (g)	38.2 ± 12.2	35.9 ± 11.9	NS	37.3 ± 12.7	33.1 ± 11.5	*
Fats(total) (g)	56.4 ± 15.9	53.7 ± 15.5	NS	54.1 ± 17.7	47.3 ± 16.0	**
Vegetable (g)	29.2 ± 10.7	28.4 ± 11.6	NS	28.8 ± 12.1	24.5 ± 10.0	*
Animal (g)	27.2 ± 10.3	25.3 ± 9.6	NS	25.3 ± 10.6	22.8 ± 10.7	NS
Carbohydrate (g)	268 ± 45	247 ± 71	*	242 ± 56	213 ± 53	***
Calcium (mg)	577 ± 16	563 ± 197	NS	679 ± 247	624 ± 240	NS
Iron (mg)	10.8 ± 2.6	10.0 ± 2.6	NS	10.5 ± 2.8	9.3 ± 2.5	***
Sodium (mg)	4733 ± 964	4110 ± 1162	**	4520 ± 1331	4069 ± 991	**
Vitamin A (IU)	2483 ± 1551	2496 ± 2123	NS	2694 ± 1449	2403 ± 1244	NS
Vitamin B_1 (mg)	1.10 ± 0.29	1.00 ± 0.31	NS	1.11 ± 0.51	1.18 ± 1.24	NS
Vitamin B_2 (mg)	1.36 ± 0.39	1.33 ± 0.39	NS	1.44 ± 0.40	1.35 ± 0.45	*
Vitamin C (mg)	108 ± 45	102 ± 53	NS	126 ± 57	111 ± 51	NS
Protein energy ratio (%)	15.1 ± 2.1	15.8 ± 2.4	NS	16.0 ± 2.2	16.6 ± 2.3	NS
Fat energy ratio (%)	25.6 ± 5.4	26.4 ± 5.1	NS	27.3 ± 4.9	27.2 ± 5.5	NS
Carbohydrate energy ratio (%)	55.1 ± 6.8	53.6 ± 7.0	NS	55.4 ± 6.0	55.1 ± 6.7	NS

