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ORIGINAL ARTICLE

Prevalence of knee pain, lumbar pain and its coexistence in Japanese men and women: The Longitudinal Cohorts of Motor System Organ (LOCOMO) study

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Abstract The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 through a grant from the Ministry of Health, Labour, and Welfare of Japan to integrate information from several cohorts established for the prevention of musculoskeletal diseases. We integrated the information of 12,019 participants (3,959 men and 8,060 women) in the cohorts comprising nine communities located in Tokyo (two regions: Tokyo-1 and Tokyo-2), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region)], Hiroshima, Niigata, Mie, Akita, and Gunma prefectures. The baseline examination of the LOCOMO study consisted of an interviewer-administered questionnaire, anthropometric measurements, medical information recording, X-ray radiography, and bone mineral density measurement. The prevalence of knee pain was 32.7 % (men 27.9 %; women 35.1 %) and that of lumbar pain was 37.7 % (men 34.2 %; women 39.4 %). Among the 9,046 individuals who were surveyed on both knee pain and lumbar pain at the baseline examination in each cohort, we noted that the prevalence of both knee pain and lumbar pain was 12.2 % (men 10.9 %; women 12.8 %). Logistic regression analysis showed that higher age, female sex, higher body mass index (BMI), living in a rural area, and the presence of lumbar pain significantly influenced the presence of knee pain. Similarly, higher age, female sex, higher BMI, living in a rural area, and the presence of knee pain significantly influenced the presence of lumbar pain. Thus, by using the data of the

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LOCOMO study, we clarified the prevalence of knee pain and lumbar pain, their coexistence, and their associated factors.

Keywords Nation-wide population-based cohort study · Epidemiology · Prevalence · Knee pain · Lumbar pain

Introduction

Musculoskeletal diseases, including osteoarthritis (OA) and osteoporosis (OP), are major public health problems among the elderly; these diseases can affect activities of daily living (ADL) and quality of life (QOL), and can lead to increased morbidity and mortality. According to the recent National Livelihood Survey by the Ministry of Health, Labour, and Welfare in Japan, OA is ranked fourth among diseases that cause disabilities and subsequently require support for ADL, whereas falls and osteoporotic fractures are ranked fifth [1]. Studies have reported increased mortality after osteoporotic fractures at the hip and other sites [2]. An estimated 47,000,000 individuals (21,000,000 men and 26,000,000 women) aged ≥40 years will eventually be affected by either OA or OP [3].

Considering that the population of Japan is aging rapidly, a comprehensive and evidence-based prevention strategy for musculoskeletal diseases is urgently needed. However, only a few prospective, longitudinal studies designed to develop such a strategy have been conducted. Therefore, little information is available regarding the incidence of disability and the prevalence and incidence of musculoskeletal disorders, including knee pain, and lumbar pain, and their associated factors in Japan. The absence of such epidemiological data hampers the rational design of clinical and public health approaches for the diagnosis, evaluation, and prevention of musculoskeletal diseases.

Several cohorts have focused on the prevention of OP, knee OA (KOA), lumbar spondylosis (LS) or disability caused by musculoskeletal diseases. However, since the prevalence of the musculoskeletal diseases has been reported to be high [3], the extent of the population at risk after excluding those who had the target disease at the baseline seems to be small. To identify epidemiological indices, especially the incidence of musculoskeletal diseases and/or disability, a large number of subjects is required. In addition, to determine the regional differences in epidemiological indices, we need a survey of cohorts across Japan.

The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 by the members of the committee for 'the prevention of knee and back pain and bone fractures in a large cohort of regionally representative residents from across Japan,' through a grant from the Ministry of Health, Labour, and Welfare of Japan (Director, Noriko Yoshimura). This study aimed to integrate the information of several cohorts established for the prevention of musculoskeletal diseases from 2000 onwards, and to initiate a follow-up examination using the unified questionnaire from 2006 onwards in Japan.

In the present paper, by using the integrated information at the baseline of the LOCOMO study, we tried to confirm the prevalence of clinical symptoms of musculoskeletal diseases, such as knee pain and lumbar pain and their characteristics.

Materials and methods

Participants

Participants in the cohorts were residents of nine communities located in Tokyo (two regions: Tokyo-1, principle investigators (PIs): Shigeyuki Muraki, Toru Akune, Noriko Yoshimura, Kozo Nakamura; Tokyo-2, PIs: Yoko Shimizu, Hideyo Yoshida, Takao Suzuki), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region); PIs: Noriko Yoshimura, Munehito Yoshida], Hiroshima (PI: Saeko Fujiwara), Niigata (PI: Go Omori), Mie (PI: Akihiro Sudo), Akita (PI: Hideyo Yoshida), and Gunma (PI: Yuji Nishiwaki) prefectures [4]. Figure 1 shows the location of each cohort in Japan, and Fig. 2 provides the timeline of the LOCOMO study. Residents of the nine regions were recruited from resident registration lists in the relevant region. Data for the 12,019 participants were collected and registered as an integrated cohort. Numbers of participants in the LOCOMO study classified by regions of each cohort are shown in Table 1. The smallest cohort consisted of 826 individuals in Wakayama-2, and the largest consisted of 2,613 individuals in Hiroshima.

All participants provided written informed consent, and the study was conducted with the approval of the ethics committees of the University of Tokyo (nos. 1264 and 1326), the Tokyo Metropolitan Institute of Gerontology (no. 5), Wakayama (no. 373), The Radiation Effects Research Foundation (RP03-89), Niigata University (no. 446), Mie University (no. 837 and no. 139), Keio University (no. 16–20), and National Center for Geriatrics and Gerontology (no. 249). Safety of the participants was ensured during the examination and during all other study procedures.

Data collection

The baseline examination of the LOCOMO study consisted of the following: an interviewer-administered questionnaire,

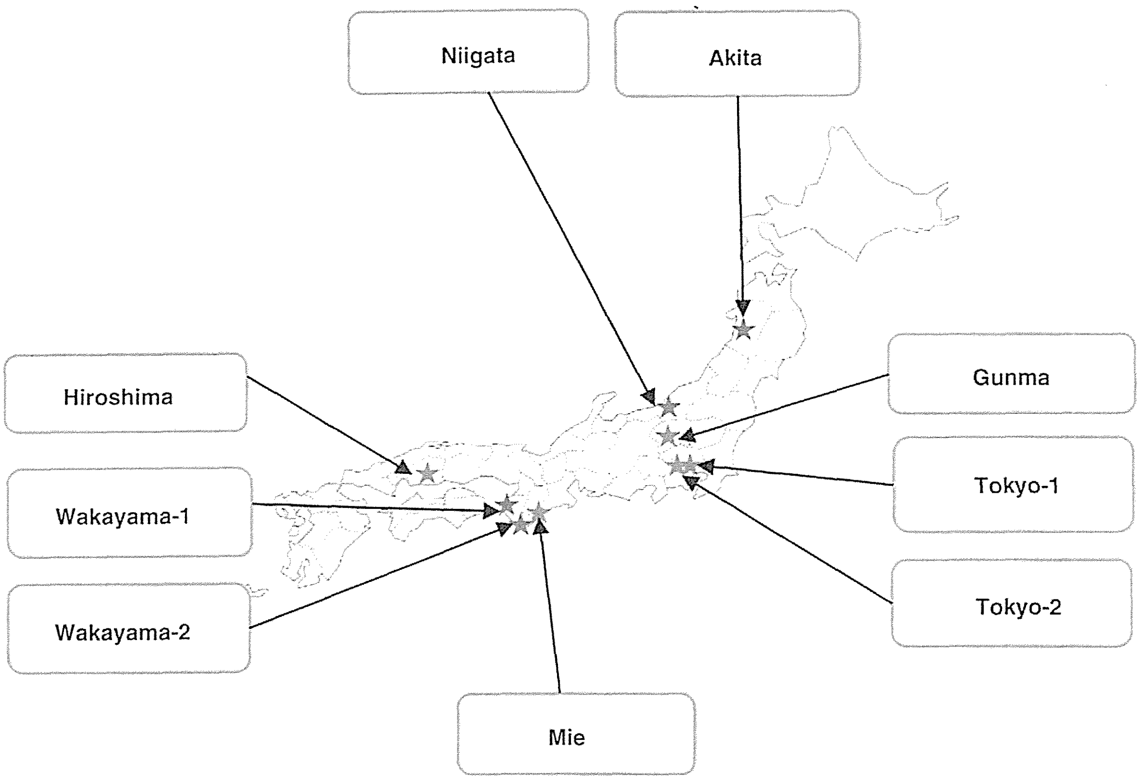

Fig. 1 Locations of the nine different regions from which the study cohorts were derived

