骨量低下をまねく要因となる．特にステロイド剤を使用する際には治療早期から骨粗鬆症治療薬を併用し，骨量減少，さらには骨折の予防を目指すべきである．経過中の定期的な骨量測定と脊椎 X 線撮影による骨の評価が必要である．

6 理学・作業療法との関連事項

骨粗鬆症による骨折が生じた場合，急性期における理学・作業療法は，疼痛緩和に重きをおいたものである．疼痛がコントロールされてからは，骨折再発予防を念頭においた転倒予防の指導が必要である．

変形性関節症の治療においては，疼痛管理，関節可動域の維持・拡大に向けて理学・作業療法が果たす役割は大きい．関節リウマチによる関節変形が強い場合には手術療法の適応となる．各診療科が連携した診療が必要であり，理学・作業療法においても病期や状態に適合した対応が必要である．

★療法士の視点から

本章で述べられていることは，理学・作業療法士にとって専門的なところであるので，逆にそのことに安心してしまい，復習や新たな知識の習得に力が注がれていない危険性もある．この点は厳に意識しておくべきで，常に研鑽する姿勢が求められる．

また，骨・運動器については，理学・作業療法士が健康教育などの場面で，一般市民に知識を提供することが多いが，時に誤った情報を提供していたり，内容は正しくとも難解に過ぎて，結果的に効果が得られていない場面に出会うこともある．

このようなことを防ぐには，たとえば，理学・作業療法士どうしで互いの知識を確認し合ったり，一般市民を想定して知識の伝え方が適当であるかなどのチェックを行うことが効果的である．

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復習のポイント

- 高齢者の骨折を引き起こす要因をまとめ，予防策を考える．
- 骨粗鬆症の診断と治療をまとめる．
- 変形性関節症の病態と部位ごとの特徴を理解する．
- OPLL（後縦靭帯骨化症）の特徴をまとめる．
- 関節リウマチの治療と理学療法・作業療法の方法を検討する．

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JPFSM: ***Regular Article***

Regular exercise history as a predictor of exercise in community-dwelling older Japanese people

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Abstract A physically active lifestyle is important across the entire life span. However, little is known about life-long participation in regular exercise among older people. The purpose of the present study was to describe regular exercise throughout a person's lifetime and evaluate the impact of exercise earlier in life on participation in exercise at age 60 and over. The participants were 984 community-dwelling older people aged 60 to 86 years. Each participant's life was divided into five age categories: 12-19, 20-29, 30-39, 40-59, and 60 years and over. The association between exercise at an earlier age and that at 60 years and over was assessed using logistic regression analysis adjusted for potential confounders. Men had exercised throughout their lives more than women. Among women, participation in exercise during their 20s and 30s showed a sharp decline. The preference for exercise differed according to age and gender. Among men, the most common patterns of exercise throughout life were exercise during all the age categories, and starting exercise at age 60 and over; whereas in women the most common pattern was no exercise at all. The adjusted odds ratio of exercise at 40-59 years for exercise at age 60 and over was 5.85 (95% confidence interval: 3.82-8.96) among men and 6.89 (4.23-11.23) among women. Regular exercise in the younger age categories affected exercise at age 60 and over among men, but not among women. Regular exercise at 40-59 years was a strong predictor of exercise at 60 years and over in both men and women.

Keywords : regular exercise, older people, life course, random sampling data

Introduction

Physical activity is an important health behavior across the course of one's life. The benefits of physical activity in preventing health decline and physical function loss have been demonstrated, especially for frail and aged people[1]. The Ministry of Education, Culture, Sports, Science and Technology in Japan reported that the participation rate of older people in physical activity and fitness has slightly increased in the past decade[2,3]. However, more than 40 % of older people aged 70 years and older did not participate in any exercise during the past year[4]. Insufficient physical activity remains a public health concern among older people in Japan.

Engaging in sports activities in childhood and adolescence is known to predict physical activity in adulthood[5]. A low level of physical activity in early life has been found to predict physical inactivity in adulthood[6]. However, most longitudinal studies have demonstrated that sports activities in early life have an effect on physical activity in young adulthood[5,6]. It remains unclear whether sports activities in early life are associated with physical activity at an older age. Some studies have found that a history of physical activity was associated with current physical activity in older people[7,8]. In an earlier study we found that the experience of exercise in adolescence was associated with a higher level of leisure-time physical activity in middle-aged and elderly Japanese women[9]. However, little basic descriptive data exists on individual variation in participation in exercise throughout the life span and the impacts of early exercise on physical activity in later life among community-dwelling Japanese older people.

The purpose of the present study was to describe regular exercise throughout the life course and evaluate the effect of early exercise on the participation in exercise at the age of 60 years and over.

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Methods

Study population. The investigation is a part of the 4th survey of the National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA), which is a follow-up study on the causes of geriatric diseases and health problems in older people. The NILS-LSA was based on data obtained from interviews and laboratory examinations of medical, nutritional, psychological, and physical fitness variables. The details of the study can be found elsewhere[10]. The initial survey of the NILS-LSA involved 2,267 men and women aged 40-79 years, including almost 300 men and 300 women for each decade (40s, 50s, 60s and 70s). The participants were gender- and decade age-stratified random samples of the residents of Obu-shi and Higashiura-cho, Aichi Prefecture, in central Japan. The participants were drawn from resident registrations in cooperation with local governments. All subjects lived or had lived at home in the community. The participants in the present study comprised 523 men and 461 women aged 60-86 years. All the NILS-LSA procedures were already approved by the Ethical Committee of the National Center for Geriatrics and Gerontology, and all of the participants signed a written informed consent.

Measures and Procedures. Regular exercise was assessed using a questionnaire and an interview. The questionnaire was based on a questionnaire developed by the Japanese Lifestyle Monitoring Group[11]. The participants were asked for the type, time, frequency and duration of their regular exercise from the age of 12 years to the present with the question "What physical activities or sports have you participated in during these age categories?" The participants reported the types of physical activities and sports they had engaged in from a list of alternatives. These were coded as 1) light activities such as walking, gymnastic exercise and gardening, 2) moderate activities such as brisk walking, dancing and swimming for pleasure, 3) vigorous activities with increased breathing and sweating such as jogging and playing tennis, 4) exhausting activities such as various competitive sports. Frequency of participation was defined as how often they participated in physical activities or sports per week. The duration of each activity was calculated with 1 year as the basic unit. Physical activities or sports that were engaged in for at least 20 minutes, once a week and over 1 year, excluding physical education at school, were defined as regular exercise. Life span was divided into five age categories: 12-19, 20-29, 30-39, 40-59 and 60 years and over. The age categories of 40 and over included more years with reference to previous studies[7,8], showing physical activity to be stable in middle age[12].

If participants engaged in a number of regular exercises during the same period, the exercise with the longer duration was selected. Interviews were performed by trained staff.

