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ORIGINAL ARTICLE

Development of a simple screening test for sarcopenia in older adults

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Aim: To develop a simple screening test to identify older adults at high risk for sarcopenia.

Methods: We studied 1971 functionally independent, community-dwelling adults aged 65 years or older randomly selected from the resident register of Kashiwa city, Chiba, Japan. Data collection was carried out between September and November 2012. Sarcopenia was defined based on low muscle mass measured by bioimpedance analysis and either low muscle strength characterized by handgrip or low physical performance characterized by slow gait speed.

Results: The prevalence of sarcopenia was 14.2% in men and 22.1% in women. After the variable selection procedure, the final model to estimate the probability of sarcopenia included three variables: age, grip strength and calf circumference. The area under the receiver operating characteristic curve, a measure of discrimination, of the final model was 0.939 with 95% confidence interval (CI) of 0.918–0.958 for men, and 0.909 with 95% CI of 0.887–0.931 for women. We created a score chart for each sex based on the final model. When the sum of sensitivity and specificity was maximized, sensitivity, specificity, and positive and negative predictive values for sarcopenia were 84.9%, 88.2%, 54.4%, and 97.2% for men, 75.5%, 92.0%, 72.8%, and 93.0% for women, respectively.

Conclusions: The presence of sarcopenia could be detected using three easily obtainable variables with high accuracy. The screening test we developed could help identify functionally independent older adults with sarcopenia who are good candidates for intervention. **Geriatr Gerontol Int 2014; 14 (Suppl. 1): 93–101.**

Keywords: disability, rehabilitation, sarcopenia, screening, sensitivity and specificity.

Introduction

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal mass and strength with aging.[1] A recent realization that sarcopenia is associated with a risk of adverse events, such as physical disability, poor quality of life and death, has provided significant impetus to sarcopenia research.[1] Effective interventions have been vigorously sought and some interventions, such as resistance training in combination with nutritional supplements, appear promising.[2–4] It is also becoming apparent that interventions might be more effective early rather than late in the course when patients develop physical disability or functional dependence.[4,5] The early stage in the course of sarcopenia (i.e. without loss of physical or functional independence) might therefore represent a valuable opportunity to carry out interventions to decelerate the progress of sarcopenia and prevent physical disability.

However, patients with sarcopenia are generally unaware of their sarcopenic state until the gradual decline in muscle function becomes severe enough to be pathological, resulting in physical and functional dependence.[4,6] As patients are unlikely to seek medical

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attention for their sarcopenic state, population screening to detect sarcopenia before the occurrence of physical disability could improve the chance of intervention.

Currently, the recommended criteria for the diagnosis of sarcopenia require the documentation of low muscle mass and either low muscle strength or low physical performance.[1] Muscle mass is commonly assessed by dual energy X-ray absorptiometry (DXA) or bioimpedance analysis (BIA), muscle strength with handgrip strength, and physical performance with Short Physical Performance Battery or usual gait speed.[1,7] Unfortunately, the feasibility of applying the recommended diagnostic algorithm in the setting of population screening is limited by the need for special equipment and training. Hence, a screening test for sarcopenia simple enough to be carried out on a large scale is required.

Using baseline data from the Kashiwa study on functionally independent, community-dwelling older adults, we designed an analysis to develop a simple screening test for sarcopenia and examine its ability to estimate the probability of sarcopenia.

Methods

Participants

The Kashiwa study is a prospective cohort study designed to characterize the biological, psychosocial and functional changes associated with aging in community-dwelling older adults. In 2012, a total of 12 000 community-dwelling, functionally independent (i.e. not requiring nursing care provided by long-term care insurance) adults aged 65 years or older were randomly drawn from the resident register of Kashiwa city, a commuter town for Tokyo in Chiba prefecture, Japan, and asked by mail to participate in the study. A total of 2044 older adults (1013 men, 1031 women) agreed to participate in the study and comprised the inception cohort. The sample reflected the distribution of age in Kashiwa city for each sex.

Baseline examinations were carried out between September and November 2012 at welfare centers and community centers close to the participants' residential area, to obviate their need to drive. A team consisting of physicians, nurses, physical therapists, dentists and nutritionists carried out data collection. To standardize data collection protocol, they were given the data collection manual, attended two sessions for training in the data collection methods and carried out a rehearsal of data collection. A total of 73 participants who did not undergo BIA, usual gait speed or handgrip strength measurements were excluded, leaving an analytic sample of 1971 older adults (977 men, 994 women).

The study was approved by the ethics committee of the Graduate School of Medicine, The University of Tokyo. All participants provided written informed consent.

Sarcopenia classification and measurement of each component of sarcopenia

We followed the recommendation of the European Working Group on Sarcopenia in Older People (EWGSOP) for the definition of sarcopenia.[1] The proposed diagnostic criteria required the presence of low muscle mass plus the presence of either low muscle strength or low physical performance.

Muscle mass measurement

Muscle mass was measured by BIA using an Inbody 430 machine (Biospace, Seoul, Korea).[8] Appendicular skeletal muscle mass (ASM) was derived as the sum of the muscle mass of the four limbs. ASM was then normalized by height in meters squared to yield skeletal muscle mass index (SMI) (kg/m^2).[1] SMI values lower than two standard deviations below the mean values of young male and female reference groups were classified as low muscle mass (SMI <7.0 kg/m^2 in men, <5.8 kg/m^2 in women).[9]

Muscle strength measurement

Muscle strength was assessed by handgrip strength, which was measured using a digital grip strength dynamometer (Takei Scientific Instruments, Niigata, Japan). The measurement was carried out twice using their dominant hand, and the higher of two trials (in kilograms) was used for the present analysis. Handgrip strength values in the lowest quintile were classified as low muscle strength (cut-off values: 30 kg for men, 20 kg for women).

Physical performance measurement

Physical performance was assessed by usual gait speed. Participants were instructed to walk over an 11-m straight course at their usual speed. Usual gait speed was derived from 5 m divided by the time in seconds spent in the middle 5 m (from the 3-m line to the 8-m line). Good reproducibility of this measurement was reported previously.[10] Usual gait speed values in the lowest quintile were classified as low physical performance (cut-off values: 1.26 m/s for each sex).

Other measurements

Demographic information and medical history of doctor-diagnosed chronic conditions were obtained

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using a standardized questionnaire. Physical activity was assessed using Global Physical Activity Questionnaire and Metabolic Equivalent minutes per week was computed.[11] Serum albumin was measured at the time of the visit. Anthropometric measurements were obtained with the participants wearing light clothing and no shoes. Height and weight were measured with a fixed stadiometer, and a digital scale and used to compute body mass index (BMI). Upper arm, thigh and calf circumferences were measured to the nearest 0.1 cm directly over the skin using a measuring tape with the participant sitting. Upper arm circumference was measured at the mid-point between the olecranon process and the acromion of the non-dominant arm with the participant's arm bent 90° at the elbow. Calf circumference measurement was made at the maximum circumference of the lower non-dominant leg with the participant's leg bent 90° degrees at the knee. Thigh circumference was measured 15 cm above the upper margin of the patella of the dominant leg.

Statistical analysis

All analyses were stratified by sex. Differences in participant characteristics between those with and without sarcopenia were examined using Student's *t*-test or Wilcoxon rank–sum test. To develop a statistical model to estimate the probability of sarcopenia, candidate variables were selected by experts based on cost, ease of measurement and availability of equipment to measure them. The candidate variables included age, sex, BMI, grip strength, and thigh, calf and upper arm circumferences. Pearson's correlation between each component of sarcopenia and the candidate variables was first computed. We then examined the functional form of the relationships between the variables, and the logit of sarcopenia probability using restricted cubic spline plots and the Wald test for linearity.[12] We considered dichotomization, square and logarithmic transformations if the Wald test for linearity was statistically significant, rejecting the assumption of linearity.[12] A multivariate logistic regression model including all the candidate variables ("full model") was constructed. Variable selection with Bayesian Information Criteria was carried out to make the model parsimonious, and a multivariate logistic regression model including the variables selected ("restricted model") was made.[13] A bootstrapping procedure was used to obtain estimates of internal validity of the model[14] and to derive the final models by correcting the regression coefficients for overoptimism.[15] The final model was presented as a score chart to facilitate clinical application.[15] The score chart was created based on rounded values of the shrunken regression coefficients.

