In addition, our study has several strengths. First, as mentioned above, the large number of the integrated subjects included in the LOCOMO study is the biggest strength of this study. Moreover, we collected data from nine cohorts across Japan. By using the data of the LOCOMO study, we could compare the regional differences of specific clinical symptoms such as knee pain or lumbar pain, or particular diseases, such as KOA, LS, or OP, as well as its prognosis, such as the incidence of disability or mortality. In particular, we identified regional differences in the prevalences of knee pain and lumbar pain. In addition, we collected a substantial amount of information, via an interviewer-administered questionnaire, dietary assessment, anthropometric measurements, neuromuscular function assessment, biochemical measurements, medical history recording, radiographic assessment, and BMD measurement. However, all items were not recorded in all cohorts and the regional selection bias in each examination should be considered when interpreting the results.

In summary, by using the data of the LOCOMO study, we clarified the prevalence of knee pain and lumbar pain, their coexistence, and their associated factors.

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ORIGINAL ARTICLE

Effects of knee extensor muscle strength on the incidence of osteopenia and osteoporosis after 6 years

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Abstract The association of knee extensor muscle strength with bone mineral density (BMD) has been reported in cross-sectional epidemiological studies, but it remains unclear whether or not this is the case with longitudinal change. Thus, we investigated whether or not the knee extension strength can predict the incidence of osteopenia or osteoporosis after 6 years, then compared the difference between sexes. Subjects were 1255 community-dwelling Japanese men and menopaused women, aged 40–81 years. BMD of lumbar spine and femoral neck was assessed by dual-energy X-ray absorptiometry twice at 6-year intervals. Subjects were divided into three groups, normal, osteopenia, and osteoporosis, depending on their young adult mean BMD % value. In the cross-sectional analysis the correlations between the knee extension strength and BMD of the two regions were examined, using Pearson's correlation coefficient. Longitudinal analyses were then conducted to determine the odds ratio, controlled for age and BMI, given that those who were normal in the initial stage developed osteopenia or osteoporosis after 6 years, for every 1 SD decrease in knee extension strength, as well as those who first had normal or osteopenia and then developed osteoporosis. Cross-sectional analysis showed a statistically significant relation between knee extensor muscle strength and BMD at both the lumbar spine ($p = 0.02$) and the femoral neck ($p < 0.0001$) only in men. The longitudinal analysis showed the significant effect of muscle strength on the loss of femoral neck BMD from normal to osteopenia or osteoporosis both in men (OR 1.84, 95 % CI 1.36–2.48, $p < 0.0001$) and in women (OR 1.29, 95 % CI 1.002–1.65, $p < 0.05$), as well as on the loss of spinal BMD from normal or osteopenia to osteoporosis only in men (OR 2.97, 95 % CI 1.07–8.23, $p < 0.05$). The results suggest the importance of knee extension strength to maintain the bone health of the proximal femur and spine in aging particularly in men.

Keywords Longitudinal epidemiological study · Knee extensor strength · Bone mineral density · Femoral neck · Lumbar spine

Introduction

Bone mineral density (BMD) is the greatest determinant of bone strength [1], so the loss of bone mass leads to the increased risk of fracture at that site. Several factors are known to affect the BMD or future bone loss, such as body weight [2, 3], age [2], nutrition [4], smoking [5, 6], physical exercise [7–11], physical training [12] or physical activity [6, 13, 14] and body composition like muscle mass [14–20]. Muscle strength is also known to associate with BMD [2, 6, 12, 13, 18, 19, 21–29]. Their association seems to be site-specific [26, 27] as well as systemic [13]. However, not many epidemiological studies have been carried out on a large scale regarding the influence of leg

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strength on the longitudinal BMD changes; particularly those investigating the gender difference are rare. The purpose of our study is to clarify whether or not the knee extension strength can predict the incidence of osteopenia or osteoporosis after 6 years in the two regions of lumbar spine and femoral neck, and to compare the difference in sexes, utilizing a large cohort of local inhabitants.

Materials and methods

Subjects

The subjects were selected among people who participated in both the 2nd and 5th waves of the National Institute for Longevity Sciences Longitudinal Study of Aging (NILS-LSA). Details of the NILS-LSA are described elsewhere [30], but a brief description follows. This biannual examination to check the physical and mental condition so as to clarify the aging mechanism of ordinary Japanese people is conducted by the National Center for Geriatrics and Gerontology (NCGG), located in central Japan. The NILS is a research section of NCGG. The participants are chosen randomly among residents of Obu City and Higashiura-cho, in Aichi Prefecture in Japan.

For this study, data were analyzed from 763 men (57.3 ± 10.2, mean ± SD) and 476 women (62.0 ± 8.3, mean ± SD). In order to avoid the effect of menopause, we excluded the premenopausal women in the 2nd stage. Their age ranged from 40 to 81 (from 40 to 81 for men, and 41 to 80 years for women) at initial time (2nd wave). The 2nd and 5th waves were from April 2000 to May 2002, and July 2006 to July 2008, respectively, so the interval between the 2nd and 5th waves was 6 years. The number of participants who had a BMD examination in the 2nd wave were 1101 men and 732 women. So the response rates were 69.3 % (763 out of 1101) in men, and 65.0 % (476 out of 732) in women.

The reasons for non-response were various; such as moving out, health related problems, becoming the residents in the nursing homes, death, etc.

Measurements of bone mineral density

Bone mineral densities were measured using Hologic QDR4500, both at the initial time and after 6 years. Mean follow-up interval was 6.24 years ± 0.33. Data on the lumbar spine (L2–4) and the right side of the femoral neck were used for the analysis. For the state of bone density in terms of osteoporotic conditions, we adopted the classification widely used in Japan, as recommended by the Japanese Society for Bone and Mineral Research. Those who had equal or more than 80 % young adult mean (the YAM value of BMD), between 20 and 40-year-old, were classified as "normal," those who had equal or more than 70 and less than 80 % YAM as "osteopenia," and those with less than 70 % YAM as "osteoporosis." In the 2nd wave, numbers of subjects classified as normal, osteopenia and osteoporosis in lumbar spine were 633, 98, and 30, respectively, in men and 280, 134, and 78, respectively, in women, while in the 5th wave those classified as normal, osteopenia and osteoporosis in lumbar spine were 591, 121, and 51 in men, and 226, 176, and 90 in women, respectively. As for the femoral neck lesion, numbers of subjects classified as normal, osteopenia and osteoporosis in the 2nd wave were 680, 69, and 14, respectively, in men, and 352, 106, and 34, respectively, in women, while in the 5th wave those classified as normal, osteopenia and osteoporosis were 591, 121, and 51 in men, and 226, 176, and 90 in women, respectively.

Measurements of knee extension strength

Isometric knee extension strength was measured in the upright sitting position with knee and hip flexed 90°, as is often adopted in the usual epidemiological studies [31]. For more accuracy than by a handheld-dynamometer, we used a measurement device (Fig. 1) built by Takei Kiki Co., Niigata, Japan. This company has the responsibility for the verification and maintenance of this device every year. Measurements of knee extension strength were repeated three times, and the maximum values were used. Values measured for the right knee at the initial time wave were used for the analysis.