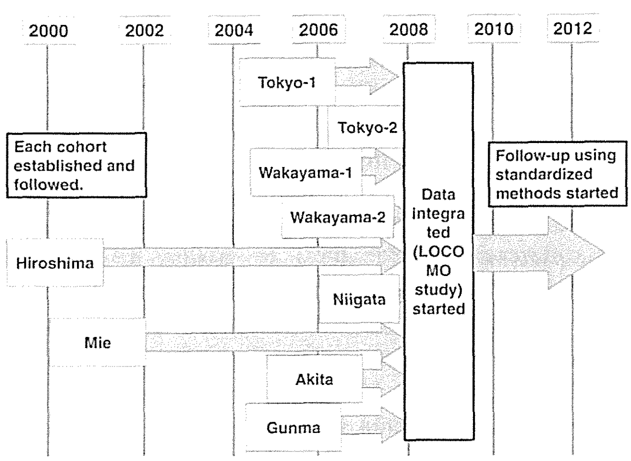

Fig. 2 Timeline of the LOCOMO study

Table 1 Numbers of participants in the LOCOMO study classified by regions of each cohort

Regions of each cohort	Start year	Total	Men	Women
Tokyo-1	2005	1,350	465	885
Tokyo-2	2008	1,453	59	1,394
Wakayama-1 (mountainous)	2005	864	319	545
Wakayama-2 (seaside)	2006	826	277	549
Hiroshima	2000	2,613	794	1,819
Niigata	2007	1,474	628	846
Mie	2001	1,175	423	752
Akita	2006	852	366	486
Gunma	2005	1,412	628	784
Total		12,019	3,959	8,060

anthropometric measurements, medical information recording, radiography, and bone mineral density (BMD) measurement.

Interviewer-administered questionnaire

A questionnaire was prepared by modifying the questionnaire used in the Osteoporotic Fractures in Men Study (MrOS) [5], and some new items were added to the modified questionnaire. Knee symptoms were evaluated using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [6]. Health-related QOL was evaluated using the European QOL-5 dimensions instrument (EuroQOL EQ5D) [7] and the Medical Outcomes Study 8-item Short Form (SF-8) [8]. The study staff recorded all the medications administered and their doses.

Anthropometric measurements

Anthropometric factors were measured by well-trained medical nurses. Body mass index [BMI; weight in kilograms/(height in meters)^2] was calculated on the basis of the current height and weight. Hand grip strength was measured using a Toei Light handgrip dynamometer (Toei Light Co., Ltd., Saitama, Japan). Both hands were tested, and the higher value was used to characterise the maximum muscle strength of the subject. Walking speed was determined by recording the time taken by a subject to walk a determined distance, such as 5 or 6 m, at his/her usual speed. The ability to rise from a chair without using the arms (chair stand) and the ability to perform 5 chair stands was evaluated. The time required to complete the tasks was recorded.

Medical information

Medical information was obtained by experienced medical doctors in each cohort. All participants were questioned about pain in both knees by asking the following questions: 'Have you experienced right knee pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' and 'Have you experienced left knee pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' Subjects who answered 'yes' were considered to have knee pain. Lumbar pain was determined by asking the following question: 'Have you experienced lumbar pain on most days (and continuously on at least one day) in the past month, in addition to the current pain?' Subjects who answered 'yes' were considered to have lumbar pain.

In some cohorts (Tokyo-1, Wakayama-1, and Wakayama-2), the participants completed the modified Mini-Mental Status Examination-Japanese version [9] for evaluating cognitive function. Physicians explained any unclear sections of this questionnaire to the participants and assessed the cognitive status on the basis of the completed questionnaire.

Radiography and radiographic assessment

In several cohorts (Tokyo-1, Wakayama-1, Wakayama-2, Hiroshima, Niigata, and Mie), the radiographic examination of knees and/or spine was performed to evaluate the OA or fractures. Plain radiographs were obtained for both knees in the antero-posterior view with weight-bearing and foot map positioning and for the spine in the antero-posterior and lateral views.

The severity of OA was radiographically determined according to the Kellgren-Lawrence (KL) grading system as follows [10]: KL0, normal joint; KL1, slight osteophytes; KL2, definite osteophytes; KL3, narrowing of joint cartilage, and large osteophytes; and KL4, bone sclerosis, narrowing of joint cartilage, and large osteophytes. In the LOCOMO study, joints exhibiting disc-space narrowing alone and no large osteophytes were graded as KL3. In each cohort, radiographs were examined by a single, experienced orthopaedic surgeon who was masked to the clinical status of the participants. If at least one knee joint was graded as KL2 or higher, the participant was diagnosed with radiographic KOA. Similarly, if at least one intervertebral joint of the lumbar spine was graded as KL2 or higher, the participant was diagnosed with radiographic LS.

BMD measurement

In the Wakayama-1, Wakayama-2, and Hiroshima cohorts, BMD of the lumbar spine and proximal femur was measured using dual energy X-ray absorptiometry (DXA) (Hologic Discovery; Hologic, Waltham, MA, USA) during the baseline examination.

OP was defined on the basis of the World Health Organization (WHO) criteria. Specifically, OP was diagnosed when the BMD T scores were lower than the mean lumbar peak bone mass—2.5 SDs [11]. In Japan, the mean BMD of the L2–L4 vertebrae among both young male and female adults has been measured using Hologic DXA [12]. In the present study, lumbar spine BMD < 0.714 g/cm^2 (for both men and women) and femoral neck BMD < 0.546 g/cm^2 (men) or <0.515 g/cm^2 (women) were considered to indicate OP.

Statistical analysis

All statistical analyses were performed using STATA statistical software (STATA Corp., College Station, TX, USA). Differences in proportions were compared using the Chi square test. Differences in continuous variables were tested for significance using analysis of variance for comparisons among multiple groups or Scheffe's least significant difference test for pairs of groups. To test the association between the interaction between the knee pain and lumbar pain, a logistic regression model was used. First, the presence of knee pain was used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and lumbar pain (0: no, 1: yes) were used as explanatory variables. Then, lumbar pain was used as an objective variable, and knee pain was used as an explanatory variable in the identical model. All p values and 95 % confidence intervals (CI) of two-sided analysis are presented.

