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The Knee



The Knee injury and Osteoarthritis Outcome Score reflects the severity of knee osteoarthritis better than the revised Knee Society Score in a general Japanese population

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ABSTRACT

Purpose: The purposes of this study were to examine population-based reference data for sex- and age-related differences between the 2011 revised Knee Society Score (KSS2011) and the Knee injury and Osteoarthritis Outcome Score (KOOS), to assess the correlation between those scores and radiographic knee osteoarthritis (OA), and to validate the use of the scores in a general Japanese population.

Methods: This cross-sectional study included 963 volunteers (368 males, 595 females; mean age: 54.7 years). Participants were classified into five subgroups by age: under 40, 40s, 50s, 60s, and over 70 years old. The KSS2011 and KOOS were determined using self-administered questionnaires. Weight-bearing radiographs of the bilateral knee were taken and graded according to the Kellgren–Lawrence (KL) scale. The mean KSS2011 and KOOS were compared among age groups. Correlations between the severity of knee OA and each score were assessed using multiple regression analysis.

Results: The overall KSS2011 tended to gradually decrease with age. Most subscales of the KSS2011 did not show sex-related differences. Similarly, the overall KOOS and all its subscales steadily decreased by approximately 20 points per decade with age. Most subscales of the KOOS were significantly decreased in females over 50. The KL grade was significantly related to both the overall KOOS ($\beta = -0.42$, $p < 0.001$) and KSS2011 ($\beta = -0.13$, $p = 0.001$), though the correlation to the KOOS was stronger.

Conclusion: The overall KSS2011 and KOOS appear to decrease with age. In this population, the KOOS reflects the severity of knee OA better than the KSS2011.

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1. Introduction

Knee osteoarthritis (OA) is a common disorder that causes pain and disability to an increasing fraction of the population. Various risk factors associated with the incidence and progression of OA have been identified, including aging, high body mass index (BMI), female sex, previous knee injury, quadriceps muscle strength, and knee malalignment, among others [1–4]. Of these, obesity and quadriceps muscle strength are important for the prevention and suppression of the disease. To relieve knee pain and improve knee function, total knee arthroplasty (TKA) is one of the treatment options for cases of severe knee OA. Over the last two decades, the number of younger and more active patients undergoing TKA has increased [5]. Traditionally, the surgical outcomes after knee surgery have been evaluated objectively using radiographic imaging and the surgeon's assessment of the joint functions,

including the stability, lower limb alignment, and range of motion. To better characterize functional activity in line with the demands of younger patients, the traditional clinical scales have been adapted and new scales have been developed. Furthermore, patient-reported outcome scales also play an important role in the assessment of patients with knee problems after injury or in OA [6].

The Knee Society Knee Scoring System (KSS) was developed to evaluate the function of both knee prostheses and a patient's functional abilities after TKA [7]. This original score was based on only physician-derived variables, leaving an unresolved poor correlation between objective physician-assessed knee scores and patient-derived satisfaction scores. In 2011, the KSS was revised (KSS2011) to better characterize the expectations, satisfaction, and physical activities of a more diverse population of patients [8]. The KSS2011, a questionnaire that includes subjective and objective evaluations, has enabled the comprehensive assessment of patient knee function before and after surgery with high reliability [9,10].

The validation of the KSS2011 was performed in patients with knee OA before and after TKA [11]. The patient satisfaction, expectation, and

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Table 1
Number, age, BMI, and radiographic knee OA of the study participants by age group.

	<40		40s		50s		60s		≥70	
	M	F	M	F	M	F	M	F	M	F
Participants number	92	113	55	86	62	130	96	166	63	100
Age (years)	32.1	33.1	45.0	45.0	54.4	55.5	64.0	64.2	75.2	75.0
	31.1 to 33.2	32.2 to 34.0	44.3 to 45.7	44.3 to 45.6	53.7 to 55.1	55.0 to 56.0	63.4 to 64.5	63.8 to 64.6	74.1 to 76.4	74.2 to 75.9
BMI (kg/m ²)	23.2	21.0	24.0	22.2	23.5	22.1	23.3	23.1	23.4	22.7
	22.4 to 23.9	20.3 to 21.7	23.2 to 24.7	21.5 to 22.9	22.8 to 24.2	21.6 to 22.7	22.7 to 23.9	22.6 to 23.7	22.6 to 24.2	22.1 to 23.3
Number of participants with radiographic knee OA (%)	3 (3.3)	12 (10.6)	7 (12.7)	22 (25.6)	16 (25.8)	68 (52.3)	37 (38.5)	113 (68.1)	35 (55.6)	84 (84.0)