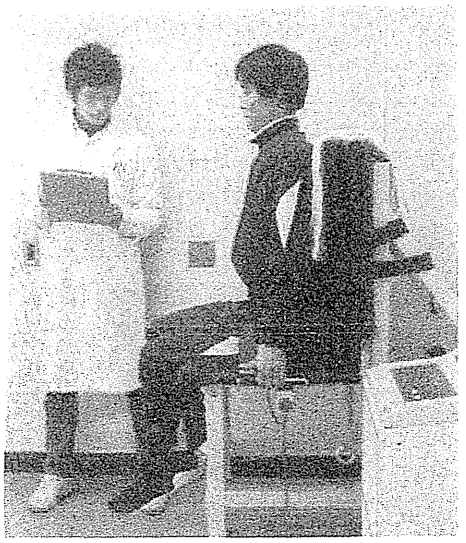

Fig. 1 Isometric knee extension strength was measured in the upright sitting position with knee and hip flexed 90°, using the fixed machine

Statistical analysis

All analyses were conducted using SAS Ver. 9.13 (SAS Institute, Cary, NC, USA). Unpaired Student *t* tests were used to compare characteristics between men and women, and also for the knee extension strength of those who had BMD examinations both at the 2nd and 5th wave and those who did so only at the 2nd. Paired *t* tests were used to compare the BMDs of the subjects at the 2nd and 5th wave.

In the cross-sectional analysis, the correlation between the knee extension strength and BMD at the lumbar spine and femoral neck were tested using Pearson's correlation coefficient controlled for age, square of age, and BMI. Men and women were calculated separately. Trend analysis was made for the change in knee extension strength, according to the age stratum, using a general linear model. As for the longitudinal analysis, multiple logistic regression analyses were conducted. We defined the statistical risk of those who had normal BMD in the initial time (greater than or equal to YMA 80 %) and would become osteopenic or osteoporotic BMD (less than 80 %) after 6 years as the "osteopenia risk." Also, we defined the statistical risk of those who had normal or osteopenic BMD (greater than or equal to YMA 70 %) in the initial time and would develop osteoporosis (BMD less than 70 %) after 6 years as the "osteoporosis risk." "Osteopenia risk and osteoporosis risk" were determined by calculating the odds ratio as a 1 SD decrease in the knee extension strength. Each analysis was conducted controlled for age and BMI.

Results

Characteristics of the subjects were shown in Table 1

Cross–sectional examination; the correlations between knee extension strength and bone mineral densities in the initial time.

Significant correlations between knee extension strength and bone mineral densities were found in men at both lumbar spine and femoral neck, and the adjusted Pearson's correlation coefficients were 0.08 and 0.16, respectively (Table 2). Correlation was rather weak at the lumbar spine. On the other hand, in women the correlation between knee extension strength and bone mineral densities was not significant either in the lumbar spine or in the femoral neck (Table 2).

Longitudinal examination; the associations between the knee extension strength in the initial time and the BMDs after 6 years.

Among 632 men in the group with normal lumbar spine in the initial time, 34 evidenced osteopenia and no men became osteoporotic in 6 years. Among 98 men of the osteopenic group in the initial time, 7 became osteoporotic in 6 years. In the meantime, 48 out of 280 women in the group with normal lumbar spine initially became osteopenic, and 4 women became osteoporotic in 6 years, while 38 out of 134 in the osteopenic group became osteoporotic. As for femoral neck BMD, among 680 men of the normal group in the initial time, 83 showed osteopenia and 7 men became osteoporotic in 6 years. Among 69 in the osteopenic group initially, 30 became osteoporotic in 6 years. In the meantime 116 out of 352 women in the normal group became osteoporotic, and 14 women became osteoporotic in 6 years, while 44 out of 106 in the osteopenic group became osteoporotic.

As for the association between the knee extension strength in the initial time and the BMD at the lumbar spine after 6 years, only the "osteoporosis risk" in men was significant (Table 3), its odds ratio being 2.97 (95 % CI

Table 1 Characteristics of subjects

	Men ($n = 763$)	Women ($n = 476$)	p
Age (years)	57.3 ± 10.2	62.0 ± 8.3	<0.0001
Height (cm)	166.0 ± 6.0	151.6 ± 5.6	<0.0001
Weight (kg)	63.6 ± 8.8	52.2 ± 7.5	<0.0001
BMI (kg/m^2)	23.1 ± 2.7	22.7 ± 3.0	0.0192
Knee extension strength	43.0 ± 10.7	25.9 ± 8.3	<0.0001
BMD at initial time			
Lumbar spine (L2–4) (g/cm^2)	0.984 ± 0.151	0.844 ± 0.143	<0.0001
Femoral neck (g/cm^2)	0.767 ± 0.108	0.667 ± 0.101	<0.0001
BMD after 6 years			
Lumbar spine (L2–4) (g/cm^2)	0.994 ± 0.170	0.817 ± 0.138	<0.0001
Femoral neck (g/cm^2)	0.726 ± 0.111	0.611 ± 0.100	<0.0001

Values are mean ± SD

* $p < 0.0001$

Table 2 Correlation analyses using Pearson's correlation coefficient of knee extensor strength and BMD

	Coefficient	(95 % CI)	p
At lumbar spine			
Men	0.081	(0.011 to 0.152)	0.024
Women	0.015	(−0.075 to 0.105)	0.739
At femoral neck			
Men	0.157	(0.087 to 0.226)	<0.0001
Women	0.022	(−0.068 to 0.112)	0.630

Correlation analyses were made between the knee extensor strength and bone mineral density using Pearson's correlation coefficient controlled for age, square of age, and BMI

Table 3 Association of knee extension strength and BMD change at the lumbar spine

	OR	(95 % CI)	p
Osteopenia risk			
Men ($n = 633$)	1.32	(0.86–2.02)	0.21
Women ($n = 265$)	0.78	(0.56–1.09)	0.143
Osteoporosis risk			
Men ($n = 731$)	2.97	(1.07–8.23)	0.036
Women ($n = 399$)	1.08	(0.74–1.55)	0.70

All analyses were conducted controlled for age and BMI

OR odds ratio as 1 strength decreases (SD)

Table 4 Association of knee extension strength and BMD change at the femoral neck

	OR	(95 % CI)	p
Osteopenia risk			
Men ($n = 681$)	1.84	(1.36–2.48)	<0.0001
Women ($n = 336$)	1.29	(1.002–1.65)	0.048
Osteoporosis risk			
Men ($n = 750$)	1.50	(0.93–2.42)	0.09
Women ($n = 442$)	1.25	(0.91–1.72)	0.18

All analyses were conducted controlled for age and BMI

OR odds ratio as 1 strength decreases (SD)

1.07–8.23). As for the BMD of the femoral neck, however, a significant effect of knee extension strength was observed in the "osteopenia risk" in both men and women. Their odds ratios were 1.84 (95 % CI 1.36–2.48), and 1.29 (95 % CI 1.002–1.65), respectively. On the other hand there was no significant difference in the "osteoporosis risk" of the femoral neck in both men and women (Table 4).

Discussion

Utilizing a large cohort of local inhabitants, we examined the effects of knee extensor muscle strength on the bone mineral densities in the longitudinal changes, as well as in the cross-sectional studies. In the cross-sectional studies, significant correlations were found in men at both lumbar spine and femoral neck, but not in women. Although we excluded pre-menopausal women in order to avoid the menopausal effect on bone mineral densities, women's bone may be more influenced by something other than the muscle force compared to men; for example, by estrogen decline [32], and also much weaker knee extensor strength in women than in men [33]. Thus, there may not be enough effect on the bone.

We have also examined the effect of knee extension strength on the longitudinal bone loss of the lumbar spine and femoral neck, checking between normal and osteopenia, as well as between osteopenia and osteoporosis. At the femoral neck, the decrease in knee extension strength had a significant effect on whether osteopenia developed or not; however, it failed to show an effect on whether or not it became osteoporosis. This was the case with both sexes. From these results, exercise for strengthening the legs seemed to be good not only for locomotive ability or prevention from falls but also for protecting against bone loss at the proximal femur in the future, particularly when bone was in healthy condition. Quadriceps femoris are the only knee extensor muscle and they originate from both above and below the hip joint. Thus, during knee extension behavior force should be applied to the proximal part of the femur, making it stronger. In the advanced stage of bone loss, however, this effect may not be strong enough.