Results

Table 2 shows the number of participants classified by age and gender. Most participants were aged ≥60 years, and

Table 2 Numbers of participants in the LOCOMO study classified by age and gender

Age strata (years)	Total (%)	Men (%)	Women (%)
≤39	125 (1.0)	49 (1.2)	76 (0.9)
40–49	483 (4.0)	183 (4.6)	300 (3.7)
50–59	963 (8.0)	320 (8.1)	643 (8.0)
60–69	3,170 (26.3)	1,161 (29.3)	2,009 (24.9)
70–79	5,041 (41.9)	1,573 (39.7)	3,468 (43.0)
80–89	2,111 (17.6)	627 (15.8)	1,484 (18.4)
≥90	126 (1.1)	46 (1.2)	80 (1.0)
Total	12,019 (100.0)	3,959 (100.0)	8,060 (100.0)

99.0 % of the participants were aged ≥40 years. Two-thirds of the participants were women, and their mean age was 1 year greater than that of the male participants.

Selected characteristics of the study populations, including age, height, weight, BMI, and proportions of participants who smoked and consumed alcohol are shown in Table 3. The participants were considered as smokers and alcohol consumers if they answered 'yes' to the question 'Are you currently smoking/drinking?' in the self-administered questionnaire. The mean values of age and BMI were significantly higher in women than in men ($p < 0.01$). The proportions of both current smokers and alcohol consumers were significantly higher among men than among women ($p < 0.001$).

Table 3 Baseline characteristics of participants in the LOCOMO study classified by age and gender

Variables	Men	Women	*p* Value (men vs. women)
Age (years)	70.0 (10.6)	71.0 (10.3)	<0.001
Height (cm)	161.1 (6.8)	148.5 (6.4)	<0.001
Weight (kg)	59.3 (9.5)	50.8 (8.6)	<0.001
BMI (kg/m^2)	22.8 (3.0)	23.0 (3.5)	0.007
Smoking (%)	34.0	4.8	<0.001
Drinking (%)	52.4	21.1	<0.001

Values are represented as mean (standard deviation)

BMI body mass index

By analysing the data at the baseline examination, we determined the prevalence of knee pain and lumbar pain. Figure 3 shows the age-sex distribution of the prevalence of knee pain and lumbar pain. Overall, the prevalence of knee pain was 32.7 % (27.9 % in men and 35.1 % in women) and that of lumbar pain was 37.7 % (34.2 % in men and 39.4 % in women). The prevalence of pain in both the knee and lumbar region were significantly higher in women than in men ($p < 0.001$). On the basis of the total age and sex distributions derived from the Japanese census in 2010 [13], our results estimate that 18,000,000 people (7,100,000 men and 10,900,000 women) aged ≥40 years would be affected by knee pain and that 27,700,000 people (12,100,000 men and 15,600,000 women) aged ≥40 years would be affected by lumbar pain.

Further, among 9,046 individuals who were surveyed on both knee pain and lumbar pain at the baseline examination in each cohort, the prevalence of both knee pain and lumbar pain was 12.2 % (10.9 % in men and 12.8 % in women). The prevalence of the coexistence of knee and lumbar pain in the participants aged <40, 40–49, 50–59, 60–69, 70–79, and ≥80 years was 4.0, 4.8, 7.4, 13.0, 13.3, and 11.7 %, respectively, (6.1, 5.3, 6.0, 10.0, 11.5, and 13.2 %, respectively, in men and 2.6, 4.6, 8.1, 14.8, 14.2, and 11.0 %, respectively, in women). The prevalence of both knee pain and lumbar pain increased with age in men, whereas that in women reached a plateau at 60–69 and 70–79 years and then declined. On the basis of the total age and sex distributions derived from the Japanese census in 2010 [13], our results estimate that 6,800,000 people

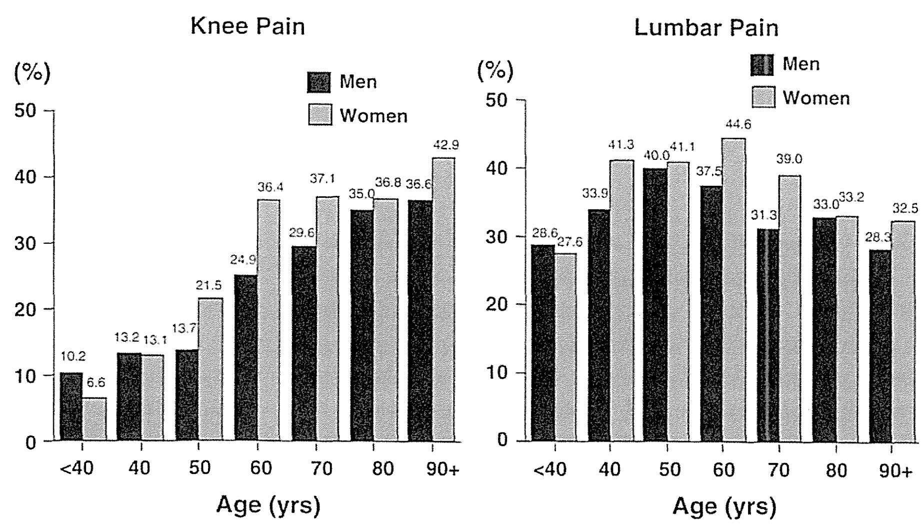

Fig. 3 Prevalence of knee pain and lumbar pain according to age and gender

Table 4 Odds ratios (OR) of potentially associated factors for the presence of knee pain/lumbar pain vs. absence of pain

Explanatory variables	Reference	OR	95% confident interval	p
Knee pain (presence vs. absence)				
Age (years)	+1 year	1.045	1.039–1.051	<0.001***
Gender	0: men, 1: women	1.602	1.441–1.780	<0.001***
Region	0: urban area, 1: rural area	2.419	2.152–2.720	<0.001***
BMI (kg/m^2)	+1 kg/m^2	1.141	1.124–1.158	<0.001***
Lumbar pain	0: absence, 1: presence	1.373	1.243–1.515	<0.001***
Lumbar pain (presence vs. absence)				
Age (years)	+1 year	1.018	1.013–1.023	<0.001***
Gender	0: men, 1: women	1.130	1.023–1.248	0.016*
Region	0: urban area, 1: rural area	2.016	1.801–2.256	<0.001***
BMI (kg/m^2)	+1 kg/m^2	1.020	1.003–1.031	0.021*
Knee pain	0: absence, 1: presence	1.375	1.246–1.518	<0.001***

BMI body mass index

* $p < 0.05$, *** $p < 0.001$

(2,800,000 men and 4,000,000 women) aged ≥40 years would be affected by both knee pain and lumbar pain.

To test the association between the knee pain and lumbar pain, the presence of knee pain was first used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and lumbar pain (0: no, 1: yes) were used as explanatory variables. Then, the presence of lumbar pain was used as an objective variable (0: absence, 1: presence) and age (+1 year), gender (men vs. women), BMI (+1 kg/m^2), regional differences (0: rural areas including Wakayama-1, Wakayama-2, Niigata, Mie, Akita, and Gunma vs. 1: urban areas including Tokyo-1, Tokyo-2, and Hiroshima), and knee pain (0: no, 1: yes) were used as explanatory variables. Table 4 shows the result of the logistic regression analysis. Higher age, female sex, higher BMI, living in a rural area, and the presence of lumbar pain significantly influenced the presence of knee pain. Similarly, higher age, female sex, higher BMI, living in a rural area, and the presence of knee pain significantly influenced the presence of lumbar pain.