Paired t-test; NS, $P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

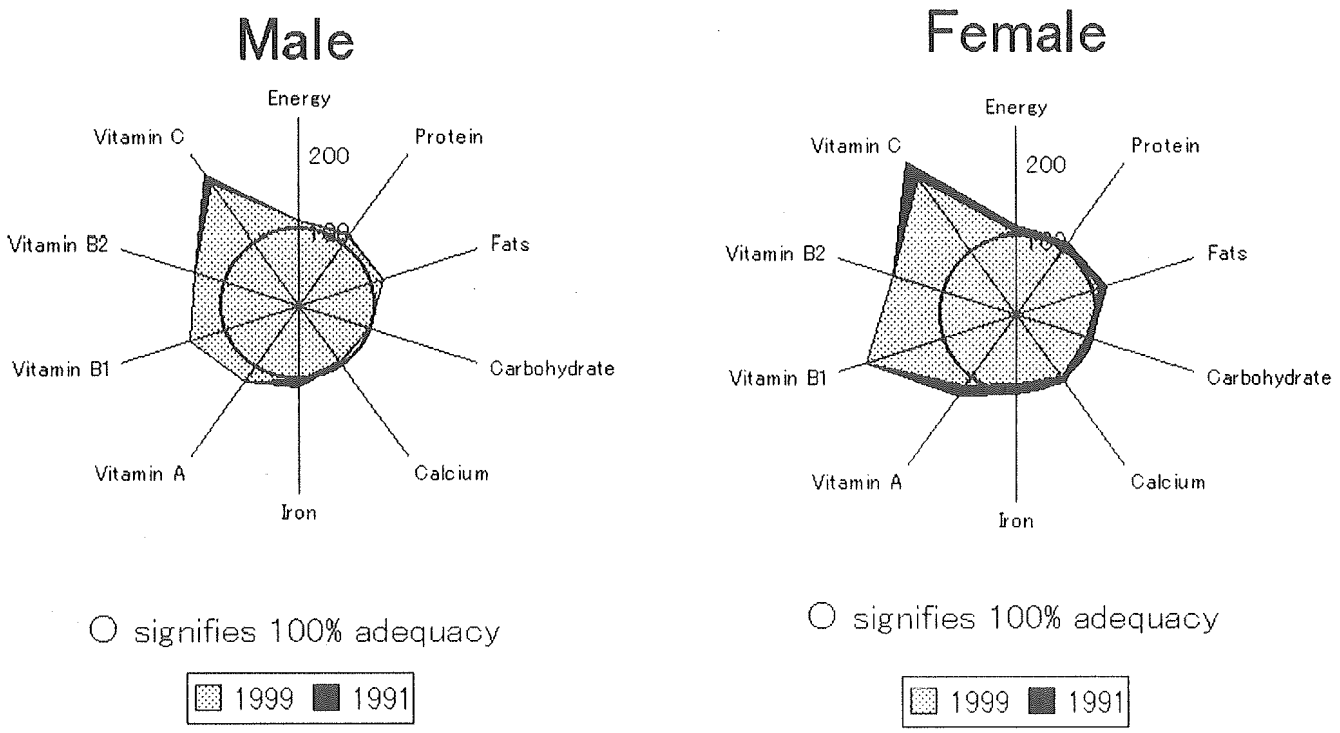

Figure 1 Age-related changes in adequacy of nutrition intake. The central circle in each graph signifies average dietary allowance of subjects examined = 100%. (▨) 1999; (■) 1991.

allows an accurate assessment of the amounts of food intake, the burden on the subjects being surveyed is also great. The recollection method involves interviewing the survey subjects and estimating the approximate amounts of food consumed during the 24 h before the interview. However, when the subject fails to recall food items that have been consumed or when the interviewer is not thorough in questioning there is a probability of omissions of food items or mistakes in the quantity of intake.[8] In this study, in order to mini-

Table 5 Hazard ratios and 95% confidence intervals of mortality by all causes for age, BMI and nutrient intake in males and females

Nutrient intake	Male		Female	
	Relative hazard	95% CI	Relative hazard	95% CI
Age (years)	1.03	0.92–1.15	1.12	0.94–1.32
BMI (kg/m^2)	1.00	0.98–1.02	0.98	0.96–1.01
Energy (kcal)	1.00	1.00–1.00	0.99	0.95–1.04
Protein (Vegetable) (g)	0.86*	0.74–1.00	1.10	0.82–1.46
Protein (Animal) (g)	1.03	0.97–1.09	0.99	0.79–1.24
Fats (Vegetable) (g)	1.04	0.97–1.11	1.07	0.69–1.64
Fats (Animal) (g)	0.95	0.88–1.03	1.22	0.77–1.93
Carbohydrate (g)	1.01	0.99–1.03	1.03	0.85–1.24

Analyzed by Cox proportional hazards model; *$P < 0.05$.

mize the risk of depending on memory, we used a dietary record based on the recollection method coupled with direct interview.[6] Furthermore, previous study has indicated that to obtain representative data of the routine dietary habit, long-term dietary survey for one week, one month, or even one year is necessary.[9] In our Institute, we had chosen to use a 3-day survey considering the feasibility of implementation in field survey. The results of nutrition survey are sent back to the subjects by mail. Therefore, we cannot exclude the possibility that intervention might have been introduced in response to the result.

Although many cross-sectional studies on the changes of dietary intake with aging have been reported, there are few reports of longitudinal studies that follow the changes with advancing age. Consequently, these changes have not been clearly elucidated. The other longitudinal study conducted in Japan, National Institute for Longevity Sciences-Longitudinal Study of Aging (NILS-LSA)[10] started its baseline survey in 1997–1999 and the research results are not yet available. Regarding studies overseas, the longitudinal study conducted in Gotheburg, Sweden[11] (1971/71–1981/82; 98 subjects, aged 70s) reported reduced energy intake and energy intake adequacy rate. The Baltimore longitudinal study[12] also observed lowered energy intake and fat energy ratio in the elderly. The 6-year follow-up study (1988/89–1995/96, 248 subjects aged over 70) conducted in New Zealand by Fernyhough *et al.*[13] and the 4-year follow-up study (1993–1997, 82 subjects) conducted in France by Nicolas *et al.*[14] both reported little changes in intake of macronutrients and micronutrients with aging. The variable results in these reports suggest that the effects of aging on nutrient intake observed in longitudinal studies are not only caused by the aging phenomenon but may also include elements of changes in socioeconomic factors with time in that particular region.[12] Therefore, these results have to be interpreted with caution.