In the meantime, as for the lumbar spine, the decrease in knee extension strength had a significant effect on whether osteoporosis developed only in men, but not in women. Since this is not site-specific, it may reflect physical activity and the systemic effect on the bone metabolism. The decline of muscle strength in men was more prominent in aging than in women [33], and might affect physical activity more.

As for the relation of muscle strength on longitudinal BMD change, Iki and colleagues [26] demonstrated a site-specific relation of the back in women; trunk muscle strength was related with BMD loss in the lumbar spine during a 4-year period. Since they did not investigate BMD in the hip lesion, they had no results about the site-specific association of muscle strength and bone loss in the lower extremities. In that study, they failed to demonstrate any relation between lumbar BMD and knee extensors, and flexors as well in women, which is consistent with our results at 6 years.

In a study over longer time intervals, Sirola et al. [28] investigated the loss of BMD in the lumbar spine and femoral neck BMD over 10 years. Although the study showed a good relation with grip strength change at both sites, the knee extensor or trunk muscles were not examined, so no mention was made in the site-specific connection.

There are some limitations in this study. First, our response rates were 69.3 % (763 out of 1101) in men, and 65.0 % (476 out of 732) in women. Thus, there may be some difference between the responder (who participated in both the 2nd and 5th wave) and non-responder (who participated only in the 2nd wave). Actually non responders were about 7-year-older than responders. Moreover, knee extension strength was also stronger in the responder, but when we controlled with sex and age, the difference was minimum (only 0.3 kg). Another limitation is that we excluded premenopausal women in order to

eliminate the effect of estrogen on bone, which made for a significant age difference between sexes. Our study focused on the relation between knee extensor muscle strength and longitudinal bone loss. However, some factors may influence BMD, like nutrition [4], physical activity [6, 13, 14] or exercise status [7–10]. These might be confounding factors, which should be the next target for investigation.

The strong point of our study is that our samples were randomly selected from people in the local community with very little bias in the selection process. NILS-LSA is one of the few major epidemiological studies for investigating the aging mechanism that is designed to select the subject in a completely random manner, so as to avoid bias when conducting epidemiologic study in many ways.

In summary, we investigated whether or not knee extension strength can predict the incidence of osteopenia or osteoporosis after 6 years, utilizing a large-scale cohort of subjects randomly selected from the local community. We showed the clear effect of muscle strength on BMD loss in the early stage in the femoral neck both in men and women, but not in the lumbar spine. The effect proved to differ by gender; it affected men in the late stage of bone loss in lumbar spine, but not in women. This suggests the importance of knee extension strength to maintain the bone health of the proximal femur and lumbar spine in aging particularly in men.

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33. MONOGRAPH The Second Wave (2000–2002) National Institute for Longevity Sciences, Longitudinal Study of Aging (NILS-LSA)

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Cereal Intake Increases and Dairy Products Decrease Risk of Cognitive Decline among Elderly Female Japanese

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Abstract

BACKGROUND: If cognitive decline can be prevented through changes in daily diet with no medical intervention, it will be highly significant for dementia prevention.

OBJECTIVES: This longitudinal study examined the associations of different food intakes on cognitive decline among Japanese subjects.

DESIGN: Prospective cohort study.

SETTING: The National Institute for Longevity Sciences - Longitudinal Study of Aging, a community-based study.

PARTICIPANTS: Participants included 298 males and 272 females aged 60 to 81 years at baseline who participated in the follow-up study (third to seventh wave) at least one time.

MEASUREMENTS: Cognitive function was assessed with the Mini-Mental State Examination (MMSE) in all study waves. Nutritional intake was assessed using a 3-day dietary record in the second wave. Cumulative data among participants with an MMSE >27 in the second wave were analyzed using a generalized estimating equation. Multivariate adjusted odds ratios (OR) and 95% confidence intervals (CI) for an MMSE score ≤27 in each study wave according to a 1 standard deviation (SD) increase of each food intake at baseline were estimated, after adjusting for age, follow-up time, MMSE score at baseline, education, body mass index, annual household income, current smoking status, energy intake, and history of diseases.

RESULTS: In men, after adjusting for age, and follow-up period, MMSE score at baseline, the adjusted OR for a decline in MMSE score was 1.20 (95% CI, 1.02-1.42; p=0.032) with a 1-SD increase in cereal intake. After adjusting for education and other confounding variables, the OR for a decrease in MMSE score did not reach statistical significance for this variable. In women, multivariate adjusted OR for MMSE decline was 1.43 (95% CI, 1.15-1.77; p=0.001) with a 1-SD increase in cereal intake and 0.80 (95% CI, 0.65-0.98; p=0.034) with a 1-SD increase in milk and dairy product intake.

CONCLUSIONS: This study indicates that a 1-SD (108 g/day) decrease in cereal intake and a 1-SD (128 g/day) increase in milk and dairy product intake may have an influence of cognitive decline in community-dwelling Japanese women aged 60 years and older. Further studies are needed in order to explore the potential causal relationship.

Key words: Cereal, milk and dairy products, diet, Japanese, elderly.

Introduction

Dementia, including Alzheimer's disease, is one of the most serious geriatric diseases because it interferes with a person's daily routines and social life. With the aging of the population, there is a growing concern that the number of dementia cases will increase in Japan (1). However, because there are no treatment strategies for dementia to date, there is a pressing need to establish prevention strategies. Many factors such as medical history, lifestyle habits, and psychological and genetic factors are thought to be associated with the onset of dementia (2). Concurrently, reports that indicate a possible link between dietary factors and cognitive function are beginning to emerge. Food consumption is vital for human life, and is an essential factor for health maintenance and health promotion throughout life. From a public health perspective, if cognitive decline can be prevented through changes in daily diet with no medical intervention, it will be highly significant for dementia prevention.

High intake of vegetables (3), fish (4), and dairy products (5) are thought to play a protective role against age-related cognitive decline or Alzheimer's disease. However, these reports were based on studies conducted in Western countries. Japanese cuisine is based on a combination of staple foods, typically rice or noodles (6), and Japanese consume higher levels of fish, salt, and soy products compared with the Western diet, which includes high intake of meat and dairy products (7). For example, the main sources of protein among Japanese subjects in the 2008 National Health and Nutrition Survey in Japan were fish (22%), meat (18%), and beans (7%) (8). Thus, it is important to determine whether there is a specific dietary factor that would help reduce the risk of cognitive decline among Japanese. Recently, dietary patterns characterized by a high intake of soybeans, vegetables, algae, and milk and dairy products and a low intake of rice were reported to be associated with reduced risk of dementia during a median of 15 years of follow-up in the general Japanese population (9). However, that

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study defined dietary patterns based on a food frequency questionnaire; thus, the effect of each dietary factor and the amounts eaten on the risk of dementia were not clear. No other longitudinal studies in Japan have reported the association between dietary factors and cognitive decline.

The present longitudinal study was carried out in elderly community-dwelling Japanese subjects to clarify the effectiveness of different food intakes calculated by dietary records on cognitive decline.