Discussion

In the present study, we integrated the information of individual cohorts established for the prevention of musculoskeletal diseases, and created the nationwide large-scale cohorts comprising the LOCOMO study. By using the data of the LOCOMO study, we found that the prevalence of knee pain was 32.7 % and that of lumbar pain was 37.7 %. Both knee pain and lumbar pain were prevalent in 12.2 % of the total population. In the present study, we also clarified that the factors associated with knee or lumbar pain were age, sex, body build, and residential characteristics. In addition, the presence of knee pain affected the lumbar pain, and vice versa. This association remained even after the adjustment for the above-mentioned associated factors. To our knowledge, this is the first study to report the frequency of the knee pain and lumbar pain and to estimate the total number of prevalent subjects, by using a large-scale population-based cohort study in Japan.

With regard to musculoskeletal pain, several population-based epidemiological studies have demonstrated that chronic pain is a highly prevalent condition. Soni et al. [14] reported that the prevalence rates of self-reported knee pain using the baseline data in 1,003 participants from the Chingford Women's Study were 22.97 % in the left knee and 24.80 % in the right knee. The definition of the presence of the knee pain (based on the following two questions: 'Have you had any knee pain in either knee in the last month?' and 'How many days of pain have you experienced in the last month?') was similar but not identical to our definition used in the LOCOMO study, and the subjects' age was younger in the Chinford study than in the LOCOMO study. Therefore, we could not compare the prevalence between the Chinford and LOCOMO studies directly. However, at a glance, the prevalence seems to be higher in the Japanese population. This may be due to the fact that the prevalence of KOA (KL grades ≥2) was higher in the Japanese population than that in the Caucasian population [15]. Verhaak et al. [16] reviewed epidemiological studies on chronic benign pain among adults, including subjects aged between 18 and 75 years, and reported that the prevalence ranged between 2 and 40 % of the population. Coggon et al. did not perform a population-based study, but instead conducted a cross-sectional survey comparing the prevalence of disabling low back pain and disabling wrist/hand pain among groups of workers carrying out similar physical activities in different cultural environments in 18 countries including Japan. They reported that the 1-month prevalence of disabling low back pain in nurses ranged from 9.6 to 42.6 %, and that of disabling wrist/hand pain in office workers ranged from 2.2 to 31.6 % [17]. We could not compare our results to those of Coggon's results directly because of the difference in the characteristics of the targeted population. However, previous reviews and reports demonstrated that the prevalence of the chronic pain varied in the population surveyed, and therefore, estimating the prevalence and number of patients in pain would require a study that comprises various regions with a large number of subjects. Our LOCOMO study contains 12,019 participants from the cohorts consisting of nine communities in different locations in Japan. Therefore, we believe that our estimation of the prevalence of knee pain and lumbar pain is appropriate, and the number of patients was sufficient.

With regard to the characteristics of subjects with chronic pain, Soni et al. [14] reported that among subjects who could be followed up for 12 years, a higher BMI was predictive of persistent knee pain (odds ratio = 1.14) and incident knee pain (odds ratio = 1.10). Verhaak et al. [16] demonstrated that chronic pain generally increased with age, with some studies reporting a peak prevalence between the ages of 45 and 65 years. These results were not consistent with our results. Moreover, we noted that living in a rural area was associated with the presence of knee pain and lumbar pain, which may be due to the difference of the primary occupation in that area. Muraki et al. [18] reported that the presence of KOA and LS was influenced by the primary occupation of the participants. According to their report, the prevalence of higher K/L grades of KOA and LS was significantly higher among agricultural, forestry, and fishery workers than among clerical workers and technical experts [18]. For occupational activities, sitting on a chair had a significant inverse association with K/L grades ≥2 for KOA and LS, whereas standing, walking, climbing and heavy lifting were associated with higher K/L grades for KOA [18]. An association between occupational activities and KOA was also observed in several studies [19–21]. Agricultural, forestry, and fishery workers seemed to be more common in rural areas than in urban areas. In addition, occupational activities, such as sitting on a chair, might be observed more commonly in clerical workers than in agricultural, forestry, and fishery workers. These findings might support the regional differences of pain that were observed in the present study. The main focus of the present study was pain, and not OA; however, the most probable diagnosis underlying knee pain among older people was reported to be OA [22].

There are also several reports regarding the coexistence of pain. The above-mentioned Coggon's investigation indicated that the rates of disabling pain at 2 anatomical sites—the lumbar spine and wrist/hand—covaried ($r = 0.76$) [17]. In their cross-sectional study, Smith et al., examined the presence and sites of chronic pain in 11,797 women. The presence of chronic pain was noted in 38 % of women; among them, the percentage of women experiencing chronic pain at 1, 2, 3, 4, and ≥5 sites was 23.2, 24.4, 20.0, 14.3, and 18.2 %, respectively [23]. These results showed that chronic pain coexists at other anatomical sites. In the present study, the prevalence of both knee pain and lumbar pain was 12.2 % (10.9 % in men and 12.8 % in women) among the general population. However, among the subjects with lumbar pain, 37.3 % also had knee pain (39.0 % in men and 36.6 % in women). Unfortunately, in the LOCOMO study, we were unable to collect the data regarding pain at anatomical sites other than knee pain and lumbar pain. Nevertheless, the coexistence of pain was commonly noted, which is inconsistent with previous reports.

There were several limitations in the present study. First, the current subjects do not truly represent the entire Japanese population. We should carefully consider this limitation, especially when determining the generalisability of the results. However, the LOCOMO study is the first large-scale population-based prospective study with more than 12,000 participants. Although it does not comprise the whole population of Japan, the number of participants in the cohorts established for the prevention of the musculoskeletal diseases appears to be biggest worldwide. Second, all the items of our survey in the baseline examination were not recorded in all cohorts. For example, radiographic examination of knees was performed only in Tokyo-1, Wakayama-1, Wakayama-2, Niigata, and Mie prefectures and radiographic examination of the lumbar spine was performed only in Tokyo-1, Wakayama-1, Wakayama-2, Hiroshima, and Mie prefectures. Third, the radiographic findings for OA assessment using KL scales have not been integrated yet, because of the delay in the standardisation of reading methods of the observers. Radiographs should be assessed by a single observer to omit the inter-observer variability, and if this is impossible, then the inter-observer variability among observers should be tested using the standardised criteria. Therefore, in the present study, we could not evaluate the severity of knee/spinal OA or vertebral fractures for assessing knee pain and lumbar pain. After suitable evaluation of intra-observer and inter-observer variability in the assessment of radiography findings and integration of this information, we hope to re-analyse the factors associated with the presence of chronic pain. Moreover, not only OA and fractures, but also rheumatoid arthritis and spondyloarthritis should be considered as parameters for assessing knee pain and lumbar pain. Although collection of the information on the diagnosis may be difficult on a large scale due to the associated cost, it may be possible to obtain this information in at least two cohorts.