In our 8-year longitudinal study, the elderly subjects in Koganei City took large quantities of green and yellow vegetables, fruits, fish and shellfish, fats and oils, and milk or milk products. Especially, the intake of milk or milk products by males (138 g) and females (207 g) living in Konami was considerably higher than the national average. Females consumed more milk or milk products than the daily national average for the elderly, which is approximately 200 g. Among these food groups, fruit consumption is the only item that decreased significantly with aging in both males and females. This decrease in consumption is suspected to relate the fact that shopping is harder as age advances, especially for fruits that are heavy and bulky; the trouble of peeling; and also the high price.

Regarding the aging-related changes in nutrient intake, significantly decreased intake was observed for carbohydrate and sodium in both males and females, and for energy, protein and fats in females. However, the PFC energy ratio remained unchanged. In addition, the nutrient intake was higher than the recommended dietary allowances in both males and females, showing that despite aging, these subjects had maintained an appropriate level of nutrient intake. In other words, aging-related changes were not observed in nutrient intake adjusted for body weight and physical activities. These findings imply the following: in the natural course of aging, physical activities decrease and food intake also decreases, resulting in weight loss and reduced obesity; however, by taking an adequate quality and quantity of foods during the early aging period and then maintaining this dietary habit, this practice will enrich the diet in the later aging period and is related to achievement of healthy longevity. Even viewing from the manner of food intake, the PFC energy ratio indicated that these subjects consumed a balanced diet.

When examining the relationship between mortality and dietary habit or nutrition, obviously this relation changes according to individual diseases, which pre-

sents difficulties in identifying the appropriate dietary habit or nutritional factors. Furthermore, the cause of death in the elderly usually involves a mixture of multiple diseases or lesions. Analysis based on cause of death by specific disease does not seem to be relevant. We therefore used mortality by all causes as an indicator in our analysis.

Regarding the relationship between nutrition and vital prognosis, although the contribution of nutrition to individual diseases and death has been investigated in middle- and old-age groups, it is important to examine which food or nutrient affects the total mortality in the elderly. However, there are few studies on nutrient and vital prognosis in the elderly living in the community during the process of normal aging.[15,16] We found no report that examines life expectancy using nutrient intake as a independent variable. Kumagai *et al.*[17] analyzed from the viewpoint of food pattern. They reported that vegetable protein has a negative effect on all-cause mortality, and suggested that antioxidants such as vitamin C and beta-carotene may have beneficial effects.[18]

In the present study, we examined the relationship between mortality by all causes and nutrient intake, and added in the analysis another independent variable, BMI, that has been shown from our past results of TMIG-LISA to be strongly related to total mortality.[19] The present results showed that even after controlling intake of other nutrients, vegetable protein alone showed a significant correlation with mortality. Vegetable protein is a food item that has attracted much attention recently accompanying the growing knowledge concerning their physiological activities in the human body. According to the study of Ashton *et al.*[20] soy protein contains digestive peptides that lower fat metabolism mediated by hormones, contributing to lowering of serum cholesterol and increase of HDL-cholesterol, leading to reduction of the risk of coronary heart disease. The series of studies conducted by Nagata *et al.*[21,22] suggested that the estrogen-like substance in soy products may affect the mental and psychological status of women, and consumption of soy products and isoflavones may have a protective effect against hot flush during menopause. The functional characteristics of these vegetable foods may contribute to prolong life.

The present cohort took vegetable protein mostly from tofu, natto, and beans. We observed a high frequency of finding natto or tofu as the main dish both in the 1991 and 1999 surveys, and these foods were eaten at meal once a day. Incidentally, the main dish is defined as the dish occupying the central place among the dishes other than stable food, which is made from soybean, egg, fish, or meat, and typically contains 30 g of the main ingredient equivalent to over 6 g of protein in the traditional Japanese dietary habit. From the old days in Japan, food processing and cooking using soybean have been developed actively, and soybean and soybean products are utilized as a valuable protein source to supplement rice. Apart from the functional properties, beans and bean products are cheap and do not require elaborate cooking. They are easy to use food items that can be served directly after being purchased. These are convenient foods for the elderly and are a food item that can be promoted in nutrition guidance.