Potential confounders, included age, education, marital status (never married, married, separated, divorced and bereaved), annual income (6,500,000 yen or less vs. more than 6,500,000 yen) and chronic conditions including smoking status (never, former and current), self-rated health (excellent, very good, good, fair and poor) and prevalent diseases (hypertension, ischemic heart disease, diabetes, osteoporosis, arthritis and cancer), were investigated using a questionnaire and interview by a physician. Height and weight were measured using a digital scale. Body mass index was calculated by weight divided by height squared (BMI; kg/m^2). Body fat mass was assessed by dual X-ray absorptiometry (DXA; QDR-4500A, Hologic, USA). Work-related physical activity was estimated using the same questionnaire developed by the Japanese Lifestyle Monitoring Group[11]. Work activities were assigned an intensity coefficient of 1.5, 2.5, 4.5 and 7.5 METs (metabolic equivalents) for sedentary work, work done standing or walking, moderately strenuous work and strenuous work, respectively. The work activity scores were calculated by multiplying the intensity coefficients by the total number of minutes spent on the activity over the last 12 months.

Statistical analysis. The statistical significance of the differences in social and health conditions were analyzed by the Cochran-Mantel-Haenszel test for categorical variables and Student's t-test for continuous variables according to participation in regular exercise at age 60 and over. The participation rate in regular exercise was calculated as the percentage of participants who engaged in exercise in each age category. Gender differences in the participation rate in each age category were analyzed using Pearson's chi-squared test. The relationship between regular exercise in the younger age categories and at age 60 and over was evaluated using multiple logistic regression analysis. Both the unadjusted model and the model adjusted for all potential confounders were analyzed. The analyses were performed for men and women separately, as the gender difference in the participation rate in regular exercise was considerable. Statistical testing was performed using the Statistical Analysis System (SAS), release 9.1.3 (SAS Institute Inc. NC, USA). Probability levels of less than 0.05 were considered to be significant.

Results

Table 1 shows the characteristics of the participants by gender according to participation in regular exercise at age 60 and over. The mean age of the study population was 70.0±6.6 years in men and 69.8±6.7 years in women. Age, weight, BMI, annual income, work-related physical activity, smoking, self-rated health, hypertension and arthritis for men; and height, education, work-related physical activity for women were associated with regular exercise at age 60 and over ($p<0.05$).

The participation rates in regular exercise for age categories 12-19, 20-29, 30-39, 40-59 and 60 years and over

Table 1. Charactaristics of the participants according to regular exercise at age 60 and over for men and women

		Men			Women		
		Regular exercise			Regular exercise		
		Yes	No		Yes	No	
		n=342	n=181	*p*-value	n=263	n=193	*p*-value
Age	years	**70.4 ± 6.3**	**69.2 ± 7.2**	**0.048**	69.7 ± 6.4	70.2 ± 7.0	0.503
Height	cm	163.6 ± 5.7	162.7 ± 5.9	0.108	**150.5 ± 5.6**	**149.1 ± 6.2**	**0.010**
Weight	kg	**62.3 ± 9.0**	**59.2 ± 8.3**	**<0.001**	51.8 ± 7.7	51.7 ± 8.7	0.829
BMI	kg/m^2	**23.3 ± 2.8**	**22.3 ± 2.8**	**<0.001**	22.9 ± 3.0	23.2 ± 3.4	0.246
Body fat	%	22.9 ± 4.4	22.5 ± 4.6	0.395	32.4 ± 5.1	32.6 ± 5.5	0.688
Education	years	11.9 ± 2.9	11.7 ± 3.0	0.513	**11.1 ± 2.3**	**10.6 ± 2.5**	**0.033**
Marital status	%			0.097			0.295
Never		0.0	2.2		3.1	3.7	
Married		94.4	91.2		71.7	64.0	
Separation		0.6	0.6		0.4	0.0	
Divorce		0.6	0.6		1.9	4.2	
Bereavement		4.5	5.5		23.0	28.0	
Annual income	%						
6,500,000 yen and higher		**24.8**	**35.2**	**0.013**	25.8	29.4	0.401
Work-related physical activity	METs*min* 10^{-3}	**130.8 ± 135.9**	**170.7 ± 151.7**	**0.002**	**183.0 ± 85.5**	**206.8 ± 109.0**	**0.010**
Smoking	%			**<0.001**			0.910
Never		**24.8**	**20.3**		93.9	94.2	
Former		**58.1**	**47.3**		2.3	2.6	
Current		**17.1**	**32.4**		3.8	3.1	
Self-rated health	%			**0.001**			0.287
Excellent		**6.5**	**0.6**		3.8	5.2	
Very good		**33.3**	**24.7**		21.7	15.6	
Good		**52.2**	**63.2**		65.0	66.2	
Fair		**7.7**	**9.9**		9.1	12.5	
Poor		**0.3**	**0.6**		0.4	0.5	
Prevalent diseases	%						
Hypertension		**44.5**	**31.3**	**0.003**	40.7	41.2	0.921
Ischemic heart diseases		6.2	9.3	0.188	7.2	6.8	0.852
Diabetes		11.5	11.0	0.860	7.2	5.2	0.385
Osteoporosis		1.2	3.3	0.093	16.4	17.2	0.827
Arthritis		**4.4**	**11.5**	**0.002**	11.8	17.2	0.102
Cancer		6.2	6.6	0.859	5.7	9.4	0.136

Continuous variables are presented as means ± standard deviation (SD), and categorical variables are presented as percentages. The differences between groups were analyzed by Student's t-test for continuous variables and by Cochran-Mantel-Haenszel test for categorical variables. Bold represents significant p-value (<0.05). BMI, Body mass index. METs, Metabolic equivalents

are shown Table 2. The percentage of men who had regular exercise was significantly higher than that of women in all of the age categories ($p<0.05$), except for 40-59 years. Among women, a large drop in the percentage reporting participation in exercise was found during the ages of 20-29 and 30-39 years.

The popular type of exercise reported for the different age categories is presented in Tables 3a and 3b. The most popular activities and sports differed both by gender and by age category. Men frequently reported team sports such as baseball and softball up to 40-59 years of age. In women, volleyball was frequently reported up to 30-39 years of age, while dancing and gymnastics exercise were more likely to be reported among those over 20 years of age. At age 60 and over, walking was the most popular exercise among both men and women.

All the possible patterns of participation in regular exercise from age 12 to the present were examined. Thirty-two

different patterns were identified (Figure 1). In men, the most common patterns were participation in regular exercise during all the age categories (12.6%) and participation in regular exercise at age 60 and over (12.6%). In women, the most common pattern was no regular exercise in any age category (21.1%), followed by participation in regular exercise at age 40 and over (14.3%).

Table 4 shows that participating in regular exercise at age 60 and over is related to participation in regular exercise across one's life span. The participants who had exercised at younger age categories were more likely to participate in exercise at age 60 and over for both men and women.