The ability of each model to correctly rank order participants by sarcopenia probability (discrimination ability) was assessed by the area under the receiver operator characteristic (ROC) curve.[16,17] The model fit was verified using the Hosmer–Lemeshow goodness-of-fit test.[18]

There were no missing values of any variable in the entire analytic sample.

All analyses were carried out using SAS version 9.3 (SAS Institute, Cary, NC, USA) and R statistical software version 2.15.2 (R Foundation, Vienna, Austria). Two-sided $P < 0.05$ was considered statistically significant.

Results

There were 32.2% of men and 48.9% of women classified as having low muscle mass, and 14.2% of men and 22.1% of women were classified as having sarcopenia. The participant characteristics by the sarcopenia status in each sex are shown in Table 1. Those with sarcopenia were older and had smaller body size compared with those without sarcopenia in each sex (all $P < 0.001$). Those with sarcopenia were physically less active in each sex. Chronic medical conditions were in general more prevalent in those with sarcopenia, and a statistically significant difference was observed for hypertension in women, stroke in men and osteoporosis in both sexes. Serum albumin was significantly lower in those with sarcopenia in each sex.

Table 2 shows the correlation between each component of sarcopenia and the candidate variables. SMI was correlated with all the variables, with the highest correlation coefficient observed with calf circumference in each sex. Usual gait speed was most highly correlated with age, followed by grip strength and calf circumference in the order of the magnitude of correlation, and this finding was consistent in both sexes.

Visual inspection of the restricted cubic spline plots and the Wald test for linearity suggested that the variables were linearly associated with the logit of sarcopenia probability, except for grip strength in both sexes and upper arm circumference in women (data not shown). However, neither dichotomization nor transformation improved the model fit, and we decided to use linear terms of these variables in the development of statistical models.

Table 3 shows the unadjusted and adjusted associations between sarcopenia and the variables. In bivariate analysis, all the variables were significantly associated with sarcopenia. In multiple logistic regression with all the variables (full model), age was positively, and grip strength and calf circumference were inversely associated with sarcopenia, whereas BMI, thigh circumference and upper arm circumference were not significantly associated. Variable selection resulted in the selection of age, grip strength and calf circumference, and the three selected variables were significantly associated with

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Table 1 Characteristics of study participants

	Men Sarcopenia (n = 139)	No sarcopenia (n = 838)	P	Women Sarcopenia (n = 220)	No sarcopenia (n = 774)	P
Age (years)	78.4 ± 5.5	72.2 ± 5.0	<0.001	76.2 ± 5.8	71.8 ± 4.9	<0.001
Height (cm)	160.0 ± 5.6	164.9 ± 5.5	<0.001	148.2 ± 5.6	152.3 ± 5.1	<0.001
Weight (kg)	54.1 ± 7.2	64.3 ± 8.0	<0.001	46.4 ± 5.7	52.9 ± 7.6	<0.001
BMI (kg/m^2)	21.1 ± 2.5	23.6 ± 2.6	<0.001	21.1 ± 2.6	22.8 ± 3.2	<0.001
Grip strength (kg)	27.5 ± 4.3	36.0 ± 5.3	<0.001	18.4 ± 3.2	23.6 ± 3.3	<0.001
Thigh circumference (cm)	38.8 ± 3.5	42.4 ± 3.3	<0.001	38.9 ± 3.4	41.7 ± 4.0	<0.001
Calf circumference (cm)	32.8 ± 2.3	36.3 ± 2.5	<0.001	32.1 ± 2.1	34.5 ± 2.7	<0.001
Upper arm circumference (cm)	25.7 ± 2.5	28.4 ± 2.4	<0.001	25.7 ± 2.3	27.3 ± 2.9	<0.001
SMI (kg/m^2)	6.34 ± 0.48	7.44 ± 0.58	<0.001	5.25 ± 0.41	6.02 ± 0.60	<0.001
Usual gait speed (m/s)	1.28 ± 0.24	1.51 ± 0.24	<0.001	1.26 ± 0.26	1.51 ± 0.23	<0.001
Physical activity (MET-minutes/week)	1813 (720, 3504)	2540 (1200, 4746)	0.008	1341 (33, 3209)	2587 (1092, 4824)	<0.001
Chronic conditions (%)						
Hypertension	51.1	46.5	0.32	45.9	38.1	0.04
Diabetes mellitus	18.0	14.9	0.36	8.2	8.9	0.73
Stroke	12.2	6.4	0.01	5.9	4.4	0.35
Osteoporosis	4.3	1.4	0.02	32.7	16.6	<0.001
Use of medications (%)						
Statins	18.7	17.4	0.71	29.1	30.6	0.66
Antihypertensives	53.2	45.1	0.08	42.7	36.2	0.08
Albumin (g/dL)	4.37 ± 0.26	4.43 ± 0.23	0.005	4.39 0.23	4.43 ± 0.22	0.04

Values are shown as mean ± standard deviation except for physical activity which was not normally distributed and therefore the mean value and inter-quartile range were shown. BMI, body mass index; MET, Metabolic Equivalent; SMI, skeletal muscle mass index.

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Table 2 Pearson correlations between components of sarcopenia and six candidate variables

	Age	BMI	Grip strength	Thigh circumference	Calf circumference	Upper arm circumference
Men						
SMI	−0.33***	0.70***	0.49***	0.70***	0.78***	0.69***
Grip strength	−0.46***	0.21***	1	0.27***	0.35***	0.35***
Usual gait speed	−0.35***	0.007	0.29***	0.06	0.13***	0.10**
Women						
SMI	−0.24***	0.69***	0.50***	0.67***	0.75***	0.65***
Grip strength	−0.36***	0.16***	1	0.22***	0.33***	0.21***
Usual gait speed	−0.42***	−0.08**	0.36***	0.01	0.12***	−0.02

*, **, ***Significance at 0.1%, 1%, 5% level, respectively. BMI, body mass index; SMI, skeletal muscle mass index.

sarcopenia in multiple logistic regression (restricted model). These findings were consistent in both sexes. The area under the ROC curve of the full model was 0.940 (95% confidence interval [CI] 0.920–0.959) for men and 0.910 (95% CI 0.888–0.932) for women, showing excellent discriminative ability. The area under the ROC curve of the restricted model (0.939 with 95% CI 0.918–0.958 for men and 0.909 with 95% CI 0.887–0.931 for women) was not significantly different from that of the full model in both sexes ($P = 0.71$ for men, 0.43 for women). Assessment of internal validity showed that discriminative ability of the restricted model is expected to be good in similar populations (area 0.937 for men, 0.907 for women).

The final model was presented as a score chart in each sex (Table 4). The use of the score chart with two hypothetical patients is shown in Table S1. The discriminative ability of the score chart was comparable with those of the full and restricted models in each sex (area 0.935 for men, 0.908 for women; Fig. S1).

Figure 1 shows the estimated probabilities corresponding to the sum scores as calculated with the score chart in Table 4, and the sensitivity and specificity using the sum scores as cut-off values. The sum score that maximized the sum of sensitivity and specificity was 105 for men and 120 for women. The corresponding sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios were 84.9%, 88.2%, 54.4% and 97.2%, and 7.19 and 0.17 for men, and 75.5%, 92.0%, 72.8% and 93.0%, and 9.44 and 0.27 for women, respectively.