Values of age and BMI are given as the mean and 95% confidence interval.
BMI: body mass index.

functional activities subscales of the KSS2011 questionnaire were correlated with each subscale of the Short Form-12 (SF-12) score and the Knee injury and Osteoarthritis Outcomes Score (KOOS) [11]. The Japanese version of the KOOS has been validated [12] and is reported to be a useful tool for evaluating the knee condition after TKA [13]. The Japanese version of the KSS2011 has also been used to evaluate patient satisfaction and daily activities after TKA [14]. Based on a study of the general Japanese population, Taniguchi et al. reported that the KSS2011 decreased with age and was correlated with radiographic knee OA in people older than 60 years. However, changes in the KSS2011 by sex and age group in comparison with other objective rating systems and the correlation with severity of knee OA by age group have not yet been reported. The purposes of this large-scale cross-sectional study were to examine the changes in the KSS2011 by sex and age group compared with the KOOS and to assess the correlations between these scores and the severity of knee OA in a general Japanese population.

2. Materials and methods

2.1. Subjects

The subjects in this study were volunteers who participated in the Iwaki Health Promotion project. This annual project, running since 2005, is a community-based program with the goal of improving the average life expectancy by performing general health checkups on the general population living in the Iwaki area of Hirosaki city, which is located in western Aomori prefecture, Japan [15,16]. Informed consent was obtained from all individual participants included in the study, and the protocols used in this study were conducted with the approval of the ethics committee of Hirosaki University School of Medicine. A total of 1045 volunteers from among the 12,000 residents participated in the Iwaki Health Promotion project in 2013. Of these, 23 patients with prior knee surgery, 28 participants who did not receive

radiography, and 31 participants who did not complete the questionnaire were excluded from this study, leaving 963 participants who were assessed in the present study. The KSS2011 and KOOS questionnaires for knee condition and radiographs of the knee were taken for these participants.

2.2. Evaluation of knee osteoarthritis

Bilateral weight-bearing and anterior–posterior radiographs of the knees were taken. All of the knee radiographs were graded by two trained orthopedic surgeons blinded to the participant data. The severity of each knee was graded based on the Kellgren–Lawrence (KL) grade [17]. The presence of radiographic knee OA was defined as a KL grade of 2, 3, or 4. The participants were classified as either OA or non-OA using their worse knee score.

2.3. Revised Knee Society Score (KSS2011)

Each participant filled out the self-administered areas of the KSS2011 questionnaire, including “symptoms” (three items; 25 points), “patient satisfaction” (five items; 40 points), and “functional activities” (19 items; 100 points). The “symptoms” section consisted of two numerical rating scales completed by the participants and one question about the frequency of the abnormality. The “patient satisfaction” section consisted of the pain level while sitting or lying in bed and knee function while getting out of bed, performing light household duties, and performing leisure or recreational activities. The “expectation” sections of the questionnaire were excluded because the participants did not plan to undergo TKA. The “functional activities” consisted of “walking and standing”, “standard activities” (standing from a seated position and going up and down stairs), “advanced activities” (squatting down deeper and going up a ladder or running), and “discretionary activities” (18 sports activities listed). The score for each subscale was calculated by summing the points for each item listed and was considered independent from the other domains. Higher scores indicate better outcomes in all of the subscales. The discretionary activities score was excluded from further analysis because the response rate for that section was low. The maximum possible score from these questions was 150 points.

2.4. Knee injury and Osteoarthritis Outcome Score (KOOS)

The KOOS is based on 42 knee-related items each scored from 0 to four. Five patient-relevant categories: pain (nine items), other disease-specific symptoms (symptoms; seven items), function in activities of daily living (ADL; 17 items), sport and recreation function (sports/recreation; five items), and knee-related quality of life (QOL; four items) were converted to a 100 point scale [18]. The KOOS items were scored from 0 to four and summed within each subscale. These scores were converted to percentage scores with higher scores

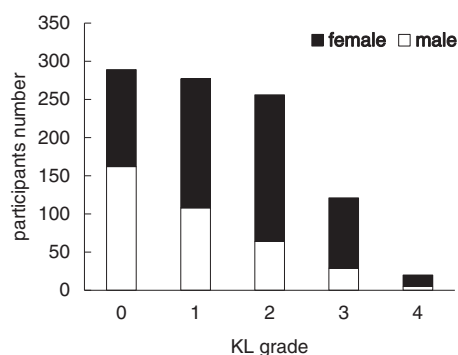


Fig. 1. Distribution of the Kellgren–Lawrence (KL) grades in the participants. Most of the participants who had knee OA were female with grade 2.