Methods

Participants

Data for this survey were collected as part of the National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA). In this project, the normal aging process has been assessed over time using detailed questionnaires and medical checkups, anthropometric measurements, physical fitness tests, and nutritional examinations. Participants in the NILS-LSA included randomly selected age- and sex-stratified individuals from the pool of non-institutionalized residents in the NILS neighborhood areas of Obu City and Higashiura Town in Aichi Prefecture. The first wave of the NILS-LSA was conducted from November 1997 to April 2000 and comprised 2,267 participants (1,139 men, 1,128 women; age range, 40-79 years). Details of the NILS-LSA study have been reported elsewhere (10). Subjects have been followed up every 2 years from the first wave, second wave (April 2000 - May 2002), third wave (May 2002 - May 2004), fourth wave (June 2004 - July 2006), fifth wave (July 2006 - July 2008), sixth wave (July 2008 - July 2010), and seventh wave (July 2010 - July 2012). When participants could not be followed up (e.g., they transferred to another area, dropped out for personal reasons, or died), new age- and sex-matched subjects were randomly recruited. All waves included nearly 1,200 men and 1,200 women. In this study, we selected participants who participated in the second wave (n=2,259; age range, 40-81 years) and also participated in more than one study wave from the third to seventh wave, as variables could be followed up at least one time from the second wave.

Exclusion criteria were as follows: 1) those who were <60 years in the second wave (n=1,114), because cognitive function tested by the Mini-Mental State Examination (MMSE) was assessed only among participants aged 60 or older; 2) those who had an MMSE score ≤27 in the second wave (n=414); 3) those who did not complete nutritional assessments in the second wave (n=40); and 4) those who did not complete the self-reported questionnaire (n=30). In addition, 91 men and women did not participate in more than one study wave from the third to seventh wave. Thus, a total of 570 Japanese (298 men, 272 women) who were between 60 and 81 years in the second wave of the NILS-LSA were available for analysis. Each wave was conducted for 2 years; the total length of the second through seventh waves was 10 years. However, the mean interval and participation times between the second and seventh wave for each participant was 8.1 years and 3.9 times, respectively (Table 1).

The study protocol was approved by the Committee of Ethics of Human Research of the National Center for Geriatrics and Gerontology. Written informed consent was obtained from all subjects.

Assessment of cognitive function

Cognitive function was assessed by the Japanese version of the MMSE through interviews with a trained psychologist or clinical psychotherapist through the second and seventh waves (11, 12). The MMSE is widely used as a brief screening test for dementia, and scores range from 0 to 30 points, with a higher score indicating better cognitive function. The MMSE includes questions on orientation of time and place, registration, attention and calculation, recall, language, and visual construction. A cut-off score of ≤23 is traditionally used to represent "suggestive cognitive impairment" (11, 12). Because only 4 to 12 individuals in each study wave had an MMSE ≤23, the number of cases was too small to analyze. However, our sample was relatively highly educated, and 58.4% of men and 39.3% of women graduated from 2- or 4-year colleges. A cut-off score ≤26 (sensitivity, 0.69; specificity, 0.91) or ≤27 (sensitivity, 0.78; specificity, 0.78) has been suggested for samples of highly educated individuals (13). Thus, we used a cut-off score of ≤27 in the main analyses. Among participants in this study with an MMSE >27 in the second wave (n=570), 134 in the third wave, 133 in the fourth wave, 137 in the fifth wave, 124 in the sixth wave, and 124 in the seventh wave had an MMSE score ≤27 and were classified as showing cognitive decline.

Nutritional assessments

Nutritional intake was assessed using a 3-day dietary record after participation in the second wave survey. The dietary record was completed over 3 continuous days (both weekdays and 1 weekend day) (14), and most subjects completed it at home and returned records within 1 month. Food was weighed separately on a scale (1-kg kitchen scales; Sekisui Jushi, Tokyo, Japan) before being cooked or portion sizes were estimated. Subjects used a disposable camera (27 shots; Fuji Film, Tokyo, Japan) to take photos of meals before and after eating. Dietitians used these photos to complete missing data and telephoned subjects to resolve any discrepancies or obtain further information when necessary. Averages for

3-day food and nutrient intakes were calculated according to the Standard Tables of Foods Composition in Japan 2010 and other sources (14).

Other measurements

Medical history of heart disease, hypertension, hyperlipidemia, and diabetes (past and current), education (≤9, 10-12, or ≥13 years of school), annual household income (11 point scale, 1; < ¥1,500,000, 11; ≥ ¥20,000,000) and smoking status (yes/no) were collected using self-reported questionnaires. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. These measurements were assessed in the second wave. Follow-up time (year) was calculated by the length of time (days) that has elapsed since the day each subjects participated in the second wave.

Statistical analysis

All statistical analyses were conducted using Statistical Analysis System (SAS) software version 9.3 (SAS Institute, Cary, NC, USA). Comparisons between baseline characteristics and food intake of subjects according to the MMSE score at the follow-up study were performed by independent t-test (continuous variables) and chi-square tests (categories), respectively.

Cumulative data were analyzed using a generalized estimating equation (GEE), which takes into account the dependency of repeated observations within participants; this is an important feature that is necessary for longitudinal analyses. An additional advantage of GEE is that participants are included regardless of missing values. Thus, participants who were lost to follow-up after early wave examination were also included in the analyses. GEE models were fitted using the GENMOD procedure of SAS. The GENMOD procedure fits generalized linear models. The correlation structure was specified to be compound symmetry.

GEE analyses were performed to estimate the odds ratio (OR) and 95% confidence interval (CI) for an MMSE score ≤27 in each study wave according to a 1-SD increase of each food intake at baseline, adjusted for the following variables. The confounding variables were 1) model 1, age (year, continuous), and follow-up time (year, continuous); 2) model 2, model 1, and MMSE score at baseline (continuous); and 3) model 3, model 2, education (≤9, 10-12, ≥13 years), BMI (kg/m^2), annual household income (11 point scale, continuous), current smoking status (yes or no), energy intake (kcal/day), and history of heart disease, hypertension, hyperlipidemia, and diabetes (yes or no). Probability levels less than 0.05 were considered significant.

Results

Number of subjects, follow-up time, and period in this study are shown in Table 1. About 31.3% of men (356/1137 cases) and 27.8% of women (296/1065 cases) had an MMSE score ≤27. Table 2 shows baseline characteristics and food intake of included subjects and excluded subjects by sex. Compared with included subjects, excluded subjects in the analyses had significantly lower MMSE scores, were less likely to be educated, and had lower body mass index in women.

Table 3 shows the longitudinal relationships between baseline food intake and OR (95% CI) for MMSE scores ≤27 10 years later. The cumulative data were analyzed with GEE. In men, after adjusting for age, follow-up period, and MMSE score at baseline, the adjusted OR for a decline in MMSE score was 1.20 (95% CI, 1.02-1.42;

Table 1. Number of subjects, follow-up time, and period in this study

	Men				Women			
			MMSE score ≤27				MMSE score ≤27	
	n	%	n	%	n	%	n	%
Second wave*	298	100.0	-	-	272	100.0	-	-
Third wave	288	96.6	77	26.7	260	95.6	57	21.9
Fourth wave	254	85.2	60	23.6	243	89.3	73	30.0
Fifth wave	225	75.5	77	34.2	219	80.5	60	27.4
Sixth wave	197	66.1	70	35.5	186	68.4	54	29.0
Seventh wave	173	58.1	72	41.6	157	57.7	52	33.1
Cumulative number	1,137	-	356	31.3	1,065	-	296	27.8
	Mean±SD				Mean±SD			
Follow-up year	8.0 ±3.0				8.2 ±2.8			
Follow-up participation times	3.8 ±0.5				3.9 ±0.4			

* Second wave is the baseline in this study. Abbreviations: MMSE=Mini-Mental State Examination