This longitudinal study shows that 'dietary habit for a long and healthy life' is characterized by continuing to maintain the recommended dietary intake even as age advances, and eating favourite and familiar foods without complicated preparations. The later aging period is vulnerable to various undesirable situations such as disease, impaired chewing ability, lowered functional capacity, poverty, and stress. These situations have adverse effects on the quality and quantity of food intake and the general dietary habit, leading easily into a poor nutritional state.[23–26] Whatever happens, it is desirable to continue maintaining the recommended intake, and take early measures to 'prevent loss of appetite' and 'prevent reduced food intake'.

Although this study only examined a relatively small sample limited to elderly ambulatory subjects living in the urban community, the aging-related changes in food intake obtained in this study helps to define the desirable dietary habit for the old-age phase.

Summary

1 The weight and BMI in females decreased significantly with aging.
2 With respect to quantity of intake by food group, consumption of fruits was significantly lowered both in males and females.
3 For nutrient intake, significant decreases in protein, fats, carbohydrate, iron, and sodium were observed in females.
4 No change in PFC energy ratio was observed.
5 The nutrient intake was above the recommended dietary allowances at baseline and also eight years later.
6 A significant relationship was observed between vegetable protein intake and vital prognosis in males.

Conclusion

In the present 8-year longitudinal study, although aging-related changes in nutrient and food intake were observed, nutrient intake was higher than the recommended dietary allowances. This field survey shows clearly that 'dietary habit for a long and healthy life' is achieved by continuing to maintain the recommended dietary intake even as age advances. These results are useful for promoting policies of health maintenance in the elderly.

References

1 The Ministry of Health and Welfare. *Recommended Dietary Allowance*, 6th edn. Tokyo: Daiichi Public, 1999. (In Japanese.)
2 Shibata H, Suzuki T, Shimonaka Y. Overview of a new longitudinal interdisciplinary study on aging (TMIG-LISA, 1991–2001). *Facts, Research and Intervention in Geriatrics: Longitudinal Interdisciplinary Study on Aging.* Paris: Sendri Publishers, 1997, 7–20.
3 The Science and Technology Agency. *Standard Tables of Foods Composition in Japan*, 4th Revised Ed. Tokyo: Printing Office, Ministry of Finance, 1990. (In Japanese.)
4 The Ministry of Health and Welfare. *Recommended Dietary Allowance*, 4th edn. Tokyo: Daiichi Public, 1989. (In Japanese.)
5 Yukawa H, Suzuki T, Yoshida H, Kumagai S, Iwama N, Shibata H. Effect of psychosocial and health conditions on the energy intake adequacy of healthy elderly individuals. *The Jap J Nutrition* 2000; **59**: 117–125. (In Japanese.)
6 Nakaji S, Sugawara K, Endoh T, Hasegawa H. Comparison of measured nutrients with the values calculated by the weighing method and duplicate method. *Tohoku J Exp Med* 1996; **179**: 253–257. (In Japanese.)
7 Briefel RR. Assessment of the US in national surveys. national collaborative efforts and NHANES. *Am J Clin Nutr* 1994; **59**: 164s–167s.
8 van Staveren WA, de Groot LC, van der Wielen RP. Assessing diets of elderly people: Problems and approaches. *Am J Clin Nutr* 1994; **59**: 221s–223s.
9 Willet W. *Nutritional Epidemiology*. New York: Oxford University Press, 1990.
10 Imai T, Sakai S, Mori K, Ando F, Niino N, Shimokata H. Nutritional assessments of 3-day dietary records in National Institute for Longevity Sciences-Longitudinal Study of Aging (NILS-LSA). *J Epidemiol* 2000; **10**: S70–S76.
11 Sjogren A, Osterberg T, Steen B. Intake of energy, nutrients and food items in a ten-year cohort comparison and in a six-year longitudinal perspective: A population study of 70- and 76-year-old Swedish people. *Age and Ageing* 1994; **23**: 108–112.
12 Hallfrisch J, Muller D, Drinkwater D, Tobin J, Andres R. Continuing diet trends in men. The Baltimore Longitudinal Study Aging (1961–87). *J Gerontol* 1990; **45**: M186–M191.
13 Fernyhough LK, Horwath CC, Campbell AJ, Robertson MC, Busby WJ. Changes in dietary intake during a 6-year follow-up of an older population. *Eur J Clin Nutr* 1999; **53**: 216–225.
14 Nicolas AS, Faisant C, Nourhashemi F, Lanzmann-Petithory D, Tome D, Vellas B. The nutritional intake of a free-living healthy French population: a four-year follow-up. *J Nutr Health Aging* 2000; **4**: 77–80.
15 Fortes C, Forastiere F, Farchi S, Rapiti E, Pastori G, Perucci CA. Diet and overall survival in a cohort of very old people. *Epidemiology* 2000; **11**: 440–450.
16 Magni E, Bianchetti A, Rozzini R, Trabucchi M. Influence of nutritional intake on 6-year mortality in an Italian elderly population. *J Nutr Elder* 1994; **13**: 25–34.
17 Kumagai S, Shibata H, Watanabe S, Suzuki T, Haga H. Effect of food intake pattern on all-cause mortality in the community elderly: A 7-year longitudinal study. *J Nutr Health Aging* 1999; **3**: 29–33.
18 Block G. Vitamin C and cancer prevention: The epidemiologic evidence. *Am J Clin Nutr* 1991; **53**: 279s–282s.
19 Suzuki T. Predictors for mortality of the community elderly-longitudinal study by TMIG-LISA. *Nippon Ronen Igakkai Zasshi* 2001; **38**: 338–340. (In Japanese.)
20 Ashton EL, Dalais FS, Ball MJ. Effect of meat replacement by tofu on CHD risk factors including copper induced LDL oxidation. *J Am Coll Nutr* 2000; **19**: 761–767.
21 Nagata C, Takatsuka N, Kawakami N, Shimizu H. Soy product intake and hot flashes in Japanese women: Results from a community-based prospective study. *Am J Epidemiol* 2001; **153**: 790–793.
22 Nagata C, Shimizu H, Takami R, Hayashi M, Takeda N, Yasuda K. Serum concentration of estradiol and dehydroepiandrosterone sulfate and soy product intake in relation to psychologic well-being in peri- and postmenopausal Japanese women. *Metabolism* 2000; **49**: 1561–1564.
23 Nagai H, Shibata H, Haga H *et al.* Chewing ability in relation to physical health status. *Jpn J Geriat* 1990; **27**: 63–68 (In Japanese.)
24 Nagai H, Shibata H, Haga H *et al.* The relationship of chewing ability to nutrient and food intakes in the community elderly. *JJPH* 1991; **38**: 853–858. (In Japanese.)
25 White JV. Risk factors for poor nutritional status in older Americans. *Am Fam Physician* 1991; **44**: 2087–2097.
26 Walker D, Beauchene RE. The relationship of loneliness, social isolation, and physical health to dietary adequacy of independently living elderly. *J Am Diet Assoc* 1991; **91**: 300–304.