The odds ratios (OR) and 95% confidence intervals (CI) for those who regularly exercised at age 60 and over are shown in Table 5. Although, among men, the results of the unadjusted model for the age category 12-19 years was of borderline statistical significance (OR1.42, 95% CI 0.99-2.05), the odds ratio for participating in exercise at age 60 and over was higher for men who had regular exercise during each age category. The highest odds ratio was 4.63 (95%CI 3.07-6.98) among men who had regular exercise at 40-59 years. In women, regular exercise in the earlier age categories did not correlate with exercise at age 60 and over. However, the odds ratio for participating in exercise at age 60 and over was about six times higher among those who had regular exercise at 40-59 years (OR 5.85, 95%CI 3.82-8.96). After adjusting for age (continuous variable), BMI (continuous variable), education (continuous variable), annual income (6,500,000 yen or less/ more than 6,500,000 yen), work-related physical activity (1SD), smoking (never/ former/ current), self-rated health (excellent/ very good/ good/ fair/ poor) and chronic diseases (Yes/ No), the associations remained in both men and women. Regular exercise at 40-59 years was strongly associated with exercise at age 60 and over in both men (OR 5.96, 95%CI 3.72-9.57) and women (OR 6.89, 95%CI 4.23-11.23).

Table 2. Participation rate in regular exercise across the life course

age (years)	Men (n=523)		Women (n=461)		*p* - value
	n	%	n	%	
12-19	311	59.5	198	43.0	<0.001
20-29	173	33.1	29	6.3	<0.001
30-39	155	29.8	62	13.5	<0.001
40-59	233	44.6	203	44.0	0.871
60 and over	342	65.4	263	57.1	<0.001

Numbers and percentages are shown for those who participated in regular exercise divided into five age categories. Pearson's chi-squared test. df=1.

Discussion

The present study described regular exercise throughout a person's life and evaluated the impact of early regular exercise on participation in exercise at age 60 and over.

Previous longitudinal studies suggest that physical activity in early life tracks to later life[5,6]. However, most studies have tracked physical activity from childhood and adolescence to young adulthood and the coefficients re-

Table 3a. Popular types of regular exercise across the life course among men (n=523)

age (years)	1st	%	2nd	%	3rd	%
12-19	Baseball	16.6	Track & Field	11.9	Judo	8.4
20-29	Baseball	11.9	Softball	4.6	Table tennis	4.0
30-39	Golf	7.6	Softball	6.5	Baseball	5.9
40-59		Golf / Walking *	16.1		Softball	7.6
60 and over	Walking	34.4	Brisk walking	18.4	Golf	13.2

Percentages are shown for those who participated in the exercise. *, Both golf and walking share in 1st place with the same percentage.

Table 3b. Popular types of regular exercise across the life course among women (n=461)

age (years)	1st	%	2nd	%	3rd	%
12-19	Volleyball	15.8	Softball	7.8	Table tennis	6.1
20-29	Volleyball	1.7	Dancing	1.3	Tennis	0.9
30-39	Volleyball	3.5	Walking	2.8	Tennis, Dancing or Softball	1.5
40-59	Walking	13.9	Gymnastics exercise	8.7	Dancing	8.5
60 and over	Walking	24.7	Gymnastics exercise	15.4	Brisk walking	9.5

Percentages are shown for those who participated in the exercise.

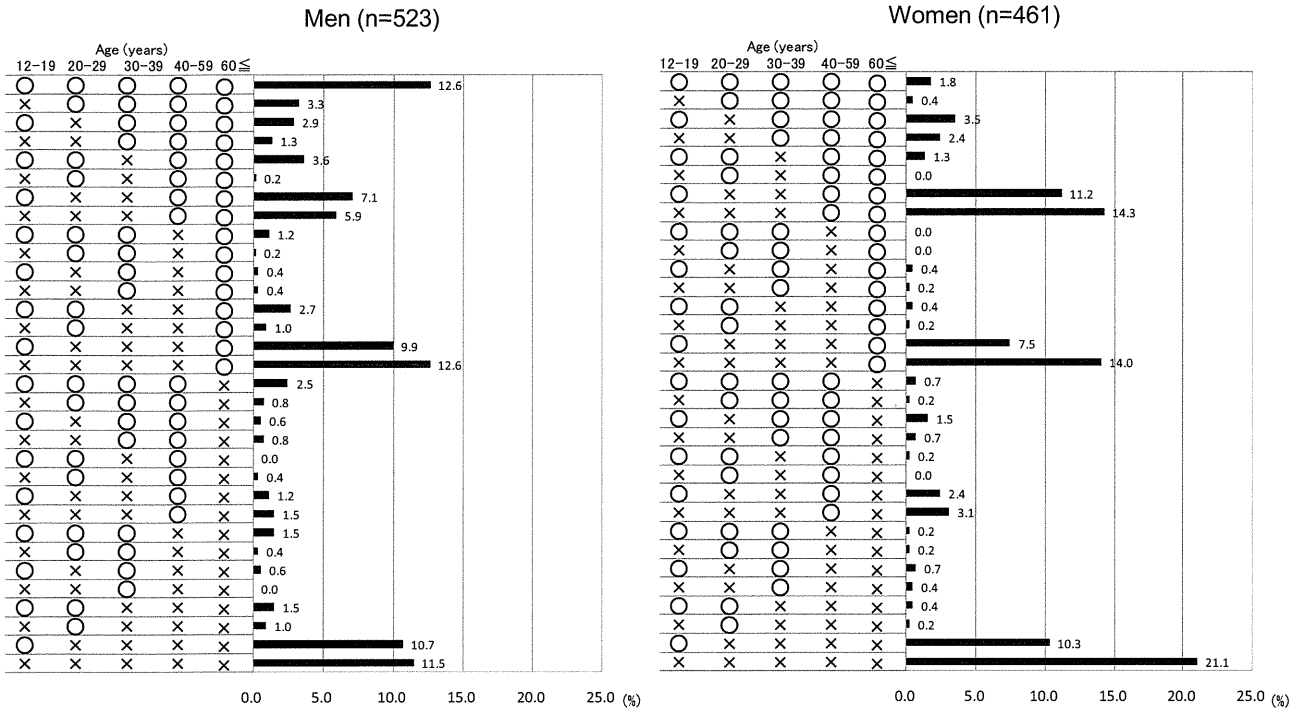

Fig. 1 Participation pattern in regular exercise across the life course for men and women, separately
Regular exercise status: (○) = participants who engaged in regular exercise, (×) = participants who did not engage in regular exercise

Table 4. Distribution of participation in regular exercisre at age 60 and over according to participation in regular exercise across the life course

age (years)	Regular exercise	Men (n=342)		Women (n=263)	
		n	%	n	%
12-19	No	130	61.3	144	54.8
	Yes	212	62.0	119	60.1
20-29	No	213	60.9	244	56.5
	Yes	129	74.6	19	65.5
30-39	No	225	61.4	223	56.0
	Yes	117	75.5	40	64.5
40-59	No	148	51.3	104	40.3
	Yes	194	83.3	159	78.3

Numbers and percentage are shown for those who engaged in regular exercise at age 60 and over.

ported have been only low or moderate[5]. In another study, the correlation between the time points studied was found to weaken over time[13]. Only a few studies have examined whether physical activity in early life tracks to an older age. Retrospective findings that past physical activity predicts physical activity in older people[7,8] can help to explain the positive association between experiences of exercise and physical activity later in life. However, basic descriptive data on individual exercise history throughout life is lacking for the community-dwelling older people in Japan. Assessing life-long regular exercise and the contribution of past exercise experience to engagement in regular exercise later in life are the underlying considerations when promoting an active lifestyle throughout a person's life.