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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サルコペニアの疫学 II

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要　　旨

無作為抽出された地域住民を対象とするコホート研究である「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）」での調査から，日本人高齢者全体で筋量減少者は850万人，筋力低下者は1,000万人，身体機能低下者は350万人を超えると推計された．また Asian Working Group for Sarcopenia のサルコペニア判定のアルゴリズムを用いてサルコペニアの有病者数の推計を行った結果，男性が132万人，女性が139万人と推計された．

はじめに

現在の日本は4人に1人が65歳以上の高齢者であり，今後も高齢化率はさらなる上昇が見込まれる状況を考慮すると，日常生活における障害や寝たきりを引き起こすサルコペニアへの対策は喫緊の課題である．サルコペニアの予防，治療戦略を構築するうえで我が国のサルコペニアの実態の把握が不可欠であるが，サルコペニアに関する疫学研究は諸外国と比較しても少ないのが現状である．

本稿では，無作為抽出された地域在住の中高齢者を対象とする大規模コホートデータをもとに，日本人高齢者のサルコペニアの実態について概説する．

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キーワード：地域住民，NILS–LSA，Asian Working Group for Sarcopenia，有病率

地域住民におけるデータの収集

一般の地域住民を対象とするコホート研究である「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）」は，1997年より開始された[1]．NILS–LSAは日本人の老化および老年病に関する詳細な縦断的データを収集し，日本人の老化像を明らかにするとともに，老化および老年病に関する危険因子を解明することを目的としている．対象者は長寿医療研究センター周辺の，観察開始時年齢が40歳から79歳までの地域住民であり，地方自治体（大府市および東浦町）の協力を得て，住民台帳から年齢・性別に層化した無作為抽出によって選定された．選定された者を説明会に招き，調査の目的や方法などを十分に説明し，インフォームド・コンセントを得たうえで調査は実施された．

NILS–LSAは同一人物を対象に，医学，運動生理学，身体組成，栄養学，遺伝子解析などの千項目以上に及ぶ調査を2年ごとに繰り

返し行う縦断調査であり，現在も継続して実施されている．NILS-LSAにおけるサルコペニアの評価に関連する調査としては，二重エネルギーX線吸収法（DXA）による全身の筋量測定，形態計測，筋力測定，歩行能力測定，転倒調査，ADL低下に関する調査などを実施してきた．また，日常の身体活動量調査や食事・栄養摂取量調査，さらには血液サンプルから抽出されたDNAを用いた遺伝子多型調査についても実施されている．

本稿では，NILS-LSAの第7次調査に参加した65歳以上の男性479人，女性470人を対象に，筋量，筋力，身体機能についてAsian Working Group for Sarcopenia（AWGS）の基準値を当てはめてデータ解析を行った．またAWGSのサルコペニア判定のアルゴリズムを用い，日本人高齢者におけるサルコペニアの有病率を求めるとともに，総務省統計局発表の5歳階級別人口推計（平成26年1月時点）をもとに，サルコペニアの有病者数の全国推計を行った．

筋量減少者の頻度

筋量はサルコペニアの古典的定義であり[2]，筋量の減少はサルコペニアの判定において重要視されている．測定には，MRIやCT，DXA，生体インピーダンス法（BIA）を用いる[3)4)]．MRIやCT，DXAは機器が据え置きであることや放射線などの影響から[4]，臨床や研究場面において用いられることが多い．それに対しBIAで用いられる体組成計は，移動可能であることや測定が簡便であることなど，研究のみならず地域住民を対象とした保健指導などの場で優位性がある[4]．AWGSではDXAとBIAの基準値が示されており[4]，四肢の筋量を体重の二乗で除したskeletal muscle index（SMI，kg/m^2）を用いて評価する[5]．DXAの基準値は男性が$7.0kg/m^2$，女性が$5.4kg/m^2$，BIAの基準値は男性が$7.0kg/m^2$，女性が$5.7kg/m^2$とされている[4]．

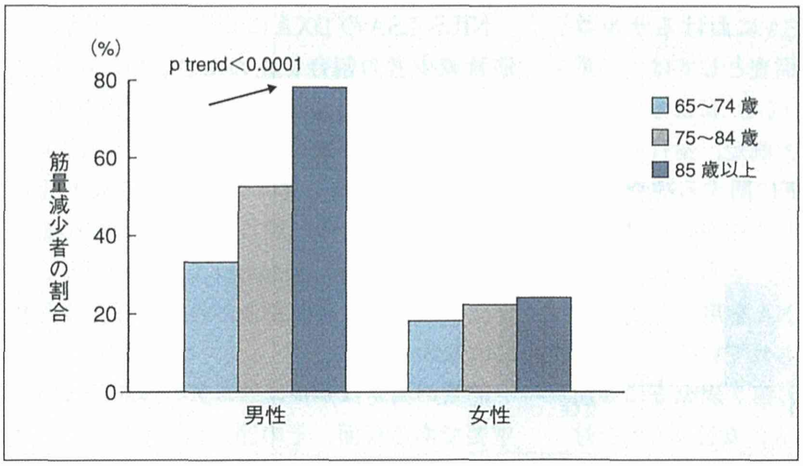
NILS-LSAのDXAによるデータを用いて筋量減少者の割合を求めたところ，65歳以上の男性全体では43.2%が，女性では20.2%が該当した．年代別に検討したところ（図1），男性では年代の上昇に伴って筋量減少者の割合は上昇したのに対し（p trend <0.0001，Cochran–Mantel–Haenszel test），女性では年代と筋量減少者の割合との間に関連は認められなかった．

筋量の測定はサルコペニアの診断において重要である反面，その測定にはDXAやBIAなど，いずれも高額な専用機器を必要とする点で制約が生じる．形態測定と簡易体力測定の結果から四肢筋量を推定する方法についても報告されているので，ここに紹介する．男性では「SMI＝0.326×BMI－0.047×腹囲（cm）－0.011×年齢＋5.135」，女性では「SMI＝0.156×BMI＋0.044×握力（kg）－0.010×腹囲（cm）＋2.747」の推定式より算出される[6]．また，40歳から89歳までを対象とした研究において，立位時の下腿最大周囲長とDXAで得られたSMIとの間に，正の相関関係があることが報告されている[7]．それによると，AWGSのDXAによるSMI基準値評価のための下腿周囲長の最適カットオフ値は，男性が34.3cm（感度89%，特異度88%），女性が32.8cm（感度78%，特異度72%）としている[7]．

筋力低下者の頻度

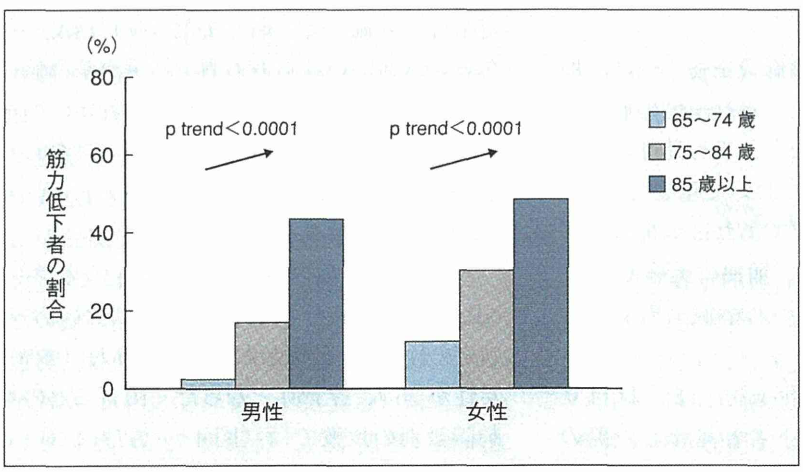
筋力の低下は実生活に直結する．とりわけ脚筋力の低下は移動の制限や転倒の原因になるなど，高齢者では特に注意が必要である．その反面，脚筋力の測定には専用の測定機器を必要とすることから，研究分野での使用が主となっている．一方，握力は脚筋力と比較して簡便に測定可能であり，我が国では新体力テストの測定項目に含まれるなど，一般に

図1　性・年代別に見た筋量減少者の割合



NILS-LSA 第7次調査に参加した65歳以上の男女949人のDXAデータを用い，AWGSにおけるSMIの基準値（男性 7.0kg/m^2，女性 5.4kg/m^2）に基づき，筋量減少者の割合を求めた．傾向性p値はCochran–Mantel–Haenszel testによる．