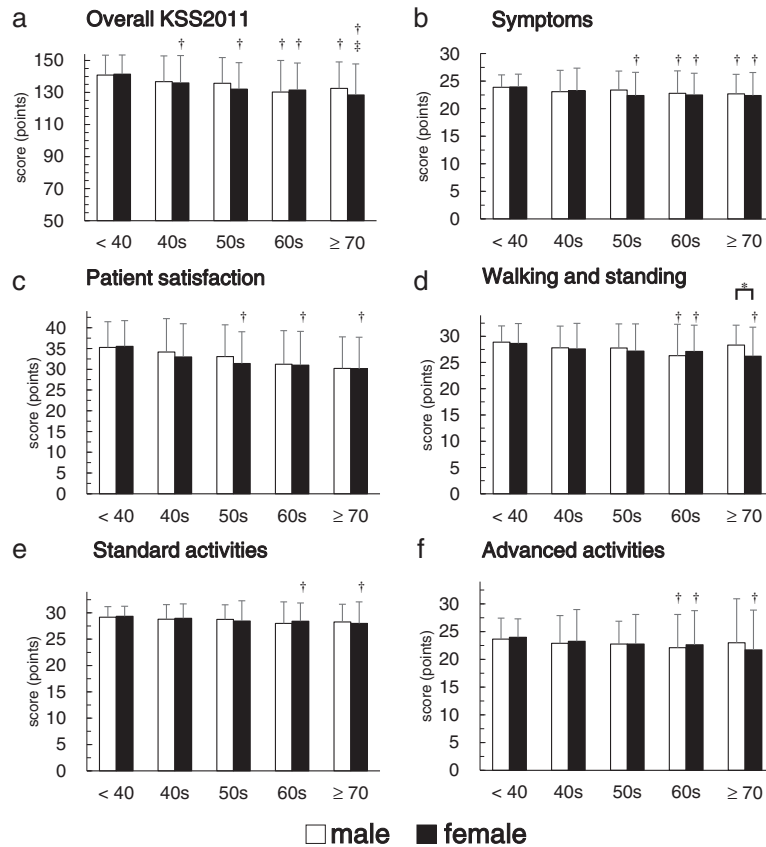


Fig. 2. Mean overall KSS2011 and KSS2011 subscales for males and females divided by age group including (a) overall KSS2011, (b) symptoms, (c) patient satisfaction, (d) walking and standing, (e) standard activities, and (f) advanced activities. The overall KSS2011 and each subscale tended to gradually decrease with age. The subscales did not show sex-related differences, except for the walking and standing score in patients over 70 years. p-Values less than 0.05 are shown as *: p < 0.05 between males and females. †: p < 0.05 vs <40. ‡: p < 0.05 vs 40s. §: p < 0.05 vs 50s. ||: p < 0.05 vs 60s. Overall KSS: the total KSS2011 summed from the individual subscales.

Table 2

KSS2011 and KOOS reported as mean and 95% confidence interval for males (M) and females (F) by age group.