Sensitivity analysis

Because there are no established reference cut-off values for grip strength and usual gait speed in Japanese older adults, we used the lowest quintiles of the observed distributions to classify low muscle strength and low physical performance. As sensitivity analysis, we used the lowest deciles of grip strength and usual gait speed to capture participants with more severely impaired muscle function (i.e. strength or performance), and defined them as having sarcopenia, with the same cut-off values for muscle mass as in the main analysis. We then examined the model performance with all six variables and with the same set of three variables as selected in the main analysis (age, grip strength and calf circumference). The cut-off value of grip strength was 27 kg for men and 17 kg for women, and that of usual gait speed was 1.16 m/s for men and 1.13 m/s for women. The prevalence of sarcopenia was 9.6% in men and 12.7% in women. Both models performed well (area of the full model: 0.932 for men, 0.919 for women; area for the restricted model; 0.931 for men, 0.918 for women; Figure S2).

Discussion

To estimate the probability of sarcopenia in functionally independent, community-dwelling Japanese older adults, we created multivariate models based on the three selected variables (age, grip strength and calf circumferences), and found excellent discrimination ability of the models: the area under the curve was 0.939 for men and 0.909 for women. We constructed a score chart in each sex so that the approximate probability of sarcopenia could be easily obtained from the values of the three variables, and confirmed that the score charts also had excellent discrimination.

Although our multivariate models had excellent discrimination capacity, the model's sensitivity and specificity at candidate diagnostic thresholds must be assessed to judge the model's clinical usefulness.[18] Higher sensitivity can be achieved at the expense of lower specificity and vice versa. For example, if higher sensitivity was desired; for example, 90%, then the cut-off score would be 101 for men and 104 for women, and the specificity would be lower at 82.2% for men and 70.4% for women. Higher specificity, 90%, could be achieved with the higher cut-off score of 107 for men

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Table 3 Unadjusted and adjusted associations between sarcopenia and the variables

Variables	Men Bivariate OR (95% CI)	P	Men Multivariate (full model) OR (95% CI)	P	Men Multivariate (restricted model) OR (95% CI)	P	Women Bivariate OR (95% CI)	P	Women Multivariate (full model) OR (95% CI)	P	Women Multivariate (restricted model) OR (95% CI)	P
Age	1.21 (1.17–1.26)	<0.001	1.07 (1.02, 1.12)	0.008	1.07 (1.02, 1.12)	0.008	1.16 (1.13, 1.20)	<0.001	1.10 (1.05, 1.14)	<0.001	1.09 (1.04, 1.13)	<0.001
BMI	0.68 (0.63–0.74)	<0.001	0.96 (0.78, 1.18)	0.69			0.82 (0.78, 0.87)	<0.001	0.86 (0.74, 1.00)	0.05		
Grip strength	0.71 (0.67, 0.75)	<0.001	0.73 (0.68, 0.78)	<0.001	0.73 (0.68, 0.79)	<.001	0.57 (0.53, 0.62)	<0.001	0.58 (0.53, 0.64)	<0.001	0.59 (0.55, 0.65)	<0.001
Thigh circumference	0.73 (0.69, 0.78)	<0.001	1.05 (0.91, 1.21)	0.53			0.82 (0.78, 0.86)	<0.001	0.94 (0.85, 1.04)	0.24		
Calf circumference	0.57 (0.52, 0.63)	<0.001	0.62 (0.53, 0.73)	<0.001	0.62 (0.56, 0.69)	<.001	0.68 (0.64, 0.74)	<0.001	0.80 (0.69, 0.91)	<0.001	0.71 (0.65, 0.78)	<0.001
Upper arm circumference	0.63 (0.57, 0.68)	<0.001	0.97 (0.82, 1.15)	0.71			0.80 (0.75, 0.85)	<0.001	1.15 (0.98, 1.35)	0.10		

BMI, body mass index; CI, confidence interval; OR, odds ratio.

and 118 for women, resulting in lower sensitivity of 77.7% for men and 76.8% for women (Fig. 1). The trade-off between sensitivity and specificity depends on the cost of incorrect classification of those with sarcopenia relative to the cost of incorrect classification of those without sarcopenia. The cost of incorrect answers would vary according to the clinical or research scenario and personal preferences.[16,17]

Several observations suggested that the selection of three variables (age, grip strength and calf circumference) was not based on chance. First, sarcopenia was classified based on muscle mass, muscle strength and physical performance, all of which were significantly correlated with the three variables. Calf circumference was used to represent muscle mass, considering the highest correlation between SMI and calf circumference among the variables considered. A strong correlation between calf circumference and muscle mass was previously shown in Caucasian older women who were on average more obese than women in the present.[19] Grip strength was used as an indicator of muscle strength. Usual gait speed, a measure of physical performance, was significantly correlated with each of the three variables. Second, sarcopenia was associated with each of the three variables in both bivariate and multivariate analyses in each sex, and *P*-values for these findings were comfortably below 0.01. Third, the models with the three variables had excellent discrimination for sarcopenia based on more stringent cut-off levels for grip strength and usual gait speed.

There have been several prior attempts at estimating the quantity of muscle mass using a variety of variables with varying degrees of accuracy.[20–23] Although these studies were inspired by the desire to facilitate the diagnosis of sarcopenia, recently developed definitions of sarcopenia entail the presence of low muscle function, as well as muscle mass.[1,24] The present study developed statistical models with high accuracy for sarcopenia, which was defined based on muscle mass and muscle function.

This study had several limitations. First, the measurement method of usual gait speed was different from those used by the majority of previous studies.[25] The measurement method used in the present study required the participant to walk 3 m before the measurement started. An attribute of this method is that it is less affected by the gait initiation phase where age-related changes independent of gait speed occur.[26,27] This method has been widely used in Japan,[9,28] and has been shown to be reliable,[10] but because it starts measuring after the gait initiation phase, it tends to yield higher values than those obtained with other measurement methods, such as usual gait speed over a 4- or 6-m course,[25] making direct comparison difficult. Second, the current analysis was carried out on data from Japanese older adults, and our findings therefore might not

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Table 4 Score charts for estimated probability of sarcopenia

Variables	Value													
Men														
Age			<66	66	68	70	72	74	76	78	80	82	84	86≦
Score			0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11
Grip strength		<20	20	23	26	29	32	35	38	41	44	47	50≦	
Score		+99	+90	+81	+72	+63	+54	+45	+36	+27	+18	+9	0	
Calf circumference	<26	26	28	30	32	34	36	38	40	42≦				
Score	+81	+72	+63	+54	+45	+36	+27	+18	+9	0				
Estimated individual probability of sarcopenia														
Sum score	70	80	90	95	100	105	110	115	120	125	130	135	140	145
Probability (%)	1	2	5	8	13	19	28	39	51	64	74	83	89	93
Women														
Age			<66	66	68	70	72	74	76	78	80	82	84	86≦
Score			0	+2	+4	+6	+8	+10	+12	+14	+16	+18	+20	+22
Grip strength		<14	14	16	18	20	22	24	26	28	30	32	34≦	
Score		+110	+100	+90	+80	+70	+60	+50	+40	+30	+20	+10	0	
Calf leg circumference			<26	26	28	30	32	34	36	38	40	42≦		
Score			+63	+56	+49	+42	+35	+28	+21	+14	+7	0		
Estimated individual probability of sarcopenia														
Sum score	80	90	95	100	105	110	115	120	125	130	135	140	145	150
Probability (%)	1	3	5	8	12	19	28	39	51	63	74	82	88	93

Values for each variable are given with such intervals that the scores show small steps, and scores for intermediate values can be estimated by linear interpolation. The exact formula to calculate the scores are as follows: score in men, 0.62 × (age – 64) – 3.09 × (grip strength – 50) – 4.64 × (calf circumference – 42); score in women, 0.80 × (age – 64) – 5.09 × (grip strength – 34) – 3.28 × (calf circumference – 42). The corresponding probabilities of sarcopenia are calculated with the following formulae: probability in men, $1 / [1 + e^{-(\text{sum score} / 10-11.9)}]$; probability in women, $1 / [1 + e^{-(\text{sum score} / 10-12.5)}]$.