図2　性・年代別に見た筋力低下者の割合

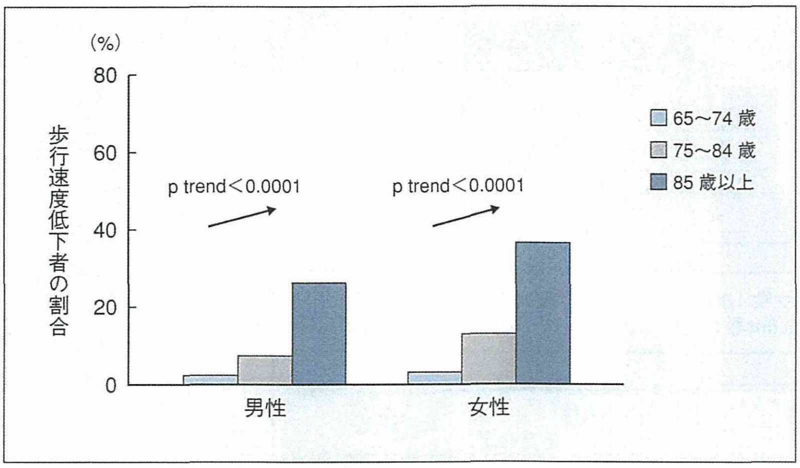


NILS-LSA 第7次調査に参加した65歳以上の男女949人の握力データを用い，AWGSにおける基準値（男性 26kg，女性 18kg）に基づき，筋力低下者の割合を求めた．傾向性p値はCochran–Mantel–Haenszel testによる．

広く知られた測定方法となっている．握力はADL低下との関連が報告されるなど，有害転帰の予測指標となることが示唆されており[8]，脚筋力とも関連することから，サルコペニアの判定においても握力が指標として採用されている[3)4)]．AWGSによる握力の基準値は男性 26kg，女性 18kgとされている[4]．

NILS–LSAのデータを用いて筋力低下者の割合を求めたところ，65歳以上の男性全体では10.0%が，女性では21.5%が該当した．年代別に検討したところ（図2），男女ともに年代の上昇に伴って筋力低下者の割合は上昇した（p trend<0.0001；Cochran–Mantel–Haenszel test）．

図3 性・年代別に見た身体機能低下者の割合



NILS-LSA 第7次調査に参加した65歳以上の男女949人の普通歩行速度データを用い，AWGSにおける基準値（男女ともに0.8m/秒）に基づき，身体機能低下者の割合を求めた．傾向性p値はCochran-Mantel-Haenszel testによる．

身体機能低下者の頻度

歩行速度は筋力低下の影響を強く受け，加齢に伴い低下する．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，簡便に実施できる．AWGSによる歩行速度の基準値は男女ともに0.8m/秒とされている[4]．

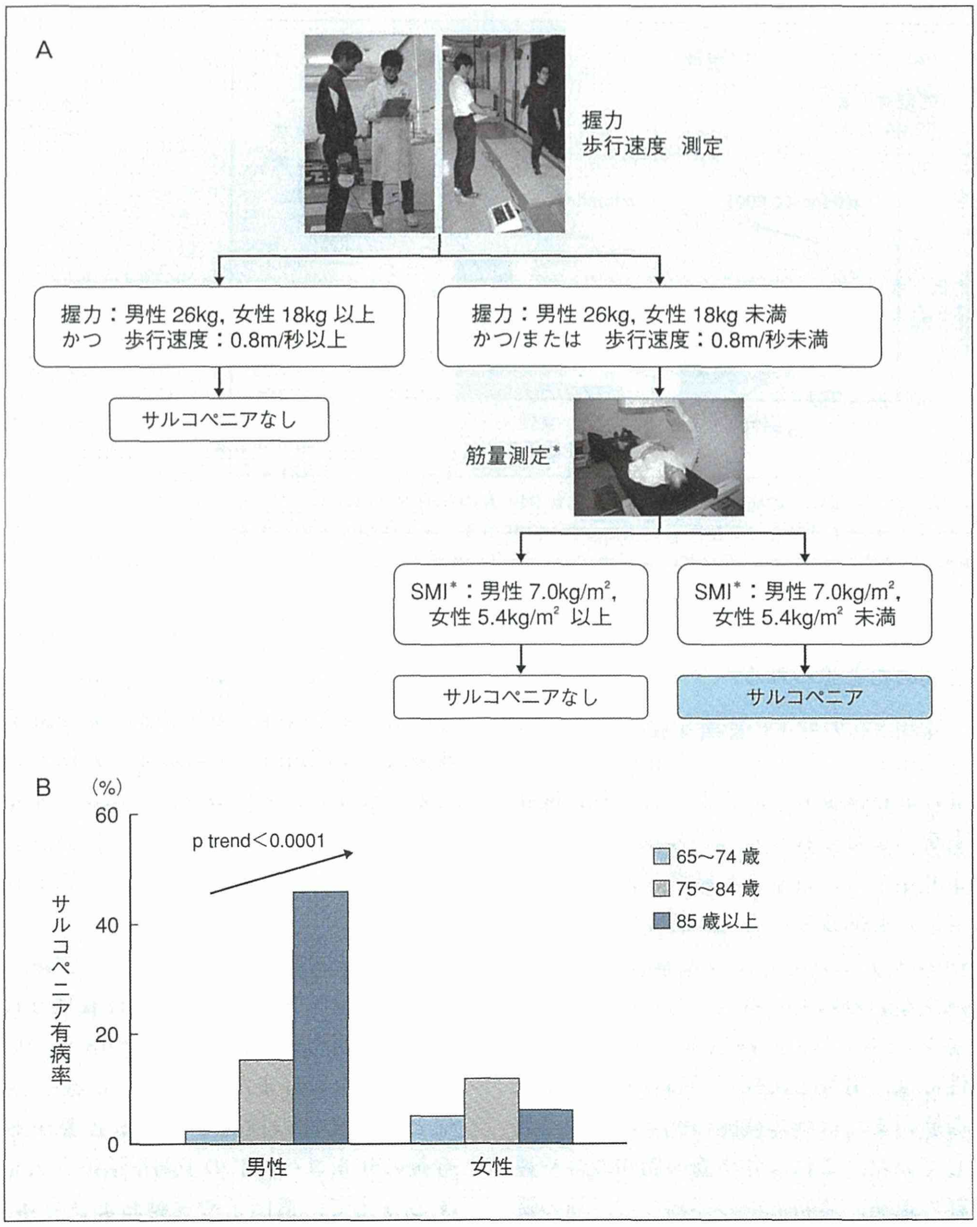
普通歩行速度0.8m/秒未満，または自立歩行困難を身体機能低下者と見なした際のNILS-LSAにおける身体機能低下者の割合は，65歳以上の男性では5.4%，女性では9.2%であった．年代別に検討したところ（図3），筋力低下者と同様に，男女ともに年代の上昇に伴って身体機能低下者の割合は上昇を示した（p trend＜0.0001，Cochran-Mantel-Haenszel test）．

サルコペニアの判定と有病率

図4にAWGSの提示するサルコペニア判定のアルゴリズムを示す[4]．それによると，高齢者を対象として握力および歩行速度の測定を行う．続いて，握力または歩行速度のどちらか，あるいは両方の測定結果が基準値に満たない者について筋量の測定を行い，筋量が基準値以上であれば「サルコペニアなし」，基準値未満であれば「サルコペニア」として判定することとなっている．