	<40		40s		50s		60s		≥70	
	M	F	M	F	M	F	M	F	M	F
Overall KSS2011	140.9 138.3 to 143.4	141.5 139.2 to 143.7	136.7 132.4 to 141.1	136.0* 132.4 to 139.7	135.7 131.6 to 139.8	132.1* 129.2 to 135.0	130.3* 126.3 to 134.3	131.5* 128.9 to 134.1	132.5* 128.3 to 136.7	128.4*† 124.5 to 132.2
Symptoms	23.9 23.4 to 24.3	24.0 23.5 to 24.4	23.1 22.0 to 24.1	23.3 22.4 to 24.1	23.4 22.5 to 24.2	22.4* 21.6 to 23.1	22.8* 21.9 to 23.6	22.5* 21.9 to 23.1	22.7* 21.9 to 23.6	22.4* 21.6 to 23.2
Patient satisfaction	35.3 34.3 to 36.6	35.5 34.4 to 36.7	34.2 32.1 to 36.3	33.0 31.2 to 34.7	33.1 31.1 to 35.0	31.4* 30.0 to 32.7	31.2 29.6 to 32.8	31.0* 29.7 to 32.2	30.2 28.1 to 32.3	30.1* 28.6 to 31.7
Walking and standing	28.9 28.3 to 29.5	28.6 27.9 to 29.3	27.8 26.7 to 28.9	27.6 26.5 to 28.6	27.8 26.6 to 28.9	27.2 26.3 to 28.1	26.3* 25.0 to 27.5	27.1* 26.3 to 27.9	28.3‡ 27.4 to 29.3	26.2* 25.1 to 27.3
Standard activities	29.2 28.8 to 29.6	29.3 29.0 to 29.7	28.8 28.0 to 29.5	29.0 28.4 to 29.5	28.8 28.1 to 29.5	28.4 27.8 to 29.1	28.0 27.2 to 28.6	28.4* 28.8 to 28.9	28.3 27.4 to 29.1	28.0* 27.1 to 28.8
Advanced activities	23.7 23.1 to 24.2	24.0 23.5 to 24.4	22.9 21.8 to 24.0	23.3 22.4 to 24.1	22.7 21.7 to 23.8	22.7 22.0 to 23.5	22.1* 21.1 to 23.0	22.6* 21.8 to 23.3	23.0 21.9 to 24.0	21.7* 20.7 to 22.8
Overall KOOS	487.9 483.2 to 492.7	481.8 476.1 to 487.6	484.2 477.2 to 491.3	473.2 462.7 to 483.8	471.2‡ 458.2 to 484.3	450.1*† 438.7 to 461.5	452.1*†‡ 437.5 to 466.7	431.7*† 419.6 to 443.8	449.6*†‡ 432.4 to 466.9	409.1*†‡ 391.0 to 427.1
Pain	96.1 95.0 to 97.2	94.5 93.2 to 95.9	95.6 94.1 to 97.2	94.4 92.4 to 96.4	93.7‡ 90.9 to 96.4	91.0*†‡ 88.9 to 93.3	92.7*†‡ 90.1 to 95.3	89.1*†‡ 87.0 to 91.3	92.5*‡ 89.5 to 95.5	88.2*†‡ 85.3 to 91.2
Symptoms	98.7 97.9 to 99.5	97.1 95.8 to 98.4	97.5 96.0 to 99.0	95.9 93.9 to 97.9	95.4‡ 93.1 to 97.8	92.0 89.9 to 94.1	92.0‡ 89.2 to 94.7	89.2*† 86.9 to 91.4	92.9‡ 91.0 to 96.0	86.1*† 82.7 to 89.6
ADL	99.5 99.1 to 99.9	99.3 96.7 to 99.3	99.4‡ 98.7 to 100.2	98.2 93.6 to 99.0	98.3‡ 96.9 to 99.7	95.9* 87.6 to 93.8	95.6*†‡ 93.6 to 97.6	93.7*† 80.6 to 87.8	94.0*†‡ 91.2 to 96.7	89.4*†‡ 66.7 to 78.6
Sports/recreation	97.9 96.6 to 99.2	98.0 90.8 to 95.2	98.5 97.2 to 99.9	96.3 84.6 to 92.2	95.6 92.3 to 99.0	90.7* 76.8 to 84.1	88.4*†‡ 84.1 to 92.6	84.2*† 71.9 to 79.3	84.6*†‡ 79.3 to 89.9	72.6*†‡ 67.7 to 77.5
QOL	95.7‡ 93.7 to 97.8	93.0 90.8 to 95.2	93.1 89.5 to 96.7	88.4 84.6 to 92.2	88.2*‡ 83.6 to 92.6	80.5*† 76.8 to 84.1	83.5*†‡ 79.0 to 87.9	75.6*† 71.9 to 79.3	85.7*‡ 80.5 to 90.9	72.6*† 67.7 to 77.5

Values of KSS2011 and KOOS are shown as the mean and 95% confidence interval. Comparisons between the total scores and each subscale among the age groups (<40, 40s, 50s, 60s, and >70) were analyzed using ANOVAs with Tukey's post-hoc tests. Mann-Whitney U tests were used to compare the males and females in each subscale and age group. p-Values less than 0.05 are shown as *: p < 0.05 vs <40. †: p < 0.05 vs 40s. ‡: p < 0.05 vs 50s. §: p < 0.05 vs 60s. ¶: p < 0.05 between males and females. ADL: activities of daily living; QOL: quality of life; overall KOOS: the total KOOS summed from the individual subscale scores.