Our finding that men are more physically active than women throughout their lives is partially supported by pre-

Table 5. Odds ratio and 95% confidence interval for those who had regular exercise at age 60 and over

	Model 1				Model 2			
	Men		Women		Men		Women	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Regular exercise								
At 12-19 years of age	1.42	0.99 - 2.05	1.30	0.89 - 1.90	**1.69**	**1.10 - 2.58**	1.06	0.71 - 1.60
At 20-29 years of age	**2.03**	**1.35 - 3.05**	1.43	0.65 - 3.14	**1.87**	**1.21 - 2.90**	1.26	0.55 - 2.87
At 30-39 years of age	**2.02**	**1.32 - 3.09**	1.47	0.84 - 2.58	**2.00**	**1.27 - 3.15**	1.29	0.69 - 2.41
At 40-59 years of age	**4.63**	**3.07 - 6.98**	**5.85**	**3.82 - 8.96**	**5.96**	**3.72 - 9.57**	**6.89**	**4.23 - 11.23**

OR, odds ratio; CI, confidence interval. Model1: unadjusted, Model2: adjusted for age, BMI, education, income, work-related physical activity, smoking, self-rated health, chronic diseases. Bold represents significant p-value (<0.05)

vious studies[14,15]. Women may perceive more traditional, social and environmental barriers than men to engaging in exercise[8,15]. For instance, exercise has been considered "not ladylike"[16]. These aspects may in part be responsible for the lower rate of participation in exercise throughout life among women. Furthermore, a large drop in participation in exercise was observed among women in their 20s and 30s. The transition from adolescence to adulthood is a period of general decline in physical activity[17]. Some life changes, such as getting married and having children, affect physical activity in young adulthood in women more than in men[5]. National data in Japan show that the age of first marriage for men was 26.9 years and for women 24.2 years in 1970[18]. The most common age range for giving birth is 20-39 years[19]. After the fourth decade of life, most people's family and job situations seem to be established and stable. Retirement, in turn, tends to increase physical activity[20]. These life events may be associated with regular exercise. Further research on the relationship between life events and exercise is needed to clarify this issue.

The most popular activities and sports changed between the earlier and later age categories; there was also a gender difference in popular types of activities throughout life. Previous studies have reported a high frequency of ball games among men across ages 14 to 31 years[21]. Dance and gymnastics were more popular with women[15,22]. Our finding supports the previous gender difference in the traditional preferences for specific types of exercise. From the perspective of age, team sport activities were common in adolescence and young adulthood, and individual sports in middle age and older. A possible explanation of the shift is that social situations and lifestyle change according to age, for instance, it is more difficult for a large number of adults to get together, whereas individual sports can be performed in one's own time[21]. Individual sports are sometimes labeled lifetime sports[23] and adult-like activities[17]. Previous studies have reported walking and gardening as the most common activities among older adults[24]. To maintain their exercise levels, people may have to choose specific types of exercise as their lifestyles change with aging[25]. We may consider that older people who engage in regular exercise in our study are those who are able to find suitable activities to match their life changes.

In this study, we tracked regular exercise from adolescence to age 60 and over, and described the individual variation in participation in exercise. A number of participants reported participating in regular exercise at some time in their life, although reports of consistent engagement in regular exercise across several decades were scarce. We have already shown cross-sectionally in Table 2 that the prevalence of regular exercise in the 20s and 30s was low. Figure 1 illustrates the findings as individual transitions of regular exercise throughout life. Although the percentage in each pattern was small, and the patterns of exercise frequency seemed to be similar in both men and women, we found that among men the most frequent pattern was participation in regular exercise at all the life stages; whereas among women the most frequent pattern was no regular exercise at all. Results suggest that encouragement and support for older women should be provided by health professionals as well as the community, since participation in exercise may induce a major behavioral change among older women. There may be a need to tailor health promotion messages and interventions according to gender and personal exercise history.

After fully adjusting for confounding factors such as age, BMI, education, annual income, smoking, work-related physical activity, self-rated health, and chronic diseases, both men and women who had participated in regular exercise during 40-59 years of age had a 5 to 7-fold higher rate of participation in exercise at age 60 and over. This result suggests that participation in exercise during 40-59 years of age predicts exercise at age 60 and over. Our findings are in line with those of some previous studies[7,8]. Frändin et al. , who studied age groups from the age of 10 years, found that physical activity during earlier life was not correlated with physical activity at the age of 76, except for the last age period 66-76 years[7]. Other studies also found the last age group to be better predictors than earlier ones[8,26]. The short interval may be one of the causes for the strong relationship between regular exercise at 40-59 years of age and that at age 60 and over. A number of studies have suggested that childhood is usually considered the best time for socialization into physical activity[8], for encouraging physical activity in adults through the developing of habits[25] and for promoting exercise-related feelings of pleasure and joy[7]. Furthermore, sports activities may have an effect on motor and coordination skills that may be of value later in life[21]. We believe that the positive effects of exercise in early life are associated with physical activity in older life. In fact, regular exercise during all the age categories studied affected exercise at age 60 and over among men. However, demographic, psychological, behavioral, social and environmental factors are associated with adulthood participation in physical activity[27]. These multiple factors may decrease the positive effect of earlier exercise at older ages. Health problems were reported to be the most common barrier to increasing physical activity[28]. We found that the effect of regular exercise at 40-59 years of age on participation in exercise at age 60 and over increased among women who had a history of hypertension in the sub-analyses (data not shown). Chronic health problems may also have influenced the motivation for physical activity as a part of clinical care. Our finding that regular exercise during 40-59 years of age was associated with that at age 60 and over was true for a lot of people who had not engaged in regular exercise earlier in their lives. The motivation to engage in regular exercise in the fourth and fifth decades of life may have important implications for promoting increased physical activity in older age.

This study has several limitations. The first limitation

is that our study was a retrospective study and the regular exercise data were based on self-reports. Possible memory failure and potential recall bias may have influenced the results. In addition, we were not able to take into account the short-term substitution of one exercise for another as regular exercise was defined as an activity lasting one year. Therefore our study may underestimate regular exercise as an indicator of physical activity. Secondly, social and environment factors, which have been indicated as predictors of physical activity, were not widely examined in our study. Environmental factors are among the important factors promoting participation in physical activity[16]. Recent studies suggested that environmental problems, such as poorly lit streets or noisy traffic, are correlated with inactivity[29]. Further studies are needed to confirm the association between regular exercise and a comprehensive range of factors. Finally, the definition of regular exercise in this study was lower than the well-known recommendation of physical activity for adults by the American College of Sports Medicine[30]. However, we previously found that continuation of regular exercise by the same definition as used in this study was associated with higher muscle strength and power in both elderly men and women[31]. A number of older people are physically inactive. "Tojikomori", being housebound, which has been defined in recent studies as going outdoors once or less than once a week, is a serious concern in relation to older people[32]. Pate et al. suggest that an active lifestyle does not require a regimented, vigorous exercise program[33]. To avoid causing undue stress coming from misconceptions, it may be sufficient just emphasizing to older people the importance of being physically active as opposed to having to maintain a disciplined workout schedule.