Geriatrics and Gerontology International 2003; **3:** *S63–S68*

ORIGINAL ARTICLE

Changes in TMIG-Index of Competence by subscale in Japanese urban and rural community older populations: Six years prospective study

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Objective: To examine the longitudinal changes in higher-level functional capacity in Japanese urban and rural community older populations.

Design: Population-based cross-sectional, and prospective cohort studies.

Setting: Koganei city in a suburb of Tokyo, and Nangai village, Akita Prefecture, Japan.

Participants: One thousand, five hundred and six older persons (793 in Koganei and 713 in Nangai) aged 65–83 years living at home.

Main outcome measures: Disability in Instrumental Self-Maintenance (IADL), Intellectual Activity or Social Role, measured by the Tokyo Metropolitan Institute of Gerontology Index of Competence.

Results: At baseline, older men and women in the rural area, Nangai, had higher prevalence of disability in Intellectual Activity compared with respective counterparts in the urban area, Koganei. By contrast, disability in Social Role was more prevalent among elderly people in Koganei than in Nangai. In both areas older men and women had lowest prevalence of disability in IADL among three subscales. The six-year longitudinal survey on older persons who had initially no disability in all three subscales demonstrated that in urban Koganei older persons were most likely to be disabled in Social Role with advancing age, followed in turn by Intellectual Activity and IADL. By contrast, elderly people in rural Nangai were most likely to be disabled in Intellectual Activity, followed by Social Role and instrumental ADL. The Cox-proportional hazard model analysis for those who had no IADL disability at baseline revealed that the baseline level of Intellectual Activity or Social Role predicted significantly future onset of IADL disability in both areas even after controlling for sex, age, and chronic medical conditions.