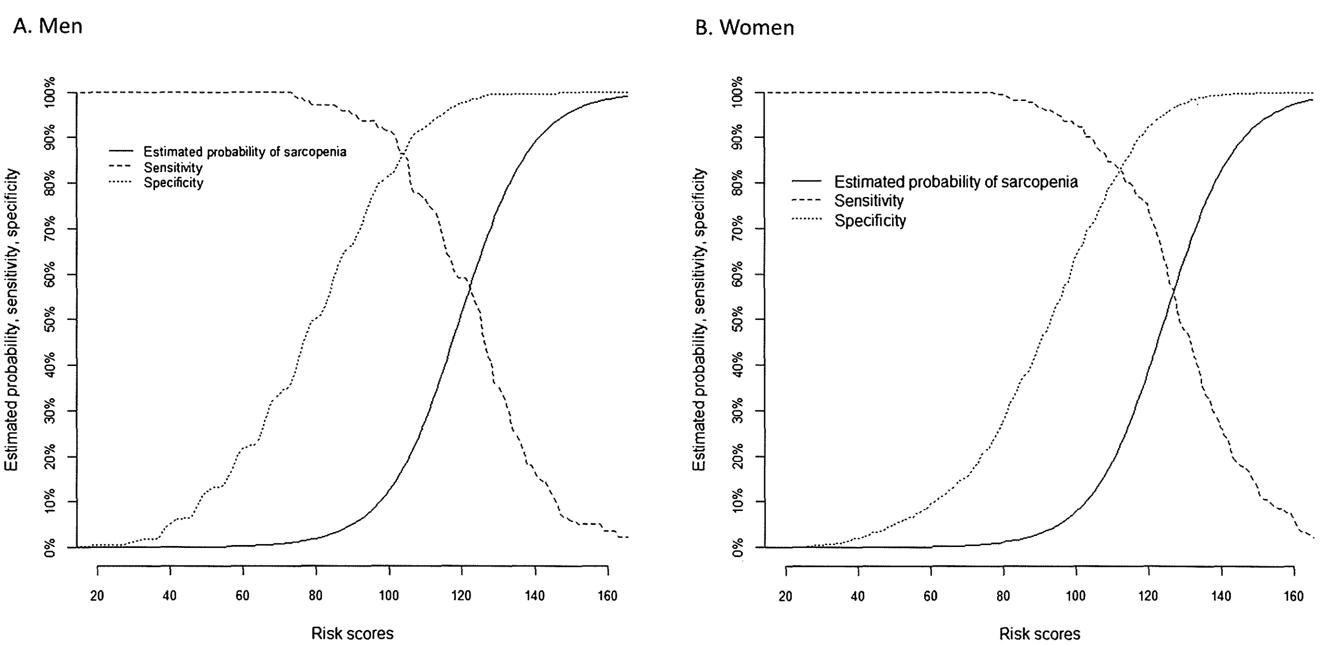

Figure 1 Estimated probabilities, sensitivity and specificity corresponding to sum scores. The sum scores and corresponding estimated probabilities are read from Table 3.

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be applicable to populations of other race/ethnicity or in other countries. Similarly, caution should be exercised in projecting beyond the range of our data. For example, the obese were underrepresented in our data, and the performance of our models was not assessed for the obese. However, the present findings suggest that three variables, namely age, grip strength and calf circumference, should be considered for inclusion in the development of sarcopenia screening in other populations. Third, although the internal validity was good (i.e. the models would perform well in a similar population), assessment of external validity is still warranted to determine whether the results can be extended to other Japanese populations. Finally, we could not exclude the possibility of the healthy volunteer effect (i.e. volunteers for clinical studies tend to be healthier than the general population). Although participants were randomly selected from the resident register, participation was voluntary and the response rate was approximately 17%. However, the sensitivity analysis showed that the models' ability to estimate the probability of sarcopenia remained excellent when participants with more severely impaired muscle function were categorized as having sarcopenia.

In conclusion, we showed that the presence of sarcopenia in older adults could be detected with high accuracy using three easily obtainable variables. Importantly, we derived the models from a functionally independent, community-dwelling population. Functionally independent older adults with sarcopenia are good candidates for interventions to prevent further physical limitations, given their potential for regaining muscle mass and restoration of muscle function. The score charts we developed can be used as an effective screening tool and help identify functionally independent older adults with sarcopenia.

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Disclosure statement

The authors declare no conflict of interest.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1 Receiver operating characteristic curves of models estimating the probability of sarcopenia.
Figure S2 Receiver operating characteristic curves of models estimating the probability of sarcopenia based on different cut-off values for grip strength and usual gait speed.
Table S1 Application of Score Chart in two hypothetical patients.

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地域在住高齢者における社会性と緑黄色野菜摂取量の関連 －千葉県柏市における大規模健康調査（柏スタディー）から－

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要 約

【緒言】千葉県柏市在住の地域在住高齢者において，社会性（孤食，居住形態，人とのつながり）と緑黄色野菜摂取量との関連を明らかにすることを目的とした．

【方法】平成25年度に千葉県柏市で実施された大規模健康調査（柏スタディー）において，無作為抽出され参加した65歳以上の自立もしくは要支援認定の高齢者1,400名（平均年齢73.7±5.4歳，男性724名，女性676名）を対象とした．緑黄色野菜摂取量の評価には，食品摂取頻度調査（Food Frequency Questionnaire Based on Food Groups）を用いた．摂取量は男女別に4分位に分け，下位4分位を「低摂取群」，残りの集団を「高摂取群」とした．社会性の評価には，家族および友人とのつながり（Lubben Social Network Score）や，独居・孤食状態｛同居者の有無で評価した居住環境と，「1日に1回以上は誰かと一緒に食事をしていますか」という質問で評価した食事環境（孤食もしくは共食）を掛け合わせて作成した4群｝を用いた．基本属性としては，年齢，性別，うつ傾向の有無｛Geriatric Depression Scale（GDS）簡易版≧6点｝，認知機能（Mini-Mental State Examination）を評価した．統計解析では，緑黄色野菜「低摂取群」に対する二項ロジスティック回帰分析を実施した．

【成績】349名（24.9%）が「低摂取群」と評価された．二項ロジスティック回帰分析の結果，同居かつ孤食（OR=1.95，95%CI：1.2-3.1），家族とのつながり（OR＝0.953，95%CI：0.92-0.99），年齢（OR＝0.970，95%CI：0.95-0.99），うつ傾向（OR＝1.49，95%CI：1.1-2.0），認知機能（OR=0.922，95%CI：0.86-0.99）が「低摂取群」と有意な関連がみられた．

【結論】本研究では，地域在住高齢者において，「家族とのつながりの希薄化」，「同居者がいるにも関らず孤食」といった日常生活における社会性の乏しさが，緑黄色野菜摂取量の低さと関連することが同定された．未病対策として，緑黄色野菜の摂取量の改善を通して良好な栄養状態を維持していくにあたり，社会的孤立，特に食事における孤立や家族との関係性に着目する必要性が示唆された．

Key words　社会性，緑黄色野菜，孤食，地域在住高齢者

1 緒 言

人間の身体は摂取した食事から構成されるものであり，バランスのとれた食事摂取は心身健康を保つために重要な役割を担っている．未曽有の高齢化社会を迎え地域高齢者のフレイル（虚弱）化予防の重要性が叫ばれる昨今，バランスのとれた食事からの栄養摂取はフレイルに影響する重要な因子であり，ある意味原点でもある．しかし，高齢期の食習慣は崩れ易く，かつ軽視される傾向にあり，改めて有効的な介入指導方法の探索が求められる．

なかでも充分な緑黄色野菜は抗酸化作用をもつカロテノイドやクロロフィルを始め鉄分やカルシウムも含み，良好な心身機能の維持に重要である[1,2]．緑黄色野菜を含む食事摂取が偏ると栄養状態の悪化を招き，ひいてはサルコペニアを始めとする身体機能低下につながるリスクがある[3,4]．