The strengths of the present study include a large number of randomized community-dwelling people and regular exercise data tracked from age 12 to 60 years and over. These data provide important information for demonstrating the value of life-long physical activity. The participants had a face-to-face interview by trained staff, which increases the reliability of the answers and reduces missing data in the questions. We were able to take into account essential social and health condition data such as education, smoking and disease as confounders. Our study described individual variation in regular exercise throughout the various stages of a person's life and showed the positive impact of experiences of exercise in earlier life on regular exercise in later life; and thus lays a good foundation for persuading the general population of the importance of maintaining physical activity throughout life.

Conclusion

The present study found that men engaged in regular exercise more than women throughout their lifetime. Exercise preferences differed depending on age and gender. Among women, those reporting no regular exercise were the largest group. Among men, regular exercise earlier in life positively affected regular exercise at age 60 years and over. Regular exercise in middle age markedly increased participation in exercise later in life regardless of social and health conditions among both men and women.

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血清カロテノイドが2年後の骨粗鬆症／骨量減少発症リスクに及ぼす影響

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血清カロテノイドが2年後の骨粗鬆症／骨量減少発症リスクに及ぼす影響

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1. 緒　言

骨粗鬆症は超高齢社会を迎えた我が国の国民病の一つであり，有病者数は1200万人と言われる．また一旦発症すると骨密度の改善は難しいことからも，栄養・運動による一次予防が重要と考えられる．骨粗鬆症の予防因子として栄養分野では従来からビタミンD[1]やカルシウム[2,3]に関する研究が多いが，近年，野菜や果物摂取[3,4]にも骨吸収抑制作用があることが報告されている．野菜や果物には抗酸化物質であるカロテノイドやビタミンCが大量に含まれており，これらの栄養素と骨粗鬆症に関する報告[5,6]もあるが，結論は一定していない．

本研究では野菜や果物から摂取されるカロテノイドの安定した指標として血清カロテノイド濃度を用い，地域在住中高年者の骨密度や骨粗鬆症とカロテノイドとの関連について縦断的に検討するとともに，カロテノイドとビタミンC摂取の相互作用が骨密度・骨粗鬆症に与える影響を明らかにすることを目的とした．

2. 方　法

対象は「国立長寿医療研究センター・老化に関する縦断疫学研究（NILS-LSA）」[7]の第5次調査（2006.7～2008.7）参加者2,419人の中で血清カロテノイド測定が行われ，第6次調査(2008. 7～2010. 7)にも参加した2,088人（(男性1,058人，女性1,030人，平均年齢60.1 ± 12.3歳，継続参加率（86.3%)）である．

なお，NILS-LSAは愛知県大府市および知多郡東浦町に在住の中高年者から年齢・性を層化した無作為抽出で選ばれた者で文書による同意（インフォームド・コンセント）の得られた約2,400人を対象とした，老化と老年病に関する長期縦断疫学研究である．NILS-LSAの研究は国立長寿医療研究センター倫理委員会の承認を受け，すべての対象者から文書による同意を得て行われている．

血清カロテノイドは第5次調査時の凍結保存血清を用い，ルテイン，リコピン，α-カロテン，β-カロテン，β-クリプトキサンチン，ゼアキサンチンを京都微生物研究所に委託し，高速液クロマトゴラフィーで測定した．ビタミンC摂取量は，第5次調査時に3日間の食事秤量記録調査[8]を行い，ビタミンCの一日平均摂取量を求めた．骨密度は第5次調査・第6次調査において，DXA（Dual-energy X-ray Absorption，Hologic社製QDR-4500）を用い，第2-4腰椎・右大腿骨頸部骨密度を測定し，日本骨代謝学会の診断基準[9]に準拠して，YAM（若年成人平均）の70%未満である者をそれぞれ腰椎および大腿骨頸部で判定した「骨粗鬆症」，80%未満である者を「骨量減少」（骨粗鬆症を含む）とした．

血清カロテノイドが2年後の骨粗鬆症，骨量減少に及ぼす影響について，第5次調査時点で腰椎，大腿骨頸

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部それぞれにおいて骨粗鬆症，骨量減少のなかった者を対象とし，2年後の第6次調査でYAMの70%未満（＝新規骨粗鬆症者），およびYAMの80%未満（＝新規骨密度低下者＋新規骨粗鬆症者）となるリスクについて，第5次調査時点の6種の血清カロテノイド値3分位で対象を3群に分け，最も濃度の低い第1分位に対する第2，第3分位のオッズ比を性別に年齢，BMI，季節および男性では喫煙，女性では閉経を調整した一般化推定方程式（Generalized Estimating Equation）で求めた．同様な解析方法を用いてビタミンCと各カロテノイドの交互作用についても検討した．統計解析にはSAS9.1.3を用い，$p<0.05$を統計的有意とした．

3. 結　果

第5次調査時に腰椎で骨量減少のなかった男性859人，女性643人の中で，2年後骨量減少を示した者は，それぞれ12人（1.4%），40人（6.2%）であった．同様に腰椎での新規骨粗鬆症者は男性，女性それぞれ982人中11人（1.1%），824人中24人（2.9%）であった．大腿骨頸部に関しては，新規骨量減少者は男女それぞれ657人中36人（5.5%），534人中67人（12.5%）であり，骨粗鬆症者は919人中19人(2.1%)，788人中44人(5.6%)であった．

第5次調査時点の6種の血清カロテノイド値3分位で対象を3群に分け，最も濃度の低い第1分位に対する第2，第3分位骨粗鬆症／骨量減少発症のオッズ比を性別に年齢，BMI，季節および男性では喫煙，女性では閉経を調整した一般化推定方程式で求めたところ，男性では有意な結果は得られなかったが，女性では腰椎骨量減少に対してα-カロテンが有意で，第1分位に対する第2分位のOdds比は0.54（95%信頼区間　0.24-01.24，p=0.0752），第1分位に対する第3分位のOdds比は0.44（0.19-0.99，p=0.068）でOdds比の傾向性検定の結果も有意であった（p=0.0481）．また女性の大腿骨頸部骨粗鬆症に対してはα-カロテン，β-カロテンが有意であった．α-カロテンでは第1分位に対する第2分位，第3分位のOdds比はそれぞれ0.49（0.2244-1.0749，p=0.1497），0.31（0.13-0.73，p=0.0068）でOdds比の傾向性検定の結果も有意であった（p trend=0.0053）．同様にβ-カロテンでは第1分位に対する第2分位，第3分位のOdds比は0.99（0.47-2.10，p=0.9771），0.35（0.14-0.85，p= 0.0200）で，Odds比の傾向性検定の結果も有意であった（p trend=0.0172）（図1）．