Table 2. Baseline characteristics and food intake of subjects by sex

	Men (total n=583)			Women (total n=562)		
	Subjects available for analyses	Subjects excluded From the analyses*	p value	Subjects available for analyses	Subjects excluded From the analyses	p value
Number of subjects	298	285		272	290	
Age(mean± SD, years)	67.7±5.6	71.1±5.6	0.915	68.0±5.3	71.3±5.7	0.235
MMSE score(mean± SD)	29.0±0.8	26.6±1.9	<.0001	29.1±0.8	26.7±2.2	<.0001
Body mass index (mean± SD, kg/m²)	22.9±2.7	22.7±3.0	0.085	22.7±2.9	23.3±3.6	0.0003
Alcohol (mean ± SD, ml/day)	13.9±18.2	12.3±16.8	0.201	2.3±6.1	1.8±4.1	<.0001
Household annual income score (mean ± SD, 1-11 scale)	5.7±2.6	5.4±2.7	0.721	5.0±2.8	4.8±2.8	0.889
Education (n, %)						
≤ 9 years	84 , 28.2%	127 , 44.6%	<.0001	102 , 37.5%	162 , 55.9%	<.0001
10-12 years	40 , 13.4%	48 , 16.8%		63 , 23.2%	71 , 24.5%	
≥13 years	174 , 58.4%	110 , 38.6%		107 , 39.3%	57 , 19.7%	
Smoking status (n, %)						
Current	84 , 28.2%	88 , 30.9%	0.477	14 , 5.1%	3 , 1.0%	0.005
Former/never	214 , 71.8%	197 , 69.1%		258 , 94.9%	285 , 98.3%	
Clinical history (n, %)						
Heart disease	26 , 8.7%	31 , 10.9%	0.344	24 , 8.8 %	24 , 8.3 %	0.876
Stroke	22 , 7.4%	28 , 9.8%	0.281	9 , 3.3%	7 , 2.4%	0.542
Hypertension	102 , 34.2%	112 , 39.3%	0.182	99 , 36.4%	126 , 43.4%	0.071
Hyperlipidemia	47 , 15.8%	36 , 12.6%	0.310	78 , 28.7%	85 , 29.3%	0.786
Diabetes	37 , 12.4%	44 , 15.4%	0.284	14 , 5.1%	27 ,9.3%	0.053
Energy (mean ± SD, kcal/day)	2266.4±373.5	2157.1±386.7	0.565	1849.5±326.3	1789.3±345.0	0.367
Cereals (mean ± SD, g/day)	516.8±145.6	535.4±144.7	0.928	394.4±108.4	405.2±109.6	0.861
Potatoes (mean ± SD, g/day)	51.6±42.4	45.9±37.2	0.032	47.1±37.5	46.5±36.0	0.510
Beans (mean ± SD, g/day)	78.9±54.8	70.6±54.3	0.865	70.3±46.9	66.2±48.9	0.494
Green yellow vegetables (mean ± SD, g/day)	132.2±74.4	117.8±74.0	0.925	133.8±71.7	115.4±72.3	0.890
Non-green yellow vegetables (mean ± SD, g/day)	203.5±87.8	187.6±91.8	0.456	184.9±77.6	177.2±77.2	0.931
Fruits (mean ± SD, g/day)	173.3±142.7	145.5±127.9	0.073	178.6±127.0	171.3±132.1	0.529
Fish and shellfish (mean ± SD, g/day)	113.6±55.8	106.0±49.1	0.038	87.3±44.3	82.5±40.0	0.097
Meats (mean ± SD, g/day)	60.6±35.6	52.3±34.6	0.648	47.4±28.7	46.1±29.7	0.598
Eggs (mean ± SD, g/day)	50.2±27.2	48.7±30.8	0.037	42.9±23.9	41.5±26.8	0.068
Milk and dairy products (mean ± SD, g/day)	163.3±134.0	153.6±130.4	0.661	166.3±128.1	158.5±128.5	0.964
Sweets (mean ± SD, g/day)	33.5±37.4	27.7±33.9	0.105	44.6±39.5	38.6±39.4	0.967

*Subjects excluded from the analyses included those who were older than 60 years or scored ≤27 in the second wave and those who did not participate in the follow-up survey or had any missing values. The number of excluded subjects according to the characteristics listed ranged from 249-285 in men and 253-290 in women. P value for continuous variables, independent t-test was used; for categorical variables, chi-square test or Fisher's exact probability test was used. Abbreviations: MMSE=Mini-Mental State Examination.

Table 3. Longitudinal relationships between baseline food intake and odds ratios (95% CI) for MMSE scores≤27 10 years later. Cumulative data were analyzed with generalized estimation equations

			Men (total n=1,137)			Women (total n=1,065)		
			1 SD	Odds ratio (95%CI)	p value	1 SD	Odds ratio (95%CI)	p value
Energy intake	1 SD kcal/day increase	Model 3	374	1.09 (0.90 - 1.31)	0.378	326	0.90 (0.72 - 1.12)	0.343
Cereals	1 SD g/day increase	Model 1	146	1.18 (1.00 - 1.40)	0.056	108	1.38 (1.13 - 1.68)	0.002
		Model 2		1.20 (1.02 - 1.42)	0.032		1.29 (1.05 - 1.57)	0.013
		Model 3		1.18 (0.97 - 1.43)	0.103		1.43 (1.15 - 1.77)	0.001
Potatoes	1 SD g/day increase	Model 1	42	0.97 (0.82 - 1.15)	0.747	37	1.06 (0.86 - 1.30)	0.611
		Model 2		0.95 (0.81 - 1.11)	0.528		1.09 (0.89 - 1.34)	0.389
		Model 3		0.97 (0.83 - 1.13)	0.707		1.11 (0.88 - 1.40)	0.365
Beans	1 SD g/day increase	Model 1	55	0.93 (0.78 - 1.11)	0.429	47	0.80 (0.65 - 0.98)	.0.035
		Model 2		0.93 (0.78 - 1.11)	0.417		0.82 (0.67 - 1.00)	0.053
		Model 3		0.96 (0.79 - 1.15)	0.649		0.84 (0.68 - 1.03)	0.094
Green yellow vegetables	1 SD g/day increase	Model 1	74	0.83 (0.69 - 0.99)	0.041	72	0.95 (0.76 - 1.18)	0.626
		Model 2		0.84 (0.69 - 1.03)	0.087		1.00 (0.80 - 1.25)	0.993
		Model 3		0.86 (0.71 - 1.05)	0.144		1.07 (0.84 - 1.37)	0.563
Non-green yellow vegetables	1 SD g/day increase	Model 1	88	0.92 (0.78 - 1.09)	0.347	78	0.86 (0.70 -1.06)	0.152
		Model 2		0.90 (0.77 - 1.06)	0.202		0.83 (0.67 - 1.02)	0.075
		Model 3		0.91 (0.77 - 1.07)	0.247		0.87 (0.70 - 1.08)	0.206
Fruits	1 SD g/day increase	Model 1	143	0.96 (0.82 - 1.13)	0.634	127	0.98 (0.79 - 1.22)	0.866
		Model 2		0.92 (0.79 - 1.07)	0.271		1.06 (0.85 - 1.32)	0.623
		Model 3		0.92 (0.78 - 1.07)	0.265		1.15 (0.90 - 1.46)	0.266
Fish and shellfish	1 SD g/day increase	Model 1	56	0.98 (0.82 - 1.17)	0.824	44	1.06 (0.86 - 1.30)	0.605
		Model 2		1.02 (0.86 - 1.21)	0.795		1.09 (0.89 - 1.33)	0.400
		Model 3		1.00 (0.85 - 1.19)	0.956		1.18 (0.94 - 1.47)	0.149
Meats	1 SD g/day increase	Model 1	36	0.95 (0.80 - 1.13)	0.576	29	0.88 (0.70 -1.09)	0.244
		Model 2		0.99 (0.83 - 1.18)	0.908		0.83 (0.65 - 1.04)	0.109
		Model 3		1.01 (0.84 - 1.21)	0.931		0.83 (0.66 - 1.06)	0.138
Eggs	1 SD g/day increase	Model 1	27	0.93 (0.78 - 1.10)	0.395	24	1.16 (0.93 - 1.45)	0.194
		Model 2		0.89 (0.75 - 1.04)	0.137		1.13 (0.89 - 1.42)	0.313
		Model 3		0.88 (0.75 - 1.05)	0.151		1.16 (0.93 - 1.46)	0.195
Milk and dairy products	1 SD g/day increase	Model 1	134	0.99 (0.85 - 1.17)	0.939	128	0.78 (0.65 -0.92)	0.004
		Model 2		0.95 (0.81 - 1.11)	0.516		0.77 (0.63 - 0.93)	0.007
		Model 3		0.95 (0.81 - 1.11)	0.533		0.80 (0.65 - 0.98)	0.034
Sweets	1 SD kcal/day increase	Model 1	37	0.96 (0.81 - 1.13)	0.622	39	1.00 (0.82 - 1.22)	0.982
		Model 2		0.94 (0.79 - 1.10)	0.428		0.96 (0.79 - 1.17)	0.694
		Model 3		0.93 (0.79 - 1.10)	0.412		1.01 (0.81 - 1.26)	0.934