日本の緑黄色野菜の推奨量は120g/日である．平成24年度国民健康・栄養調査（厚生労働省）の報告では，緑黄色野菜の平均摂取量は60歳代において101±82g/日，70歳以上で105±84g/日とされ，推奨量から20.0g/日ほど下回る計算だが，実質的にはこの程度ではない．緑黄色野菜摂取量の中央値は60歳代で81.9g/日，70歳以上で84.4g/日であり，少なくとも日本高齢者の半数は推奨量から

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40.0g/日程度下回っているのが現状である．更に，標準偏差が平均値と同程度に大きな値であることから，日常的に多量摂取している集団がいる一方で殆ど摂取していない集団も多く存在するなど，緑黄色野菜摂取量における個人格差が大きいことが危惧される．従って，高齢期の緑黄色野菜必要摂取量の確保は極めて重大な問題であり，有効的な介入方法の開発を目的とした摂取量の関連因子の特定が急務である．

この問題解決策として，地域一般で実施可能な介入領域として，食事摂取量の有意な関連因子として着目されつつある『社会性』[5,6]に対する介入の有効性が期待される．『社会性』と比較すると，一般的な食事・栄養指導では対象限定的であり，国民全般の摂取量向上に対する寄与には限界がある点においても『社会性』の有用性が期待される．しかし，『社会性』は多岐にわたる人間関係や社会参加の概念を指す表現語であるが故に評価が画一化されておらず，食事摂取量，特に緑黄色野菜摂取量をアウトカムとした研究はまだ少ない．

本研究では，千葉県柏市在住の地域在住高齢者を対象に大規模健康調査を実施し，『社会性』と緑黄色野菜摂取量との関連性を同定することで，有効的な介入方法の開発に対する一助となることを目的とした．特に『社会性』については，検討が不十分である「孤食」に着目し，居住環境（独居か同居か）別に比較した．更に，家族や友人とのつながりなど，複数の要素から異なる側面の比較検討によるより詳細な解析を行った．

2 方法

平成25年度に千葉県柏市で実施された大規模健康調査（柏スタディー）において，無作為抽出され参加した65歳以上の自立もしくは要支援認定の高齢者1,400名（平均年齢73.7±5.4歳，男性724名，女性676名）を対象とした．

緑黄色野菜摂取量の評価には，質問票による食品摂取頻度調査（Food Frequency Questionnaire Based on Food Groups）を使用し，解析には残差法によるエネルギー調整済み値を用いた．摂取量を男女別に4分位に分け，下位4分位を「低摂取群」，残りの集団を「高摂取群」とした．

『社会性』は2項目を評価した．まず，家族および友人とのつながりをLubben Social Network Scoreの下位尺度を使用して評価した．また，独居・孤食状態については，同居者の有無で評価した居住環境と，「1日に1回以上は誰かと一緒に食事をしていますか」という質問で評価した食事環境（孤食もしくは共食）を掛け合わせて4群（①独居かつ孤食，②独居にも関わらず共食，③同居にも関わらず孤食，④同居かつ共食）を作成した．

基本属性としては，年齢，性別，うつ傾向の有無，認知機能を評価した．うつ傾向の有無はGeriatric Depression Scale（GDS）簡易版を用いて，6点以上をうつ傾向とした[7]．認知機能はMini-Mental State Examination（MMSE）を用いて評価し，連続変数として解析に使用した．

統計解析は主に二段階に分けて検討を行った．まず単変量解析を用いて緑黄色野菜の「低摂取群」と「高摂取群」の比較を行った．名義・順序尺度に関してはカイ二乗検定，連続尺度に関しては対応のないt検定を使用した．次に，緑黄色野菜の摂取量を従属変数として「低摂取群」に対する二項ロジスティック回帰分析を行った．モデル1では独立変数として『社会性』のみを投入，モデル2では性別と年齢を調整因子に追加，モデル3では更にうつ傾向の有無と認知機能も追加した．統計解析ソフトはIBM SPSS Statistics 22を使用し，有意水準は5%未満をもって有意とした．

3 成績

対象者1,400名のうち，349名（24.9%）が「低摂取群」と評価された．エネルギー調整済みの緑黄色野菜摂取量は，男性（n=724）において平均85.9±83（下位4分位は22.7）g/日，女性（n=676）においては106±92（下位4分位は37.8）g/日であった．

154名（11.0%）が独居，229名（16.4%）が孤食状態にあった．独居と孤食を掛け合わせた4群の内訳は，「独居かつ孤食」が137名（9.8%），「独居にも関わらず共食」が17名（1.2%），「同居にも関わらず孤食」が92名（6.6%），「同居かつ共食」が1154名（82.4%）であった．

単変量解析による差の検定においては，「高摂取群」と比較し「低摂取群」の孤食やうつ傾向の割合が有意に高く，人とのつながりや認知機能が有意に低い結果となった（図1）．

二項ロジスティック回帰分析の結果，同居かつ孤食（オッズ比（OR）=1.95，95%信頼区間（CI）：1.2-3.1），家族とのつながり（OR＝0.953，95%CI：0.92-0.99），年齢（OR＝0.970，95%CI：0.95-0.99），うつ傾向（OR＝1.49，95%CI：1.1-2.0），認知機能（OR=0.922，95%

CI：0.86-0.99）が「低摂取群」と有意な関連がみられた（図2）.

4 考察・結論

本研究では，地域在住高齢者において，「家族とのつながりの希薄化」，「同居にも関らず孤食」といった日常生活における『社会性』の乏しさが，緑黄色野菜摂取量の低さと関連することが同定された.

「家族とのつながりの希薄化」が摂取量の低さと関連する理由としては，料理や買い物を手伝ってくれる人による手段的ソーシャル・サポートや，親密な人間関係から得られる情緒的ソーシャル・サポートが減ることで，バランスのよい健康的な食事の準備や摂取に対する意欲が失われると推察される．また，コミュニケーションが減り貴重な情報源を失うことで緑黄色野菜摂取の必要性や調理方法などに関するリテラシーの減少も関与している可能性がある.

「同居にも関わらず孤食」であることが緑黄色野菜の低摂取量と関連する理由としては，この集団が閉じこも

変数	高摂取群（n=1051）				低摂取群（n=349）				p−値
	平均値±標準偏差		n (%)		平均値±標準偏差		n (%)		
基本属性									
年齢	73.9	± 5.3	−		73.4	± 5.6	−		0.157
性別（男性）	−		544	(51.8)	−		180	(51.6)	0.952
通学年数	12.9	± 2.8	−		12.7	± 2.7	−		0.195
BMI(kg/m²)	22.4	± 3.0	−		22.4	± 3.1	−		0.908
内服薬の数	2.74	± 2.8	−		3.03	± 2.8	−		0.103
うつ傾向の有無（GDS）	−		156	(14.8)	−		78	(22.3)	0.001
認知機能（MMSE）	28.6	±1.7	−		28.4	±1.7	−		0.021
社会性									
独居	−		112	(72.7)	−		42	(27.3)	0.476
孤食	−		155	(14.7)	−		74	(21.2)	0.005
家族とのつながり得点	8.00	±3.8	−		7.20	±3.7	−		0.001
友人とのつながり得点	4.86	±2.3	−		4.59	±2.2	−		0.049

❑ 図1　緑黄色野菜の高摂取群と低摂取群の比較（n=1400）

変数	Model1			Model2			Model3		
	OR	95%CI	p値	OR	95%CI	p値	OR	95%CI	p値
独居＆孤食	1.33	(0.89−2.0)	0.166	1.39	(0.93−2.1)	0.112	1.41	(0.94−2.1)	0.100
独居＆共食	0.780	(0.22−2.7)	0.699	0.780	(0.22−2.8)	0.699	0.734	(0.21−2.6)	0.634
同居＆孤食	1.94	(1.2−3.0)	0.004	2.05	(1.3−3.2)	0.002	1.95	(1.2−3.1)	0.004
同居＆共食	−	−	−	−	−	−	−	−	−
人とのつながり（家族）	0.950	(0.92−0.99)	0.005	0.946	(0.91−0.98)	0.003	0.953	(0.92−0.99)	0.012
人とのつながり（友人）	0.995	(0.93−1.1)	0.866	0.997	(0.94−1.1)	0.917	1.00	(0.94−1.1)	0.991
年齢（歳）				0.975	(0.95−1.0)	0.037	0.970	(0.95−0.99)	0.012
性別（男性）				0.954	(0.74−1.2)	0.715	0.966	(0.75−1.2)	0.790
うつ傾向の有無（GDS）							1.49	(1.1−2.0)	0.012
認知機能（MMSE）							0.922	(0.86−0.99)	0.023