2年後の新規骨粗鬆症／骨量減少の発生に対するビタミンC摂取量3分位，各血清カロテノイド値3分位の交互作用を性別に，年齢，BMI，季節，および男性では喫煙，女性では閉経を調整した一般化推定方程式で検討

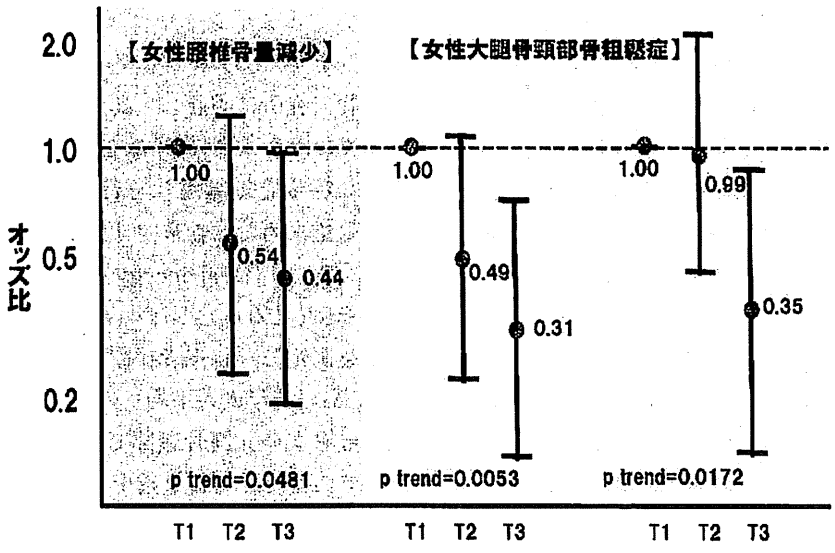
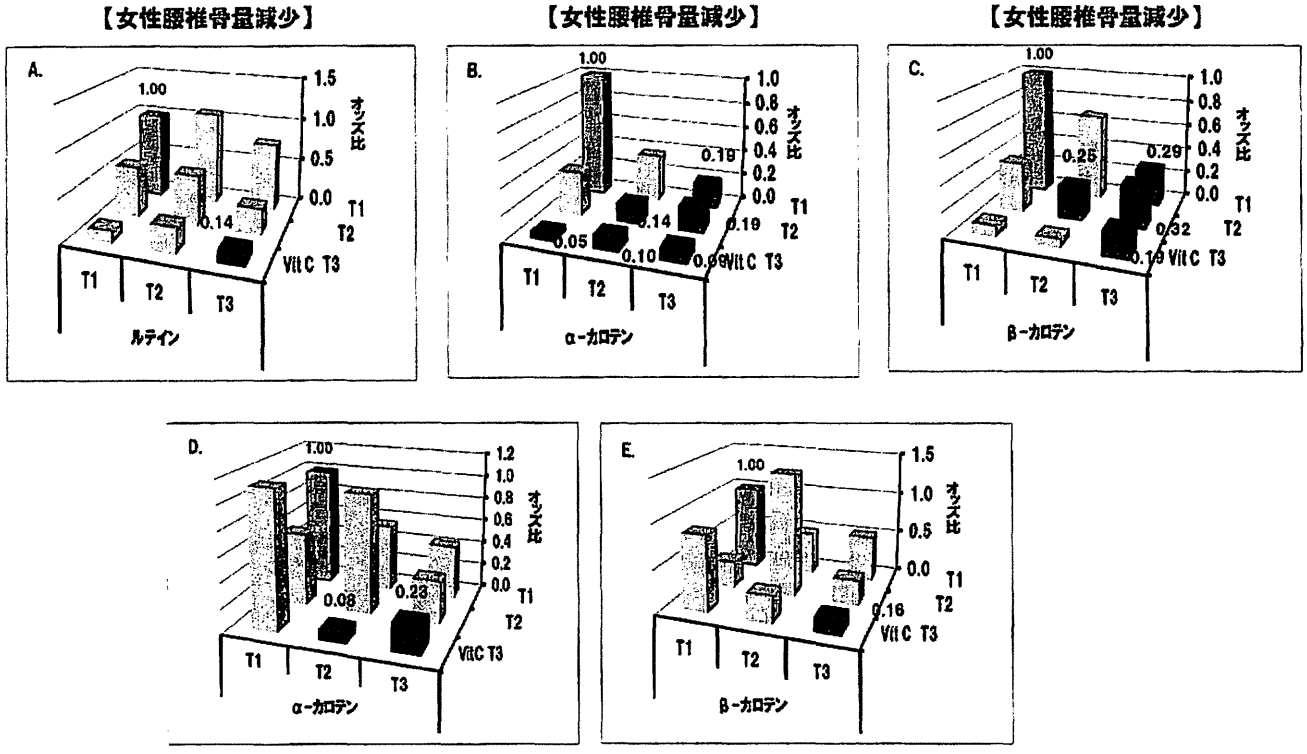


図1　血清カロテノイドの2年後の骨粗鬆症・骨量減少リスクへの影響
年齢，BMI，季節，閉経を調整した一般化線形モデルによる．T1，T2，T3は血清カロテノイド3分位による対象者の群分けを示す．



■図2 血清カロテノイドとビタミンC摂取量の2年後の骨粗鬆症・骨量減少リスクへの影響
年齢，BMI，季節，閉経を調整した一般化線形モデルによる．T1，T2，T3は血清カロテノイド，ビタミンC摂取量3分位による対象者の群分けを示す．図中灰色の棒クラブはレファレンス（基準値），濃い灰色はレファレンスに比してオッズ比が有意に低かった群を示す．

したが，統計的に交互作用が有意なモデルはなかった．

しかし，ビタミンC摂取量第1分位，血清カロテノイド値第1分位を基準として各分位のOdds比を求めたところ，女性の腰椎骨量減少に対して，ルテイン第3分位・ビタミンC第3分位のOdds比は0.140（95%信頼区間 0.026-0.753，p=0.0221）と有意に低かった．同様に女性の腰椎骨量減少に対してα-カロテン，β-カロテンが，また女性の大腿骨骨粗鬆症に対してもα-カロテン，β-カロテンが，ビタミンC3分位との掛け合わせにおいて，有意な相加効果を示した（図2）．

4. 考察および結語

血清カロテノイドが2年後の骨密度に及ぼす影響について検討した結果，女性では血清α-カロテン，β-カロテン値が高い群では，2年後の骨粗鬆症／骨量減少発生リスクが低いことが示された．またカロテノイドとともにビタミンCを摂取することがカロテノイドの抗骨粗鬆症作用を増強することが示唆された．心臓血管疾患[10]や動脈硬化[11,12,13]と骨粗鬆症との間には有意な関連が報告されており，加齢・喫煙・糖尿病などによる慢性的な過酸化状態が共通の背景要因と考えられている．本研究においてカロテノイドやビタミンCは中高年者の骨密度低下に予防的に働く可能性があると考えられた．（この研究の一部は果樹試験研究推進協議会の委託研究費によって行われた．）