Accepted for publication 11 September 2003.

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Conclusions: In both urban and rural community older populations, disability in Social Role and Intellectual Activity preceded IADL disability, and predicted significantly the future onset of IADL disability.

Keywords: community dwelling elderly people, instrumental self-maintenance, intellectual activity, social role, TMIG Index of Competence.

Introduction

High functional capacity has been regarded as one of essential components for successful aging.[1] Although many recent studies have examined what factors contribute to decline in functional capacity[2–11] most of these studies, however, have focused on activities of daily living (ADL)[2,3,5,6,8,9] or instrumental activities of daily living (IADL).[4,7,10,11] These longitudinal studies have almost commonly reported that age of 75 and over, less handgrip strength, and history of hospitalization were significant predictors for IADL disability. Although we have defined essential competence for elderly people to maintain socially independent life as higher-level functional capacity[12] little is known about contributors to decline in higher-level functional capacity above IADL.[11] The reasons for it may lie in the fact that an appropriate scale had not been available so far for measuring higher-level functional capacity of elderly people.

Lawton[13] defined and systemized seven stages of competence from the lowest and most basic function to the highest. The stages were, in ascending order of complexity, arranged such as Life Maintenance, Functional Health, Perception and Cognition, Physical Self-Maintenance, Instrumental Self-Maintenance, Effectance, and Social Role. This model of competence has been widely accepted and used as a theoretical framework in the development of new scales.

According to the Lawton model, Koyano *et al.*[14–16] developed a multidimensional 13-item index of competence comprising three subscales (Instrumental Self-Maintenance, Intellectual Activity, and Social Role), the so-called the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence. This index was designed to measure higher-level competence in older community residents that could not be adequately assessed by existing scales.[14–16] There were regional differences in prevalence and risk factors of decline in this index[17] but few have not been identified as cross-cultural differences in the changing pattern of higher-level functional capacity between urban and rural areas.

In 1991, we launched a longitudinal interdisciplinary study on aging[18] in which we assessed the TMIG Index of Competence for representative samples of older community residents in two different areas (urban Koganei *vs* rural Nangai); the participants were followed-up for the subsequent 6 years. The goal of this cross-cultural comparison study was to demonstrate changing pattern of TMIG Index of Competence by subscale and examined the usefulness of two other subscales, Intellectual Activity and Social Role, for predicting future decline in IADL. This is the first article to report longitudinal changes in the higher-level functional capacity of community older residents.

Methods

Study area and subjects

We obtained the data in this study from the medical science project of the Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplinary Study on Aging (TMIG-LISA). Details of this project have been described elsewhere.[18] The study areas included Koganei City in a suburb of Tokyo as an urban area and Nangai Village in Akita Prefecture as a rural area.

Koganei City, located 25 km west of central Tokyo, has a population of about 100 000 (population density, 9000 persons/km^2). It is a typical bed-town of Tokyo; 35% of residents commute to central Tokyo. Elderly people accounted for 9.7% of total population in 1991, from where we selected 996 older persons aged 65–83 years as one-tenth random sample. Out of them, 814 persons (82%) responded to the baseline interview survey conducted at home in 1991, after signing informed consent forms, which had been approved by the ethics committee of the Institute.

Nangai Village has a population of about 5100 people (population density, 52 persons/km^2), where the main industry is agriculture. Elderly people accounted for 18.9% of total population in 1992, when 940 people aged 65 years and older were registered as residents in the village. Of these, 88 were living in institutions, bedridden at home, or long-term absent. The remaining 852 were invited to participate in the baseline survey held at community halls in 1992. After signing informed consent forms, 748 took part in the survey (88% response).