AWGSによる診断アルゴリズムに基づき，NILS-LSAのデータを用いてサルコペニアの判定を行った．その結果，男性が46人（9.6%），女性が36人（7.7%）となった．10歳ごとの年齢階級別の比較では（図4），男性において年代の上昇とサルコペニアの有病率に有意な関連を認めた（p trend＜0.0001，Cochran-Mantel-Haenszel test）．対照的に，女性では年代とサルコペニアの有病率との間に有意な関連を認めなかった．サルコペニアの判定において筋力や身体機能がどれほど低下していたとしても，筋量が基準値を満たしている場合にはサルコペニアとは判定されない．筋量の減少について，女性は男性ほど加齢の影響を受けないとされており[9]，このことが女性において年代とサルコペニアの有病率との

図4　AWGS におけるサルコペニア判定のアルゴリズムとサルコペニア有病率

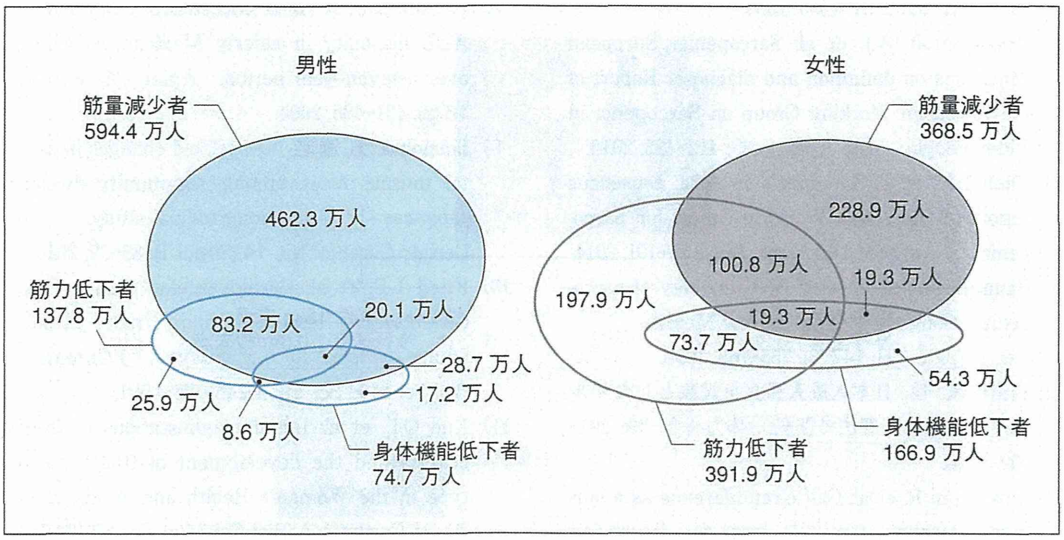


A：対象は高齢者であり，握力ならびに歩行速度の測定にてスクリーニングを行い，筋量の測定で確定診断となる（文献[4]より改変引用）．

　*筋量の測定は DXA または BIA により行う．図中の値は DXA の基準値を示す．BIA の場合は男性 7.0 kg/m²，女性 5.7 kg/m² を用いる．

B：男性で年代上昇とサルコペニア有病率との間に関連を認めた．傾向性 p 値は Cochran–Mantel–Haenszel test による．

図5　サルコペニアの有病者数



有病者数は，NILS-LSA 第7次調査における筋量，握力，普通歩行速度の測定結果と，総務省統計局発表の5歳階級別人口推計（平成26年1月時点）に基づき推計した．

関連を弱めたと思われる．

サルコペニアの有病者数推計

図5に筋量減少者，筋力低下者，身体機能低下者を，またそれぞれの重複状況を有病者数により示した．日本人高齢者におけるサルコペニアの有病者数は男性が約132万人，女性が約139万人となった．また重複状況では，筋量減少と筋力低下の重複が男女ともに最多で，サルコペニアの原因の6割以上を占めた．

女性では，男性と比較して筋量減少に非依存的な筋力または身体機能の低下者が相当数存在していた．これは骨格筋の脂肪変性や運動神経の退廃，速筋線維の萎縮など，筋の質的問題に起因するものと考えられており，特に女性でその影響は大きいためと推察される．女性高齢者では，サルコペニアの有無にかかわらずADLの低下などに注意を払う必要がある．

おわりに

サルコペニアに関する一般の認知度は必ずしも高いとは言えない．その理由の1つとして，骨格筋の減少や筋力の低下が単なる老化現象として理解されていることが挙げられる．しかしながら，サルコペニアはフレイル（虚弱）の中核的病態であり[10)11)]，自立を著しく阻害するなど，高齢になるほどその影響は大きい．

日本人を対象としたサルコペニア研究において，筋量減少に関する知見は蓄積されつつあるが，筋力低下や身体機能低下についての報告は少ない．また，サルコペニアと有害転帰との関連性の検討を進める必要がある[4)]．今後のサルコペニアの予防や治療介入を実現するうえで，遺伝子や運動および身体活動，栄養などの背景因子を含めた学際的な研究の一層の進展が望まれる．

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Epidemiology of Sarcopenia among the Elderly in the NILS–LSA

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Osteoporosis Japan

膝関節の変形および痛みと身体組成との関連

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はじめに

変形性膝関節症（膝 OA）は，高齢期に QOL や身体機能低下をきたす原因となる運動器疾患の一つである。膝 OA の痛みの増悪因子として肥満はよく知られているが，DXA などによる身体組成を含めた詳細な検討は少ない。そこで，膝関節変形ならびに痛みと身体組成の関連を明らかにするため，地域在住中高年者対象の大規模コホートにて検討を行った。

1　対象および方法

「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）」[1)]の第5次調査（2006～2008年）に参加した男女2,337名（平均年齢60.7±12.6歳，男性1,185名，女性1,192名）の4,750膝を対象とした。本研究参加者は愛知県大府市および東浦町の40歳以上の一般住民から無作為に抽出し選定した。調査項目として，膝関節変形は左右別のエックス線膝荷重位正面像について Kellgren-Lawrence 分類を基に5段階に分類し，0～I 度を正常，II度を軽度変形，III～IV度を重度変形と3群に分類し，調査票にて現在の膝関節痛の有無を左右別に調査した。さらに身体組成の指標として Hologic 社製 QDR 4500 を用いて，DXA 法にて下肢脂肪量，下肢筋肉量を測定し，下肢脂肪率（＝下肢脂肪量/体重×100），下肢筋肉率（＝下肢筋肉量/体重×100），下肢筋肉量と下肢脂肪量の比（＝下肢筋肉量/下肢脂肪量），のそれぞれを左右別に算出し，変形の程度により各指標に差があるかどうかについて，男女別および痛みの有無別に検討した。統計解析は一般線形モデルを用い，左右の膝を合わせ年齢を調整した多重比較（Tukey-Kramer 法）により SAS 9.1.3 にて行った。研究は当センターの倫理委員会の承認のもと，紙面での参加者の同意を得て施行した。

2　結　　果

対象の特性を**表1**に示す。男女別および痛みの有無別に，膝関節変形の程度による各指標を比較した結果は，以下のとおりであった。

男性においては，痛みのある例では下肢脂肪率は正常に比べ重度変形で有意に高く（$p<0.05$），下肢筋肉率，下肢筋肉量と下肢脂肪量の比は，ともに正常に比べ重度変形で有意に低かった（各 $p<0.05$，**図1A**）。一方痛みのない例では下肢脂肪率，下肢筋肉率，下肢の脂肪量と筋肉量の比はいずれも各群間に有意差はなかった（**図1B**）。女性では，痛みのある例では下肢脂肪率，下肢筋肉率，下肢筋肉量と下肢脂肪量の比のいずれも各群間に有意差はなかったが，下肢筋肉率は重度変形が軽度変形より低い傾向（$p=0.053$）があった（**図1C**）。一方痛みのない例では，下肢脂肪率は正常に比べ軽度変形で有意に