❑ 図2　社会性と緑黄色野菜の摂取に関連する二項ロジスティック回帰分析（n=1400）

りがちで社会的に内向きである可能性が挙げられる．本稿にデータは掲載していないが，独居・孤食状態の4群のうち，この集団において「家族や友人とのつながり」や「生活の広がり」(Life Space Assessment) [8]が最も低い傾向にあった．同居者がいるにも関わらず1日に1度も誰かと共に食事をする機会が無いということは，同居者との関係が親密でない可能性があり，周囲からの関心が低いばかりか，高齢者自身への関心すら低くなると考えられる．故に，健康的な生活の維持に対する意欲の低下を招いた結果，野菜の摂取量が低下していると推察できる．ヘルスリテラシーが4群の中で最も低く，うつ傾向を示すGDS得点が最も高かった事実もこれを支持するものである．「同居かつ共食」群と比較して，自分で料理していた人の割合は多かったものの，1割程度の差であり，緑黄色野菜摂取量に影響してくるのは料理の手段的サポートの問題よりも，むしろ心理的な要因の方が大きい可能性が高い．「同居にも関わらず孤食」の集団においては，共食の集団と比較すると，同居者が配偶者である割合が低く，子供や子供の配偶者の割合が高い．これは，生活パターンの違いや年代差による同居者との心理的乖離，すなわち家庭内孤立が存在する可能性を示唆している．

本研究には主に4つの限界がある．第一に，横断的研究であるため，因果関係を示すためには縦断的検討を行う必要がある．第二に，食事摂取量の調査は栄養士による聞き取りではなく自記式で行ったため，高齢者の記憶違いによる過大・過小評価による誤差は否定できない．第三に，季節変動や日間変動が存在するため，本研究から得た知見の一般化には課題が残る．そして最後に，本研究は低野菜摂取がフレイルのリスクであるという仮説の下で実施したが，本標本からの仮説検証が必要であり，今後の課題とする．

緑黄色野菜摂取量の向上に対する『社会性』の介入指導の有用性を検証するため，ロジスティック回帰分析の結果を用いて「低摂取群」に入る集団の割合を試算したところ，「同居にも関わらず孤食」の集団が「共食」になった場合は約15%減，家族とのつながりがない集団がつながりを最大限に増やした場合も約15%減，従って単純計算で計30%近く低摂取群に入る集団の割合を削減することが可能という結果であった．当然本研究は因果関係まで言及できず，試算はあくまでも参考値であるが，『社会性』に対する介入の重要性を支持するものと考える．

以上のことから，『社会性』がバランスのとれた食事において重要な役割を果たしている可能性が示唆された．未病対策として，緑黄色野菜の摂取量の改善を通して良好な栄養状態を維持していくにあたり，社会的孤立，特に食事における孤立や家族との関係性に着目する必要性が示唆された．

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Social engagement and intake of green-yellow vegetables among community-dwelling older adults - From Kashiwa-study -

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Objective: To examine the association between social engagement (eating alone, living arrangement and social support network) and intake of green-yellow vegetables among community-dwelling older adults.

Methods: This study was based on 1,400 (724 male and 676 female) randomly selected community-dwelling older adults aged ≥65 (mean 73.7±5.4) years old who participated in the cohort health study in Kashiwa-city, Chiba-prefecture. Green-yellow vegetable intakes were assessed with the Food Frequency Questionnaire Based on Food Groups. For social engagement, social support network (Lubben Social Network Score) and eating alone by living arrangement were examined. Eating alone was evaluated with a question "Do you eat your meals with someone else, at least once a day?" and was crossed with the living arrangement (living alone or living with families). As covariates, age, gender, depressive symptoms (Geriatric Depression Scale≥6) and cognitive functions (Mini-Mental State Examination) were assessed.

Results: 349 (24.9%) subjects were in the "low intake" group. Binomial logistic regression analysis showed that the factors independently associated with low intake of green-yellow vegetables were: 'living with families yet eating alone' [odds ratio (OR)=1.95, 95% Confidence Interval(CI)=1.2-3.1], social ties with families [OR=0.953, 95% CI=0.92-0.99], age [OR=0.970, 95% CI=0.95-0.99], depressive symptoms [OR=1.49, 95% CI=1.1-2.0] and cognitive functions [OR=0.922, 95% CI=0.86-0.99].

Conclusion: The social ties with families and 'living with families yet eating alone' were independently associated with the low intake of green-yellow vegetables. This indicates the importance of preventive strategies that focus on alleviating social isolation, particularly during mealtimes and in relations with families.

Key words Social engagement, green-yellow vegetables, eating alone, community-dwelling older adults

第20回日本未病システム学会学術総会
■ プロシーディング 1

地域在住高齢者における睡眠と身体活動の関連 －千葉県柏市における大規模健康調査（柏スタディー）：横断研究から－

田中 友規　黒田 亜希　鈴木 政司　飯島 勝矢

要 約

【目的】高齢者における睡眠の質は虚弱（Frailty）や死亡リスクに有意に関連する因子の1つであり，予防や対策が必要である．睡眠を改善する低コストかつ薬物に頼らない対策案として，身体活動が着目されている．今回，地域高齢者に対して大規模な健康調査を介して睡眠と身体活動との関連を検討した．特に，身体活動の中で余暇と仕事，座位との差異を比較する形で睡眠との関連を明らかにすることを目的とした．

【研究デザイン】横断研究

【研究対象者】平成24年に千葉県柏市において実施された大規模健康調査「栄養とからだの健康増進調査」において，無作為化抽出され参加した65歳以上の自立あるいは要支援認定の高齢者1912名（男性960名，女性952名）．

【方法】質問票調査にて評価．睡眠は日本語版Pittsburgh Sleep Quality Indexを用い，「睡眠障害あり」，「良質な睡眠」を評価した．身体活動は日本語版General Practice Assessment Questionnaireを用い，「余暇活動」，「仕事活動」，「座位活動」を評価した．

【結果】対象者1912名の内，590名（30.9%）が「睡眠障害あり」と評価され，逆に318名（16.6%）が「睡眠の質が非常に良い」と評価された．「睡眠障害あり」に対して，少ない座位活動が有意な関連因子であった（オッズ比：0.745 [0.57-0.98]）．対して，「睡眠の質が非常に良い」に対して，多い中強度以上の余暇活動時間が有意な関連因子であった（オッズ比：1.50 [1.1-2.0]）．仕事時間は全ての項目において有意な関連はみられなかった．

【結論】本研究では地域在住の高齢者において，座位活動が睡眠障害に関連することに加え，中強度以上の余暇活動が良質な睡眠に関連することを見出した．この結果は，座位活動を少しでも小さくし，中強度以上の余暇活動を十分に行うことが，良質な睡眠につながる改善策として有用である可能性を示唆している．さらに，従来の報告にある運動介入とは異なり，高齢期の方々の最も身近にある日常身体活動と睡眠の重要な関係性をも示している．

Key words　高齢者，睡眠，日常身体活動，座位活動，余暇活動

1 緒 言

高齢者において良質な睡眠（すなわち睡眠の質）を確保できないことは総死亡や精神疾患発症など多岐にわたりリスクを高めることが明らかになっており[1,2]，高齢期における睡眠は未病管理における最も重要な要素の1つといっても過言ではない．

しかしながら，我が国の高齢者においては，約3人に1人の割合で睡眠に対して不満をもっていると報告されており[3]，何らかの介入や予防策により睡眠の質の改善が強く求められる．