The sampling method and interview setting differed in the two study areas, leading to potential sampling bias. Thus, as the subjects of this study we selected only the baseline participants aged 65–83 years who were at least independent in transfer-

Table 1 The TMIG Index of Competence subscales questionnaires

Sub-scales	Questionnaires	
Instrumental Self-Maintenance		
1 Can you use public transportation (bus or train) by yourself?	1. Yes	0. No
2 Are you able to shop for daily necessities?	1. Yes	0. No
3 Are you able to prepare meals by yourself?	1. Yes	0. No
4 Are you able to pay bills?	1. Yes	0. No
5 Can you handle your own banking?	1. Yes	0. No
Intellectual Activity		
6 Are you able to fill out forms for your pension?	1. Yes	0. No
7 Do you read newspapers?	1. Yes	0. No
8 Do you read books or magazines?	1. Yes	0. No
9 Are you interested in news stories or programs dealing with health?	1. Yes	0. No
Social Role		
10 Do you visit the homes of friends?	1. Yes	0. No
11 Are you sometimes called on for advice?	1. Yes	0. No
12 Are you able to visit sick friends?	1. Yes	0. No
13 Do you sometimes initiate conversations with young people?	1. Yes	0. No

ring, (i.e. the very frail and homebound persons were excluded) yielding finally 793 subjects in Koganei, and 713 in Nangai.

Assessment of functional capacity

We assessed the higher-level functional capacity in older subjects using the TMIG Index of Competence.[11,14–16] This is a multidimentional 13-item index (Table 1). With the covariance structure model, the three first-order factors in the model are interpreted as Instrumental Self-Maintenance (IADL), Intellectual Activity, and Social Role, and the second factor as competence.[14] Intellectual Activity corresponds to Effectance level in Lawton's model.[13,19] Thus, we have defined IADL, Intellectual Activity, and Social Role as higher-level functional capacity.[16,19,20] The response to each item was 'yes' (able to do) or 'no' (unable), and scored 1 for 'yes' and 0 for 'no'. The total score was designed as the sum of the 13 items, such that a higher score (maximum 13 points) would indicate a higher level of competence. Three sub-levels of competence were also calculated; 0–5 scores for IADL, 0–4 scores for Intellectual Activity, and 0–4 scores for Social Role.

We used this TMIG-Index of Competence for assessing functional capacity in older participants at baseline and over the six-year follow-up period. In Koganei, well-trained personnel interviewed the subjects at home every two-years, while in Nangai the subjects were interviewed either at community halls or at home every year. Disability in total TMIG-Index of Competence, or each subscale was defined as a state reporting scores below respective full mark; < 13 points for total TMIG-Index, < 5 for IADL, and < 4 for the other two subscales. The onset of disability included institutionalization or death of persons who had shown no decline in disability at the follow-up in the past year.

Statistical analysis

Data comparisons between the urban and rural older populations at baseline were tested with χ^2 test for categorical variables and the Mann–Whitney *U*-test for age. To examine declining patterns in the respective subscale of TMIG Index of Competence, we followed-up only the subjects who had no disability at baseline in all three subscales. We made cumulated proportion curves of disability in each subscale with advancing year, on which data the General Wilcoxon-Gehan test was applied.

For evaluating predictive value of intellectual activity and Social Role at baseline for future IADL disability, we used the Cox proportional hazard model, controlling for sex, age, and chronic medical conditions for the subjects who had no IADL disability at baseline(n = 700 in urban Koganei; n = 590 in rural Nangai).

We analyzed all data with the SPSS/PC + statistical software for Windows version 10.0.

Results

Table 2 showed baseline characteristics by gender in urban Koganei and rural Nangai. No significant difference was observed in regard to distribution of age between the two areas in men and women. In both men and women, disability in total score of TMIG-Index of Competence was more prevalent in rural Nanangai than urban Koganei. Disability in Social Role was most prevalent among elderly people in urban Koganei, followed by that in intellectual activity, while in rural Nangai the

Table 2 Comparison of higher-level functional capacity at baseline between older populations in Koganei and Nangai (disability,%).

	Urban area (Koganei)				Rural area (Nangai)			
	Men		Women		Men		Women	
	n	%	n	%	n	%	n	%
Respondents to baseline survey	363	100	430	100	287	100	426	100
	(71.5 ± 5.1 years)		(72.2 ± 5.2 years)		(70.9 ± 4.7 years)		(71.5 ± 4.9 years)	
Disability in								
Total score of TMIG-Index subscales	134	36.9	195	45.3	134	46.7**	301	70.7**
Instrumental self-maintenance	40	11.0	53	12.3	29	10.1	94	22.1**
Intellectual Activity	65	17.9	105	24.4	98	34.1**	266	62.4**
Social Role	110	30.3	157	36.5*	78	27.2	129	30.3

*, **, significantly higher than that for respective counterpart at $P < 0.05$, $P < 0.01$, respectively.