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〈若手企画シンポジウム2：サルコペニア―研究の現状と未来への展望―〉

1. 日常生活機能と骨格筋量，筋力との関連

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1. 日常生活機能と骨格筋量，筋力との関連

下方　浩史[1)]　安藤富士子[2)]

要　約　サルコペニアは高齢者の日常生活機能を低下させ，健康長寿の障害となる．われわれは無作為抽出された地域在住中高年者コホートのデータを使用して，日常生活機能と筋力，筋量との関連について検討した．男女ともに40歳以降，握力，下肢筋力は年間約1パーセントずつ低下していた．どの年代でも男性は女性よりも筋力が強く，80代の男性の筋力は40代の女性の筋力にほぼ等しかった．筋力の低下は女性の日常生活機能により大きな影響を与える可能性がある．一方，四肢の筋量は男性では加齢とともに低下するが，女性では加齢による低下はほとんどなかった．このことは女性では筋肉の量的な変化よりも，質的な変化が問題になっていることを示している．日常生活機能は筋肉のパフォーマンスの影響を受け，握力と歩行速度で推定することが可能であった．高齢者の脆弱を予防するためには，これらの評価によりハイリスクの集団を見つけることが重要であろう．

Key words：サルコペニア，日常生活機能，筋量，筋力，老化

（日老医誌　2012；49：195–198）

はじめに

老化に伴う筋量減少（サルコペニア）は，高齢者のADLを低下させ，健康長寿を実現の大きな障害となる[1)2)]．しかし，老化に伴う筋量減少の実態は明らかでなく，またサルコペニア自体の簡便な基準がない．臨床の現場や住民調査などで使用できる簡便なサルコペニアの基準が必要である．これらの検討を一般住民のコホートのデータを使用して行った．

研究方法

対象は「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）」第5次調査参加者で，40歳から88歳までの無作為抽出された地域在住中高年者2,419名（男性1,200名，女性1,219名）である[3)]．上腕囲，臍高腹囲，大腿囲，下腿囲を身体指標として計測し，また体力の指標として，普通歩速度，速歩速度，上体起こし，膝伸展筋力，脚伸展パワー，握力を計測した．日常生活機能として健康関連QOL尺度であるSF36の身体機能項目を用いた．サルコペニア指標として，Dual-energy X-ray absorptiometry（DXA）（QDR 4500, Hologic）によって四肢除脂肪・除骨重量測定し，これを四肢筋量とした．Baumgartnerら[1)]の方法に準じ，四肢筋量（kg）を身長（m）の二乗で除した値をSkeletal Muscle Index（SMI）とし，サルコペニアの指標とした．その判定基準には同じQDR 4,500で測定したSanadaら[4)]によるYAM（Young Adult Mean：18～40歳）の－2SD（男性6.87 kg/m^2，女性5.46 kg/m^2）を用いた．

サルコペニアの性・年代別頻度

DXAによるSMIでの診断基準で求めたサルコペニアの有無を，性・年齢別の分布をみた（図1）．男性では25.0パーセントが，女性では24.2パーセントがサルコペニアであり，全体の割合には性差はなかった．年代別の検討では，男性では加齢とともにサルコペニアの頻度は高くなっていたが（p trend<0.0001），女性では有意な加齢変化はなかった．男性のSMIの平均値±SDは7.42±0.83 kg/m^2，女性は5.96±0.73 kg/m^{2}であり，男性の方が有意に高い値であった（p<0.0001）．男性では加齢とともにSMIは低下していたが（p trend<0.0001），女性では有意な加齢変化はなかった．男女ともに年齢が高いほど握力は低下していた（p trend<0.0001）．男性の方が低下率は大きかったが，80代でも女性の40代の握力よりも大きかった．膝伸展筋力についても握力と同様に，

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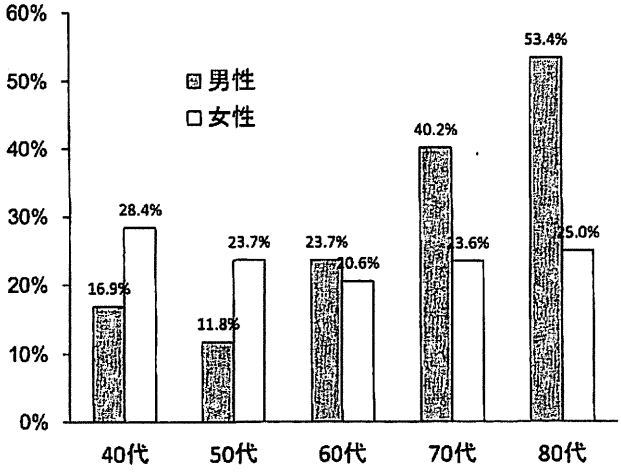

図1　サルコペニアの性・年代別頻度
DXAによるSMIでの診断基準（YAMの－2SD）での判定を行った．男性では加齢とともにサルコペニアの頻度は高くなっていたが（p　trend<0.0001），女性では有意な加齢変化はなかった．

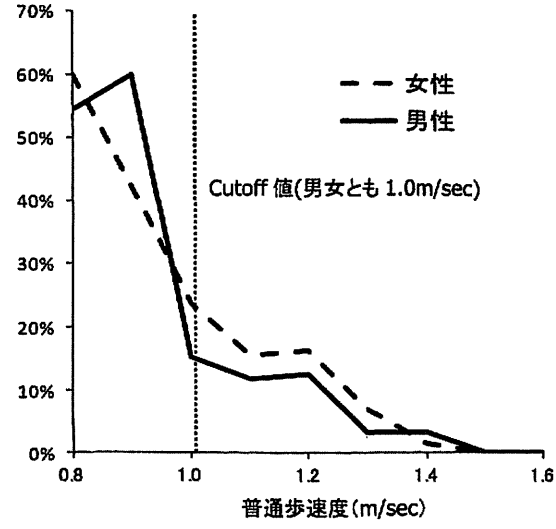

図2　普通歩速度と数百メートル以上歩くことに困難を感じる割合（65歳以上）

男女ともに加齢とともに低下していた．男性の方が低下率は大きかったが，男性の80代でも女性の40代とほぼ同じ値であった．

SMIに影響を与える変数を求めるとともに，SMIを推定するための簡便な式の作成を行うために，SMIと身体測定値，アルブミンとの相関解析を行った．SMIは上腕囲，下腿囲，大腿囲，腹囲BMIと強い正の相関があったがアルブミンとは相関はなく，体脂肪率とは弱い正の相関が認められた．SMIと最も相関が強かったのはBMIであり，相関係数は男性で0.77，女性で0.73と高かった．周囲長では女性で下腿囲が最も相関が強く，男性では上腕囲，下腿囲，大腿囲で相関係数はほぼ同じ値となった．