睡眠を改善する方法としては，薬物療法や精神状態の改善と同様に認知療法などが存在するが，高齢者に対する薬物療法は副作用が高頻度で出やすい問題もあり，改めて手間やコストの面からもより適切な予防策が求められている．そんな中にあって，睡眠を改善する低コストかつ薬物に頼らない対策案（いわゆる非薬物的アプローチ）として『身体活動』が着目されている[4]．身体活動による睡眠改善は，低コストかつ心身健康に対する恩恵も大きく，薬物療法などの現行している治療法とは一線を書くものである．既に運動介入による睡眠改善は報告されているが[5]，日常的な身体活動と睡眠の関連の報告は決して多くない．特に，運動の強度や質（余暇活動・仕事活動・座位活動）などの身体活動の多面性にまで目を配らせている検討は少ない．

東京大学高齢社会総合研究機構
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今回，我々は千葉県柏市在住の地域高齢者に対して虚弱予防に主眼を置いた大規模健康調査を介して睡眠と身体活動との関連を検討した．特に，身体活動の中で余暇と仕事，座位との差異を比較する形で睡眠との関連を明らかにすることにより，高齢者の睡眠改善に対してより効果的かつ障害のない身体活動を提言することを目的とした．

2 方法

A. 対象

平成24年9月から11月に千葉県柏市において実施された大規模健康調査「栄養とからだの健康増進調査（柏スタディー）」において，無作為化抽出され参加した満65歳以上の自立あるいは要支援認定の高齢者2044名の内，本検討で用いた項目において欠損値が見られた者を除外し，1912名（男性960名，女性952名）を解析対象とした．

B. 睡眠評価

睡眠の評価は日本語版Pittsburgh Sleep Quality Index質問票（以下：PSQI）を用いた．PSQIでは過去1ヶ月間の睡眠を評価することで，睡眠障害のスクリーニングが可能とされる．PSQIでは「睡眠の質」，「入眠困難感」，「日中覚醒困難感」，「睡眠効率」，「眠剤の使用」といった因子から構成され，0点から21点間でのPSQI得点が算出される．PSQI得点が6点以上の場合に睡眠障害ありと評価する[6]．本検討では「睡眠障害あり：総合得点6点以上」に加えて，「良質な睡眠：睡眠の質が非常に良い」を定義し検討した．回答方法としては，PSQI質問票を事前配布し，記入したものを健康調査会場にて回収した．

C.身体活動評価

身体活動の評価は，日本語版General Practice Assessment Questionnaire（以下：GPAQ）を使用した．GPAQは1週間の身体活動を運動強度・質に分けて評価することが可能である．本検討では「中強度以上の余暇活動」，「中強度以上の仕事活動（家事や庭仕事を含む）」，「座位活動（睡眠時間は除く）」を評価し使用した．回答方法は健康調査会場にて自記式にて記入したものを回収した．

D. 交絡因子

睡眠に影響を与える交絡因子として，「性別」，「年齢」，「Body Mass Index（以下：BMI）」，「抑鬱症状の有無（Geriatric Depression Scale（以下：GDS）得点6点以上）」，「軽度認知機能障害の有無（Mini Mental State Examination（以下：MMSE）得点26点以下）」を調査した[7-8]．回答方法はGDSにおいては健康調査会場にて自記式にて記入したものを回収し，MMSEは面接法にて評価し回収した．MMSEの採点は専門家の指導の下で行った．

E. 統計解析

睡眠と身体活動の関連の検討には「睡眠障害あり」，「良質な睡眠」を従属変数とした二項ロジスティック回帰分析を行った．独立変数として，GPAQより得られた種々の身体活動時間（分/日）を各3カテゴリーにピン分類し，「中強度以上の余暇活動：3分類」，「中強度以上の仕事活動：3分類」，「座位活動：3分類」を解析に用いた．さらに調整変数として，「性別」，「前期高齢者，後期高齢者」，「BMI25未満，BMI25以上」，「抑鬱傾向（GDS得点6点以上）の有無」，「軽度認知機能低下（MMSE得点26点以下）の有無」，「睡眠薬の服用の有無」をモデル投入した．統計解析ソフトは全てIBM SPSS Statistics ver.22を使用し，有意水準は5%未満をもって有意とした．

F. 倫理的配慮

本研究により得られたデータは，ID番号により匿名化され個人情報を含まない状態で解析を実施した．

3 結果

A. 対象者の特性

表1に本検討の解析対象者1912名の属性を示す．平均年齢は72.9±5.4歳であり，前期高齢者が64.7%，後期高齢者が35.3%であった．男女の分布では男性50.2%，女性49.8%とほぼ均一であった．睡眠に関しては，全体の30.9%が睡眠障害ありと評価された．また，主観的な睡眠の質が非常によいと答えた者は全体の16.6%であった．身体活動に関しては，中強度以上の余暇活動習慣があると答えた者は全体の77.5%であり，平均で44.5±51（分/日）実施していた．次に中強度以上の仕事活動習慣があると答えた者は56.7%であり，平均で41.6＋70（分/日）実施していた．最後に座位活動であるが，平均で292.0±165（分/日）であった．

❑ 表1　対象者の特性

	全体 n=1912		男性 n=960, 50.2%		女性 n=952, 49.8%	
	n	%	n	%	n	%
年齢						
65-74, 歳	1238	64.7	611	63.9	627	65.9
≧75, 歳	674	35.3	349	36.4	325	34.1
平均値±標準偏差	72.9±5.4		73.1±5.6		72.7±5.4	
Body Mass Index						
<25, kg/m²	1499	78.4	728	75.8	771	81.0
≧25, kg/m²	413	21.6	232	24.2	181	19.0
平均値±標準偏差, kg/m²	22.9±3.0		23.3±2.8		22.5±3.2	
抑鬱症状（GDS）						
抑鬱傾向（GDS得点≧6）	286	15.0	137	14.3	149	15.7
非抑鬱傾向（GDS得点<6）	1626	85.0	823	85.7	803	84.3
平均値±標準偏差, 点	2.63±2.9		2.45±3.0		2.82±2.9	
認知機能（MMSE）						
軽度認知機能低下（MMSE得点≦26）	296	15.5	144	15.0	152	16.0
認知機能正常（MMSE得点>27）	1616	84.5	816	85.0	800	84.0
平均値±標準偏差, 点	28.2±1.9		28.2±1.9		28.2±1.7	
睡眠（PSQI）						
主観的睡眠の質（非常によい）	318	16.6	167	17.4	151	15.9
入眠困難あり	382	20.0	150	15.6	232	24.4
日中覚醒困難あり	86	4.5	34	3.5	52	5.5
睡眠効率問題あり	199	10.4	92	9.6	107	11.2
睡眠薬の服用あり	235	12.3	82	8.5	153	16.1
睡眠障害あり（PSQI総得点>6）	590	30.9	249	25.9	341	35.8
平均値±標準偏差, 点	4.58±3.2		4.16±3.0		5.01±3.3	
中強度以上の余暇活動（GPAQ）						
習慣なし	430	22.5	193	20.1	237	24.9
≦17.1, 分/日	629	32.9	270	28.1	359	37.7
>17.1, ≦51.4, 分/日	575	30.1	277	28.9	298	31.3
>51.4, 分/日	708	37.0	413	43.0	295	31.0
平均値±標準偏差, 分/日	44.5±51		50.3±56		38.8±46	
中強度以上の仕事活動（GPAQ）						
習慣なし	828	43.3	431	44.9	397	41.7
≦0, 分/日	828	43.3	431	44.9	397	41.7
≦34.3, 分/日	459	24.0	229	23.9	230	24.2
>34.3, 分/日	625	32.7	300	31.3	325	34.1
平均値±標準偏差, 分/日	41.6±70		37.7±67		45.6±74	
座位活動（GPAQ）						
≦180, 分/日	659	34.5	332	34.6	327	34.3
>180, ≦300, 分/日	660	34.5	292	30.4	368	38.7
>300, 分/日	593	31.0	336	35	257	27.0
平均値±標準偏差, 分/日	292.0±165		309.6±183		274.3±143	