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表1　対象の特性

	男性（n=1185）	女性（n=1192）
年齢（歳）	60.6±12.5	60.8±12.7
身長（cm）	166.0±6.6	152.6±6.2
体重（kg）	64.1±9.3	52.5±8.6
総膝関節数（膝）	2368	2382
エックス線変形程度別の膝関節数		
正常（痛みのある膝%）	1524（7.5）	1300（10.5）
軽度変形（痛みのある膝%）	765（11.5）	859（20.7）
重度変形（痛みのある膝%）	79（50.6）	223（57.0）
BMI（kg/m^2）	23.2±2.7	22.5±3.3
下肢脂肪量（kg）	2.1±0.6	2.8±0.8
下肢筋肉量（kg）	7.4±1.2	5.2±0.8
下肢脂肪率（%）	3.3±0.6	5.3±1.0
下肢筋肉率（%）	11.6±0.9	10.0±0.9
下肢筋肉量と脂肪量の比	3.7±1.1	2.0±0.5

平均±SD

高く（$p<0.05$），下肢筋肉率では各群間に有意差はなかったが，下肢筋肉量と下肢脂肪量の比は正常に比べ軽度変形で有意に低かった（$p<0.01$，**図1D**）。

3 考　　察

膝 OA の増悪因子として肥満はよく知られているが，DXA などによる身体組成を含めた詳細な検討は多くなく，これまでの国内外における報告のほとんどは女性についての検討である。わが国では，DXA 法を用いた膝 OA 例女性 30 名と健常女性 50 名の比較で，体脂肪率は膝 OA 例のほうが健常群より大きかったが，除脂肪量は両群に有意な差を認めなかったとする報告[2]や，Bioelectrical impedance 法を用いた，下肢除脂肪率が膝 OA 群で正常群より低かったとする戸田らの報告[3]，年齢，BMI，腰椎骨密度が一致した対照群との比較で，下肢除脂肪量は膝 OA 群で有意に低下し，脂肪量は有意差がなく，膝 OA 群で進行度の高い側の脂肪量は低い側に比べ有意に高かったとする報告[4]がある。また海外においても，DXA 法で体脂肪量，体脂肪率，体筋肉量は膝 OA 群のほうが正常群より高かったが，体筋肉率は膝 OA 群のほうが低かったとする Johnston Country Osteoarthritis Project での報告[5]や，Bioelectrical impedance 法を用いた，体除脂肪量は MRI 計測での脛骨軟骨量と正，軟骨欠損と負の関連があり，体脂肪量は脛骨軟骨量と負の関連があったとする報告[6]，あるいは，骨格筋量はエックス線関節裂隙幅と正の関連があったが，脂肪量とは一定の関連を認めなかった[7]など，本報告と同様の報告がある。しかしながら，性別や痛みの有無別に行った検討は，渉猟したかぎりこれまでにはなかった。われわれの検討では正常例との比較において，男性では痛みのある例にて重度変形例で下肢の脂肪の割合が高く筋肉の割合が低く，一方女性では痛みのない例にて軽度変形例で脂肪の割合が高く筋肉の割合が低くなっていた。

ま と め

地域在住中高年者を対象とした大規模コホートにて，膝関節の変形と身体組成との関連を検討した。両者の関連は，痛みの有無を考慮した

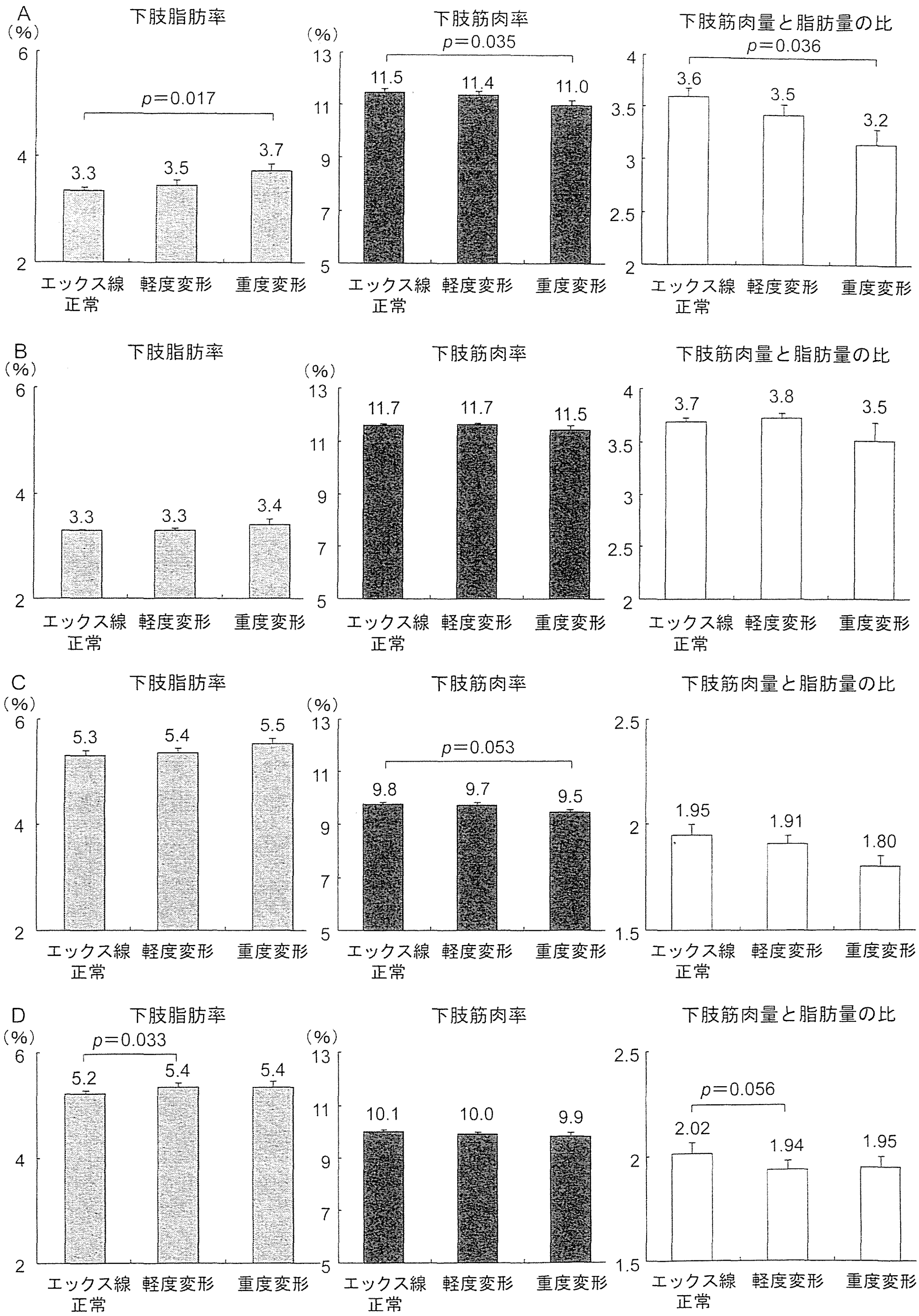

図1　エックス線膝変形の程度による各指標の比較
年齢を調整した多重比較（Tukey-Kramer 法）にて
A：痛みのある男性例，B：痛みのない男性例，C：痛みのある女性例，D：痛みのない女性例

場合，男女で異なっていた。

【C O I】本演題に関連して，筆頭著者に開示すべき利益相反はありません。

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