Model 1: Adjusted for age (year) and follow-up time (year). Model 2: Adjusted for Model 1 + MMSE score at baseline. Model 3: Adjusted for Model 2 + education (≤9, 10-12, ≥13 years), body mass index (kg/m²), household annual income (1-11 score), current smoking status (yes or no), energy intake (kcal/day), and history of heart disease, hypertension, hyperlipidemia, and diabetes (yes or no).Abbreviations: MMSE=Mini-Mental State Examination.

p=0.032) with a 1-SD increase in cereal intake. After adjusting for education and other confounding variables (model 3), the OR for a decrease in MMSE score did not reach statistical significance for this variable. On the other hand, in men, after adjusting for age and follow-up period, the adjusted OR for a decline in MMSE score was 0.83 (95% CI, 0.69-0.99; p=0.041) with a 1-SD increase in green yellow vegetable intake. Though, after adjusting for education and other confounding variables (model 3), no significant association of each food intake with MMSE score decline was observed in men.

In women, multivariate adjusted OR (model 3) for a decline in MMSE score was 1.43 (95% CI, 1.15-1.77; p=0.001) with a 1-SD increase in cereal intake and 0.80 (95% CI, 0.65-0.98; p=0.034) with a 1-SD increase in milk and dairy product intake. The OR for a decrease in MMSE score in model 3 did not reach statistical significance for any other food variable.

Discussion

This study provides longitudinal evidence that increases in cereal intake and decreases in dairy products reduce the risk of cognitive decline in community-dwelling Japanese females aged 60 years and older. This association remained after controlling for baseline MMSE score and other variables. This is the first study to examine the association between food intake amounts calculated by dietary records and cognitive decline among Japanese subjects.

In Korean older adults, a "white rice only" dietary pattern was positively associated with the risk of cognitive impairment as assessed by the Korean version of the MMSE (15). In the general Japanese population, dietary patterns characterized by a low intake of rice and a high intake of soybeans, vegetables, algae, and milk and dairy products were reported to be associated with reduced risk of dementia (9). Although the previous study examined dietary patterns instead of specific food intake, these findings may support our results. On the other hand, in a US study, bread and cereal intake were inversely associated with cognitive impairment (16). No other Western studies focused on cereal intake and cognitive impairment. The biological mechanisms through which higher cereal intake exerts adverse effects on cognition may be due to their impact on metabolic abnormalities such as dyslipidemia or hyperglycemia. Song et al. reported that a high-carbohydrate diet was associated with dyslipidemia among adults from the Korea National Health and Nutrition Examination Survey (17). High-carbohydrate diets are also linked to hyperglycemia through an increase in blood glucose levels (18). Metabolic abnormalities, including type 2 diabetes, dyslipidemia, and obesity, are associated with declines in cognitive performance in non-demented populations (19). Higher cereal intake could be a risk factor for cognitive decline through its resulting metabolic abnormalities.

We conducted 3-day dietary records and were able to analyze the effect of each cereal intake (rice, bread, Chinese instant noodles, Japanese wheat noodles (Udon and Hiyamugi), Japanese buckwheat noodles (Soba), or Italian noodles, etc.) on the risk of cognitive decline in sub-analyses. In the multivariate adjusted GEE model, higher wheat noodle intake (1 SD: 46 g/day increase) increased the risk of cognitive decline in women (OR, 1.25; p=0.04). Rice intake did not significantly increase the risk of cognitive decline (OR, 1.18; p=0.14). Therefore, our study indicates that wheat noodles, but not rice intake, could be a risk factor for cognitive decline. In Japanese meals, wheat noodles are eaten less often than rice with other dishes, and this result might mean that easily cooked cereal foods could be a risk factor of cognitive decline.

Milk and dairy products contain nutrients such as calcium and vitamins A, B2, and B12, as well as high-quality proteins and fats. Milk and dairy products or calcium intake may be a protective factor for metabolic syndrome among Japanese (20, 21). As for cognitive function, according to a study based on data from the US National Health and Nutrition Examination Survey (NHANES), a significant positive correlation was found between the intake of dairy products in a group of elderly individuals (aged ≥60 years) and cognitive function (5). Another study of local elderly residents of the state of Alabama (United States) reported that, of the various dairy products, the more cheese that was eaten, the lower the risk for cognitive impairment (16). The above-mentioned Japanese study also found that elderly individuals who adhered to a dietary pattern high in dairy products, legumes, vegetables, and algae had a low incidence of developing dementia later in life (9). Milk and dairy products are thought to have favorable effects on cognition through reducing metabolic risk and vascular factors linked to detrimental brain changes, particularly via weight reduction (22). In this study, females with a 1-SD (128 g/day) increase in milk and dairy food intake decreased the risk of cognitive decline by 20%, indicating that a half cup of milk (100 ml) may be a protective factor against cognitive decline among Japanese.

Beans and non-green yellow vegetables did not reach statistical significance, though their intake in women was negatively associated with cognitive decline. Neuroprotective effects of phytoestrogen compounds (found in soy) (23) and anti-oxidant effects (2) in vegetables could also be a protective factor against cognitive decline.

To clarify whether cereal or milk and dairy products are more protective against cognitive decline we adjusted all food groups in a multivariate adjusted GEE model. As a result, only cereal intake in women was positively

associated with cognitive decline (OR, 1.63; 95% CI, 1.21-2.18; p=0.001). This result means that groups with lower intake of milk and dairy products eat more cereal; that is, the intake amount of cereal affects the intake amount of other foods. Therefore, it could be recommended to reduce cereal intake and increase intake of other foods including milk and dairy products, beans, and non-green yellow vegetables to prevent cognitive decline, especially among females with high cereal intake.

In this study, after adjusting for age and follow-up time, intake of green yellow vegetables was negatively associated with cognitive decline in men (Table 3, model 1); however, the statistically significant association disappeared after adjustment for other confounding variables. This result means the effect of confounding variables rather than each food intake on cognitive decline was strong in male subjects. Male mice were reported to be more vulnerable than female mice to the impact of a high-fat diet on metabolic alterations, deficits of learning, and hippocampal synaptic plasticity (24). The precise mechanisms for these findings are not clear, although the inclusion of male participants might be more valuable than female participants for understanding the impact of daily diet on metabolic abnormalities. The other reason for sex differences in our study is that there might be confounding variables that we did not adjust for. The risk of mild cognitive impairment varied by age and sex in the Sydney Memory and Ageing Study (25). That study also reported sex differences in terms of cognitive lifestyle in the elderly, as female participants had more active current lifestyles (26).