65歳以上の男女について，年齢，BMI，下腿からSMIを推定する重回帰式の作成を試みた．その結果，以下の回帰式を得ることができた．

男性：SMI＝－0.1026×年齢＋0.1341×BMI＋0.6034×下腿囲＋2.5653（r^2＝0.651）

女性：SMI＝－0.0413×年齢＋0.0513×BMI＋0.4438×下腿囲＋0.5509（r^2＝0.558）

骨格筋量，筋力と日常生活機能

65歳以上の男女についてサルコペニアの有無とSF36での身体機能との関連を検討した．男性では一部の項目でサルコペニアがあると身体機能は低下していたが，その差は大きくなかった．女性ではサルコペニアによる身体機能の有意な低下はなかった．身体機能の障害の有無とSMIとの関連については，男性では身体機能の障害の有無によるSMIの差はいくつかの項目で認められたものの，その差はそれほど大きくはなかった．女性では身体機能の障害の有無によるSMIの差はほとんどなかった．

65歳以上の男女について，身体機能と歩行や筋力などの体力との正準相関係数を求めて，体力のどの項目が身体機能と関連しているのかを検討した．その結果，男女とも普通歩速度が身体機能にもっとも関連しており，筋力では脚伸展パワーの影響が男性でもっとも大きかったが，握力は男女ともに身体機能に大きな影響が与えていた．

一般住民で日常生活に影響が出るような障害は，SF36の中強度の身体活動項目に困難を感ずる障害と考え，中強度の項目のうち「数百メートル以上歩くこと」を身体機能の指標とすることとした．「数百メートル以上歩くこと」が困難になれば，日用品の買い物にも支障が生じ，独立した生活を送ることが困難となる．体力，身体計測値がどの程度まで低下すると身体機能が低下するのか，身体機能との関連が認められた項目のうち，簡便に測定できるものについてカットオフ値を求めた．図2に示すように，普通歩速度は男女ともに1 m/secよりも遅くなると身体機能が低下する割合が大きく増加した．握力に関しては，普通歩ほどカットオフ値ははっきりしなかったが，男性で25 kg，女性で20 kgをカットオフ値とした．身体計測値については，女性ではSMIが低い部分でのカットオフ値は決められなかった．男性ではカットオフ値は5.5 kg/m^2であった．BMIは女性では値

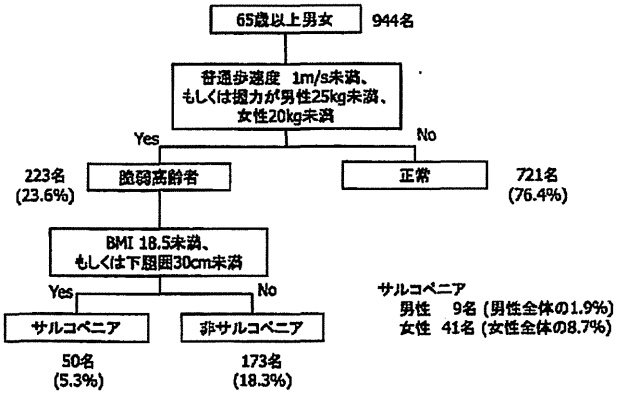

図3　サルコペニアの簡易基準案と，一般住民での分布

が小さいほど，つまりやせているほど身体機能は良くなっており，カットオフ値は決められなかったが，男性では19 kg/m²がカットオフ値であった．下腿囲も同様に女性ではカットオフ値は決められなかったが男性では30 cmであった．

サルコペニアの簡易基準の作成

サルコペニアの簡易基準の作成は，体力や身体計測値から中強度の身体機能に支障が生じる可能性のある集団を捉えることを目指した．判定に使用する項目は，簡便な器具で簡単に測定できるものとした．さらに，Muscle performanceとmuscle volumeを分けて考えることとし，Muscle performanceは普通歩速度と握力で評価し，Muscle volumeは測定に高額で放射線被曝を伴う機器が必要なSMIの代わりにBMIと下腿囲で評価することとした．また，各指標のカットオフ値は中強度の身体機能との関連で決めることとし，女性で上記の基準で決められない場合には，従来のやせの基準値や男性の値を参考に決めることとした．

European consensus[5]によるサルコペニアの簡易基準を参考に，日本人高齢者におけるサルコペニアの簡易基準の作成を試みた．図3に示すように，まず普通歩速度1 m/sec未満，もしくは握力が男性25 kg未満，女性20 kg未満である場合には脆弱高齢者と判断し，脆弱高齢者のうち，BMI 18.5 kg/m²未満もしくは下腿囲30 cm未満である場合をサルコペニアとした．

今回の検討での対象者についてこの基準を当てはめてみると，65歳以上の男女944名のうち23.6パーセント(223名）が脆弱高齢者であり，さらに全体の5.3パーセント（50名）がサルコペニアと診断された．その内訳は男性9名（男性全体の1.9パーセント），女性41名（女性全体の8.7パーセント）と女性で割合が高くなっていた．

ここに示したサルコペニアの簡易基準案は，身長，体重，握力計とメジャー，ストップウォッチがあれば実施することができる．スクリーニング検査として有用と思われるが，さらに縦断的なデータを用いて，妥当性の検討を行っていきたい．

ま と め

40歳以上の地域住民2,419名を対象としたDXAによる判定では男性の25.0パーセントが，女性の24.2パーセントがサルコペニアに分類された．男性では加齢とともにサルコペニアの割合は増加していたが，女性では加齢による変化はなかった．サルコペニアの簡易基準の作成は，体力や身体計測値から中強度の身体機能に支障が生じる可能性のある集団を捉えることを目指した．その結果，普通歩速度1 m/sec未満もしくは握力が男性25 kg未満，女性20 kg未満である場合には脆弱高齢者と判断し，脆弱高齢者のうちBMI 18.5 kg/m²未満もしくは下腿囲30 cm未満である場合をサルコペニアとした．65歳以上の男女の5.3パーセントがサルコペニアとされた．

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Association of daily physical performance with muscle volume and strength

Hiroshi Shimokata[1] and Fujiko Ando[2]

Abstract

Sarcopenia disturbs the daily life of elderly people, and hinders healthy aging. We studied the association of daily physical performance with muscle volume and muscle strength in a randomly selected community-living population. Results: Grip power and leg muscle strength decreased about 1% per year after age 40 in both men and women. Muscle strength was greater in men than in women at every age by decade, and muscle strength in men in their 80s was similar to that in women in their 40s. Therefore, the effect of a decrease in muscle strength on daily physical performance was greater in women than men. On the other hand, the muscle volume of all limbs decreased with age in men, but there was almost no decrease in muscle volume in women. These results indicate that qualitative change in muscle was more significant than quantitative change in muscle in women. Daily physical performance was influenced by muscle performance and could be assessed based on grip power and walking speed. To prevent frailty, it may be important to determine the high-risk group for frailty using these assessments.

Key words: *Sarcopenia, Daily physical performance, Muscle volume, Muscle strength, Aging*
(Nippon Ronen Igakkai Zasshi 2012; 49: 195–198)

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