(Notes) GDS: Geriatric Depression Scale, MMSE: Mini-Mental State Examination,
PSQI: Pittsburgh Sleep Quality Index, GPAQ: Global Physical Activiy Quesionnaire

B. 睡眠障害と身体活動

表2に睡眠障害と身体活動，各調整項目との関連を示す．睡眠障害ありに対しては，性別（女性），抑鬱傾向あり，睡眠薬の服用ありが有意な関連因子であった．また，座位活動時間が最も少ない群は多い群と比較すると睡眠障害になりにくい傾向がみられた．中強度以上の余暇活動や仕事活動は睡眠障害とは関連しなかった．

C. 良質な睡眠と身体活動

表2に良質な睡眠と身体活動，各調整項目との関連を示す．良質な睡眠に対しては，年齢（後期高齢者），抑鬱傾向なし，睡眠薬の服用なしが有意な関連因子であった．また，中強度以上の余暇活動時間が最も多い群は少ない群と比較すると，良質な睡眠になりやすい傾向がみられた．中強度以上の仕事活動や座位活動とは関連しなかった．

❑ 表2　睡眠（障害, 良質）と日常身体活動の関連

	睡眠障害あり n=590, 30.9%		良質な睡眠 n=318, 16.6%	
	OR	(95%CI)	OR	(95%CI)
性別				
男性	0.733**	(0.59-0.91)	0.976	(0.76-1.3)
女性	1		1	
年齢				
65-74, 歳	1.01	(0.80-1.3)	0.650***	(0.50-0.84)
≧75, 歳	1		1	
Body Mass Index				
≧25, kg/m^2	0.954	(0.73-1.2)	1.28	(0.96-1.7)
<25, kg/m^2	1		1	
抑鬱症状（GDS）				
抑鬱傾向（GDS得点≧6）	2.20***	(1.7-2.9)	0.551**	(0.36-0.84)
非抑鬱傾向（GDS得点<6）	1		1	
認知機能（MMSE）				
認知機能正常（MMSE得点>27）	0.928	(0.69-1.2)	1.11	(0.79-1.6)
軽度認知機能低下（MMSE得点≦26）	1		1	
睡眠薬の服用				
あり	11.5***	(8.1-16)	0.432***	(0.27-0.70)
なし	1		1	
中強度以上の余暇活動（GPAQ）				
≦17.1, 分/日	1		1	
>17.1, ≦51.4, 分/日	1.00	(0.76-1.3)	1.00	(0.72-1.4)
>51.4, 分/日	0.900	(0.69-1.2)	1.50**	(1.1-2.0)
中強度以上の仕事活動（GPAQ）				
≦0, 分/日	1		1	
≦34.3, 分/日	1.02	(0.77-1.3)	0.926	(0.67-1.3)
>34.3, 分/日	0.945	(0.73-1.2)	0.911	(0.68-1.2)
座位活動（GPAQ）				
≦180, 分/日	0.745*	(0.57-0.98)	0.868	(0.63-1.2)
>180, ≦300, 分/日	0.982	(0.76-1.3)	1.31	(0.97-1.8)
>300, 分/日	1		1	

*:p<0.05, **:p<0.01, ***:p<.001

(Notes) OR: Odds Ratio, CI: Confidece Interval, GDS: Geriatric Depression Scale, MMSE: Mini-Mental State Examination, PSQI: Pittsburgh Sleep Quality Index, GPAQ: Global Physical Activiy Quesionnaire

4 考察

本検討の結果，睡眠と身体活動の関連として，睡眠障害と座位活動，良質な睡眠と中強度以上の余暇活動が認められた．先行論文からは，睡眠障害に対する介入として，ジョギングやエルゴメーターなどを用いた運動介入により睡眠の質が改善されたとの報告がある[9]．本検討の結果では，日常身体活動ではこの先行研究に挙げられる運動介入のような中強度以上の活動ではなく，むしろ身近なレベルである『座位活動を少なくする』ということが睡眠障害に対して重要であることが改めてわかった．この結果の背景には座位活動を少なくすることで，睡眠と関連するとされる身体活動度の向上や光受容，社会的接触の向上などが考えられる．現実的なことを考えると，高齢者は中強度以上の身体活動よりも，むしろ低強度の身体活動時間を多く実施している現実が多いため[10]，少しでも座位活動の時間を短くし，それを低強度活動に当てるだけで，睡眠障害の予防に寄与する可能性が十分ある．また本検討の結果より，日常身体活動でも中強度以上の余暇活動は睡眠の質を良くする可能性が認められた．すなわち，多岐にわたる身体活動および活動的な余暇時間の過ごし方は，睡眠の質向上に対しておそらく大きく貢献すると思われる．

一方で，本検討では仕事時間は睡眠とは関連しなかった．高齢者の検討とは異なるが，仕事関連の活動は身体的・精神的負担から睡眠を害することに結果的につながってしまうことが報告されているが[11]，本検討では，これらの結果を支持するものではなかった．多くの者が退職している高齢期での仕事活動は現役世代とは異なる意味合いとなるものと考えるが，睡眠との関連性はみられなかった．さらに精神面の視点で見てみると，睡眠と抑鬱症状などの精神状態との強い関連性は既に報告されており[2]，本検討でも抑鬱症状は睡眠障害および良質な睡眠とも有意に関連し，先行研究の結果を支持するものであった．本研究の限界として，睡眠および身体活動の評価には質問票による主観的手法を用いており，各項目の過大評価・過小評価されている可能性が否定できない．特に，身体活動においては各項目の標準偏差が大きく個人差が大きいことから，得られた値の妥当性の確保は困難である．従って，脳波測定による睡眠ポリグラフ検査や活動量計などの客観的評価手法を用いる必要がある．

本検討から，千葉県柏市在住の高齢者において，日常身体活動においても，座位活動が睡眠障害と関連したことから，座位活動を少しでも少なくすることが睡眠障害の予防策として有用である可能性があることがわかった．また，良質な睡眠においては仕事活動よりも余暇活動をしっかり行うことが重要であることがわかった．これは，従来の報告にある運動介入ではなく，日常身体活動という高齢期の方々の最も身近にある要素と睡眠の関係性に対して着目できた研究としては意義深い．

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Habitual physical activity and sleep in community-dwelling elderly in Japan: a cross-sectional study.

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Objectives: To test the hypothesis that the habitual physical activity of elderly individuals is associated with good sleep or sleep disturbance, to investigate that which types of physical activity would be more strongly relevant to these.

Design: Cross-sectional

Setting: Community of Kashiwa city, Chiba.

Participants: Community-living Japanese aged 65 to 94 (960 men, 952 women).

Measurements: Pittsburgh Sleep Quality Index (PSQI) was used to evaluate sleep duration, Sleep onset latency, subjective sleep quality, and sleep efficiency. PSQI global score was used to estimate prevalence of sleep disturbance. Physical activity (PA) was assessed by the Global Physical Activity Questionnaire (GPAQ). To distinguish between participants with "low", "middle" and "high" level of PA, we split participants into three on the basis of the specific tertile in work-, leisure-related moderate-vigorous intensity PA (MVPA) and sedentary-related PA.

Results: 590 (30.9%) of 1912 participants were estimated as "those with a sleep disturbance", and 318 (16.6%) were conversely estimated as "those with the excellent quality of sleep". According to a multivariate-adjusted logistic regression, A low level of sedentary-related PA was associated with a sleep disturbance [Odds ratio (OR) =0.745, 95% confidence interval (CI); 0.57-0.98]. By contrast, A high level of leisure-related MVPA was associated with the excellent quality of sleep [OR=1.50, 95%CI; 1.1-2.0]. Between work-related PA and elderly's sleep, the significant correlate was not found at all.

Conclusion: These results have suggested the probability with useful as a remedy which leads to a good sleep engaging in leisure-related MVPA and reducing sedentary-related PA.

Key words　elderly, sleep, habitual physical activity, leisure-related activity, sedentary-related activity