The other reason for the lack of statistically positive correlations among male subjects might depend on the validity of the dietary assessment. We assessed nutritional intake using 3-day dietary records with photographs. Although the 3-day dietary record is one of the best ways to assess individual food intake (14), it is difficult for men to do this. More than half of the male participants in this study asked a wife, child, or daughter-in-law to record their dietary intake. Therefore, the validity of dietary records could be lower among Japanese male subjects.

Several limitations to the present study warrant consideration. First, we assessed dietary factors from one nutritional assessment at baseline. Food intake is easily changeable and affected by various factors with aging (27, 28), though we could not consider these variations during the follow-up period. Second, we used only one MMSE cut-off score of ≤27 (sensitivity and specificity, 0.78) because it has been shown to be better for detecting cognitive dysfunction compared to the value of ≤23 (sensitivity, 0.66; specificity, 0.99) among older subjects with a college education (13). On the basis of this limitation, we used the other cut-off score of 26/27 (sensitivity, 0.69; specificity, 0.91) (13) in a sub-analysis after controlling for baseline MMSE score and other variables. Significant associations were observed between cereal or bean intake and cognitive decline in women (OR of 1 SD cereal intake: 1.46, p=0.004; OR of 1 SD beans intake: 0.79, p=0.049). Milk and dairy products had no significant association with cognitive decline in women (OR of 1 SD intake: 0.79, p=0.065).

The main strengths of the present study are as follows: 1) the longitudinal design of our analyses lends strength to our inferences; the inclusion of the same individuals who were followed over 10 years (mean: 8.1 years) provides evidence of a causal association between food intake and cognitive decline; 2) the use of an older sample of randomly selected age- and sex-stratified non-institutionalized individuals from the community; the results are therefore applicable to non-institutionalized Japanese elderly; and 3) the use of the intake amount of each food assessed by 3-day dietary records with photographs helps determine how the amount of a specific food decreases/increases the risk of cognitive decline in community-dwelling Japanese.

Conclusions

In conclusion, the findings of this study indicate a 1-SD (108 g/day) decrease in cereal intake and a 1-SD (128 g/day) increase in milk and dairy products may have an influence of cognitive decline in community-dwelling Japanese women aged 60 years and older. Further studies are needed in order to explore the potential causal relationship.

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サルコペニアの診断と評価

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はじめに

加齢にともなう筋量の減少や筋力の低下は，身体機能を低下させ，転倒・骨折や寝たきりの一因となる．また寝たきりに至らずとも，日常生活動作や生活の質を悪化させるなど，サルコペニアは健康長寿の実現に対する大きな障害となる．殊に，超高齢社会にあるわが国においてその対策は急務である．

2010年には，欧州の老年医学や栄養学などの学会を中心としたEuropean Working Group on Sarcopenia in Older People（EWGSOP）によって，サルコペニアの診断に関する初の国際的なガイドラインが発表された[1)]．このガイドラインでは，筋量，筋力，身体機能障害を用いたサルコペニアの診断法を提唱しており，その基準値などを示している（表）．しかしながら，これらを体格や生活習慣などが大きく異なる日本人に当てはめることはむずかしく，日本人を対象とした独自の診断基準が必要となる．わが国では，2012年に日本老年医学会より欧州におけるサルコペニアの基準に関するコンセンサスの監訳とそのQ&Aが発表されているが[2)]，残念ながらサルコペニアの定義や診断基準などの確立には至っていないのが現状である．

本稿では，EWGSOPの診断基準にならいサルコペニアを筋量だけでなく，筋力，身体機能からとらえることとし，これまでの知見に基づいた日本人を対象とする場合のサルコペニアの診断基準，評価方法について概説する．また，臨床や保健活動において簡便に実施可能な，サルコペニアの簡易判定法についても紹介する．

筋量の評価

筋量減少はサルコペニアにおける古典的定義であり，主に以下の4種類の測定法がある．

二重エネルギーX線吸収測定法（dual-energy X-ray absorptiometry：DXA）による測定は，短時間で簡便に実施可能であり，その確度も高いことから筋量の評価法として推奨される．一方で，少量の放射線被曝をともなうことや，高額な機器であることがデメリットとなる．筋量を指標とするサルコペニアの評価は，四肢の筋量（kg）を身長（m）の2乗で除したSMI（skeletal muscle index，kg/m^2）を用いることが一般的であり[3)]，SMIの若年成

表　日欧におけるサルコペニアの診断基準[1, 5-7, 10]

対象	測定方法	EWGSOP		日本	
		男性	女性	男性	女性
筋量	DXA	7.23~7.26 kg/m^2	5.5~5.67 kg/m^2	6.87 kg/m^2	5.46 kg/m^2
	BIA	8.87 kg/m^2	6.42 kg/m^2	7.0 kg/m^2	5.8 kg/m^2
筋力	握力	30 kg	20 kg	25~31 kg	20 kg
身体機能	普通歩行速度	0.8 m/秒		1.0 m/秒	
	SPPB（最高12点）	8点		提示なし	

EWGSOP：European Working Group on Sarcopenia in Older People.
SPPB：short physical performance battery.
筋量の基準値はいずれもクラス2サルコペニアを示す．

人平均値のマイナス1標準偏差からマイナス2標準偏差までをクラス1サルコペニア（いわゆるサルコペニア予備群）とし，マイナス2標準偏差を下回る場合をクラス2サルコペニアとする[1, 5]．日本人を対象とする筋量のカットオフ値として，クラス1サルコペニアでは男性7.77 kg/m^2，女性6.12 kg/m^2，クラス2サルコペニアでは男性6.87 kg/m^2，女性5.46 kg/m^{2}が提示されている（表）[5]．無作為抽出された一般住民を対象とするコホート研究「国立長寿医療研究センター・老化に関する長期縦断疫学研究（NILS-LSA）」のデータでは，40歳以上の男性の約25.0％が，女性では約24.2%がクラス2サルコペニアに該当した[6]．

生体インピーダンス法（bioelectrical impedance analysis：BIA）による筋量の測定は，DXAと比較して安価であることや移動可能であること，また放射線被曝がないことなどが利点としてあげられ，筋量のスクリーニングに適した評価法といえる．その反面，電気的な検査であることから体内水分量の影響を強く受け，日内変動が大きい．また測定機器によって筋量算出のアルゴリズムが異なり，測定機器間のバラツキが大きいことにも注意が必要である．BIAから推定された筋量は，DXAと同様に身長で補正したSMIを評価に用いる．日本人を対象としたカットオフ値として，クラス1サルコペニアでは男性7.9 kg/m^2，女性6.3 kg/m^2，クラス2サルコペニアでは男性7.0 kg/m^2，女性5.8 kg/m^{2}が提示されており（表）[7]，BIAの場合いずれもDXAと比較してやや高い数値となっている．BIAによる筋量サルコペニアの有病率についても報告されており，65歳以上の高齢者では男性の17.2%，女性の19.9%がクラス2サルコペニアに該当していた[7]．

MRIやCTによる筋量の推定は確度が高い．また得られた筋の断面像より，筋組織内の脂肪浸潤の程度が明らかになるなど[8]，筋の質的評価を望むこともできる．一方で機器が高額である点や，体内金属の問題，画像処理に関する技術的課題などもあり，一定規模以上の集団を対象とする保健活動などでの実地使用には限界がある．

四肢や体幹部の周径囲長などの形態から筋量を推定する方法は古くから行われている．測定は巻き尺一つで簡便に行えるが，肥満や加齢の影響も受けやすく，再現性のある測定には習熟が必要となる．