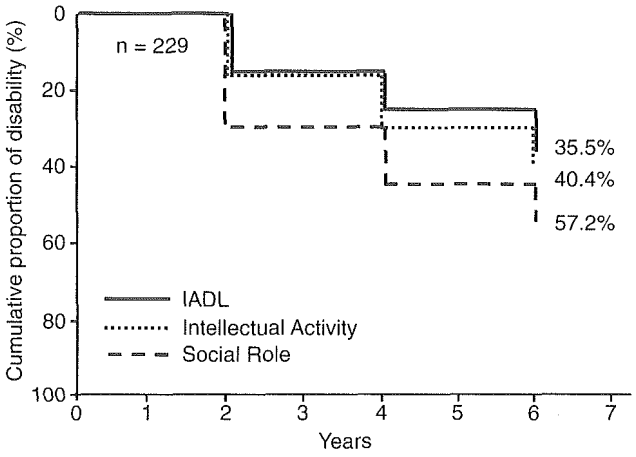

Figure 1 Declining patterns of the three subscales of TMIG-I of Competence for men in Koganei City. IADL = Instrumental Self-Maintenance. Significant differences at $P < 0.01$ between IADL and Social Role, and Intellectual Activity and Social Role by General Wilcoxon-Gehan test.

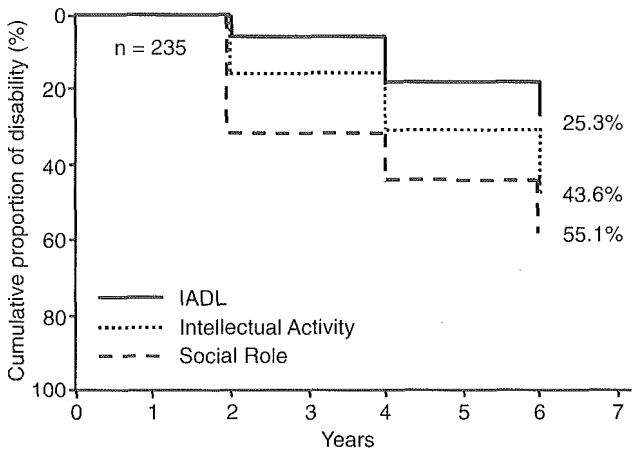

Figure 2 Declining patterns of the three subscales of TMIG-I of Competence for women in Koganei City. IADL = Instrumental Self-Maintenance. Significant differences at $P < 0.01$ between each of three subscales by General Wilcoxon-Gehan test.

most prevalent was disability in intellectual activity, followed by that in Social Role. Compared with respective counterparts, disability in Social Role was more prevalent in urban Koganei (men, 30.3 *vs* 27.2, ns; women, 36.5 *vs* 30.3%, $P < 0.05$), while disability in Intellectual Activity was significantly more prevalent in Nangai (men, 34.1 *vs* 17.9%, $P < 0.01$; women, 62.4 *vs* 24.4%, $P < 0.01$). The common finding in both areas is that older persons had the lowest prevalence of disability in IADL among three subscales.

The baseline survey identified elderly people who had no disability in all three subscales, 464 subjects (229 men and 235 women) in the urban area, and 278 subjects (153 men and 125 women) in the rural area, who comprised the cohorts for longitudinal analyses. Figures 1–4 depict how those elderly people lost functional capacity with advancing age. During the 6-year follow-up period, 25 urban subjects (16 men and 9 women) and 10 rural subjects (7 men and 3 women) died, and 12 urban subjects (4 men and 8 women) and 11 rural subjects (8 men and 3 women) were institutionalized without showing decline in TMIG-Index of Competence in the previous year; those were all defined as disability in higher-level functional capacity. Seventeen urban subjects (5 men and 12 women) and five rural subjects (4 men and 1 woman) dropped out due to long-term absence or refusal and were treated as censored cases. Although the pattern differed slightly between sexes, elderly people in the urban area showed the most likelihood to lose Social Role function, followed by Intellectual Activity (for both sexes, $P < 0.01$). On the other hand, elderly people in the rural area were most likely to lose Intellectual Activity, followed by Social Role (for men, $P < 0.05$; women, $P < 0.01$). The common finding in both areas was that IADL disability followed after Social Role and Intellectual Activity were impaired, except for men in Koganei.