筋力の評価

下肢筋力は膝関節伸展動作を対象に，等尺

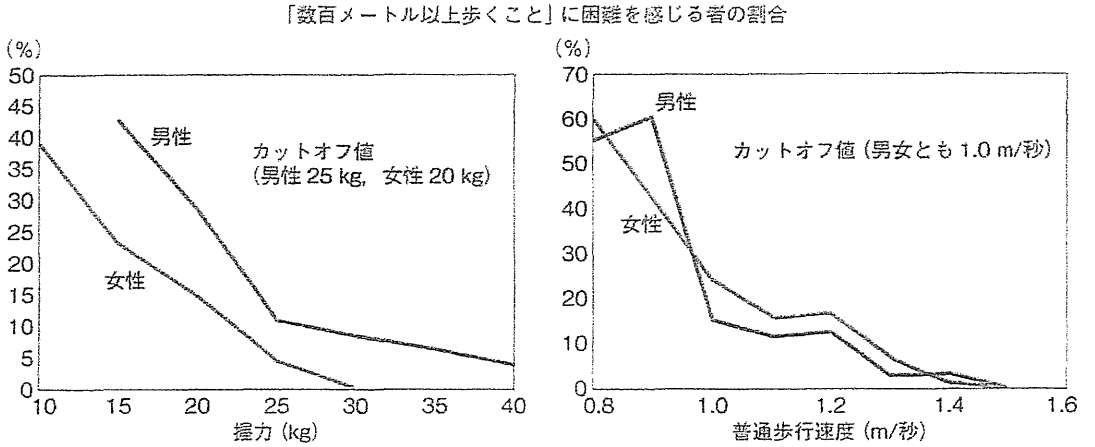

図 1　握力および普通歩行速度と「数百メートル以上歩くこと」に困難を感じる者の割合（65 歳以上）

（下方浩史，ほか．日本老年医学会雑誌 2012；49：195-8[6]より）

NILS-LSA 第 5 次調査（2006～2008 年）に参加した 65 歳以上の高齢者 944 名のデータを用いた．SF 36 の身体活動項目における「数百メートル以上歩くこと」について，「困難に感じる」または「少し困難に感じる」と回答した者を日常生活動作低下者とみなし，その割合に変化がみられる握力および普通歩行速度の値をカットオフ値としている．男性では握力が 25 kg を下回ると，「数百メートル以上歩くこと」に困難がともなうと感じる者の割合が増加した．また，女性では明確なカットオフ値は示されなかったが，先行研究や男性の結果を考慮して 20 kg に設定している．普通歩行速度では，男女ともに 1.0 m 秒がカットオフ値となった．

性収縮または等速性収縮によって評価される．下肢筋力の測定には，大型の特殊な機器を必要とするが，加齢にともなう筋力の低下は下肢において顕著であること，また下肢の筋力低下は歩行や立ち上がり動作などの身体機能の低下と強く関連することから，サルコペニアの診断において下肢筋力の評価は重要である．等尺性の膝伸展筋力と日常生活動作との関連を検討した報告では，男性では有意な関連が認められないが，女性では 27 kg を下回ると SF 36（MOS 36-item Short Form Health Survey）における身体機能得点低下のリスクが高まることが報告されている[9]．

握力は小型の検査器具で測定可能であり，文部科学省の実施する新体力テストの測定項目に含まれるなど，一般に広く知られた検査である．握力は下肢の筋力や筋量とよく関連することから，欧州におけるサルコペニア診断基準にも用いられている[1]．日本の地域在住の一般高齢者集団を対象に，移動能力制限と握力との関連を検討した報告では，男性 31.0 kg，女性 19.6 kg が移動能力制限のカットオフ値として提示されている[10]．NILS-LSA では調査に参加した 65 歳以上の男女 944 名のデータを用いて，握力と SF 36 の身体活動項目における「数百メートル以上歩くこと」に困難がともなうと感じる者の割合との関連を検討し，カットオフ値を求めている[6]．それによると，男性では握力が 25 kg を下回ると「数百メートル以上歩くこと」に困難がともなうと感じる者の割合が急激に増加することが報告されている（**図 1**）[6]．女性では明確なカットオフ値は示されなかったが，先行研究や男性の結果を考慮して[1, 10]，20 kg に設定している[6]．前者の報告では階段昇段，歩行，立ち上がり動作のうち一つでも困難を

感じる場合は，移動能力の制限ありとして評価しており，後者の報告と比較して男性でやや高い値となっている．握力を指標とする際のサルコペニアの基準として，男性では25～31 kg，女性では20 kgが妥当と思われる（表）．NILS-LSAのデータでは，男性において握力25 kgをカットオフ値とする場合，65歳以上の5.6%が該当した[6]．また女性では65歳以上の35.8%がこの基準に該当し，女性でその割合が高くなっていた[6]．

身体機能の評価

歩行速度は筋力低下の影響を強く受け，加齢にともない低下する．また，歩行速度の低下は転倒の発生と関連するなど，歩行速度の測定はサルコペニアの評価において重要である．歩行速度は，床面が水平であれば病棟の廊下などでも測定可能であり，さまざまな現場で簡便に実施できる．日本人を対象とする普通歩行速度のカットオフ値として，NILS-LSAの参加者のデータ解析では，普通歩行速度が1 m/秒を下回ると，「数百メートル以上歩くこと」に困難がともなうと感じる者の割合が男女ともに増加することが示されている（図1）[6]．1 m/秒は横断歩道の横断に必要な速度であり，日常生活によく関連したカットオフ値と思われる．NILS-LSAのデータでは，65歳以上の男性の3.0%が，女性では8.1%がこの基準に該当し，握力と同様に女性でその割合が高くなっていた[6]．

身体機能の評価法としてほかにも，立ち上がり，歩行，回転動作を含むtimed up & go（TUG）テスト，また立位バランス能力，歩行，立ち上がり動作から総合的に評価するshort physical performance battery（SPPB）などがある．TUGテストはわが国では運動器不安定症の診断基準として用いられており，11秒がカットオフ値に設定されている[11]．一方，SPPBはわが国では一般的ではなく，カットオフ値は示されていない．

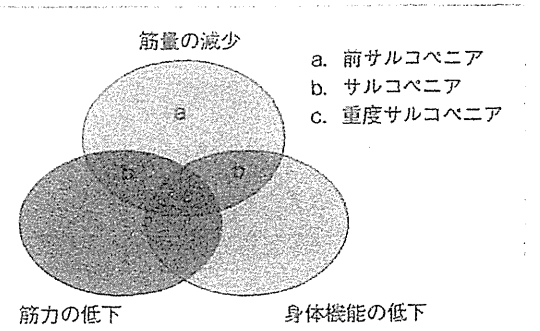

図2 EWGSOPによるサルコペニアの病期判定[1]
サルコペニアの病期判定は筋量の減少を前提とする．

サルコペニアの病期判定

EWGSOPでは，サルコペニアの病期についても提示している．それによると，筋量サルコペニアのみに該当する場合を「前サルコペニア」，筋量減少に加えて筋力低下，または身体機能低下のどちらかに該当する場合を「サルコペニア」，筋量，筋力，身体機能のすべてが減少・低下に該当する場合を「重度サルコペニア」としている（図2）[1]．いずれもサルコペニアの古典的定義である筋量減少を前提としていることが特徴である．しかしながら注意すべき点として，たとえば筋力低下のみに該当する場合，または筋量減少には該当しないが筋力低下と身体機能低下を認める場合などは，この病期分類に含まれなくなる．

サルコペニアの簡易判定法

臨床や保健活動において，安価で簡便にサルコペニアの判定が可能となる意義は大きい．