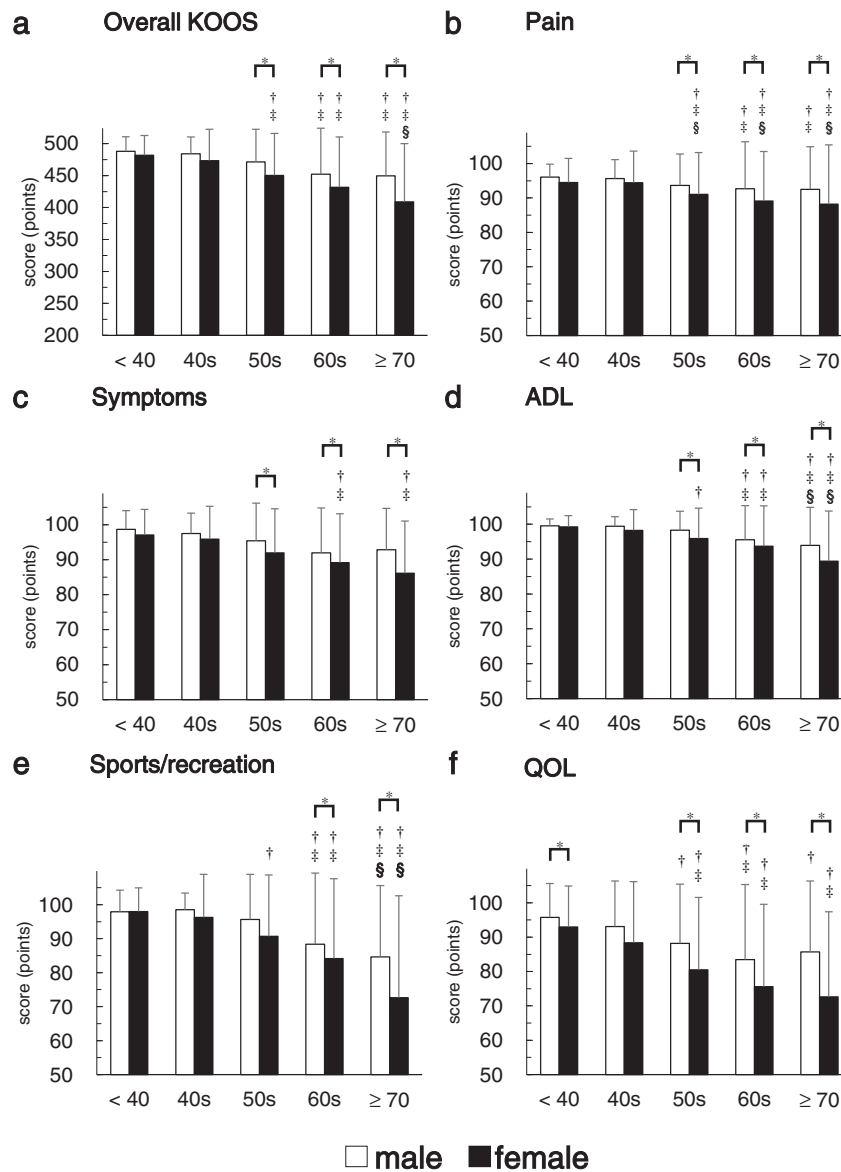


Fig. 3. Mean overall KOOS and KOOS subscales for males and females divided by age group, including (a) overall KOOS, (b) pain, (c) symptoms, (d) ADL, (e) sports/recreation, and (f) QOL. The mean overall KOOS and all subscales steadily decreased with age. In females over 50 years, all of the subscales except for sport/recreation were lower than those in the age-matched males. p-Values less than 0.05 are shown as *: $p < 0.05$ between males and females. †: $p < 0.05$ vs <40. ‡: $p < 0.05$ vs 40s. §: $p < 0.05$ vs 50s. ||: $p < 0.05$ vs 60s. ADL: activities of daily living; QOL: quality of life; Overall KOOS: the total KOOS summed from the individual subscales.

indicating better functional status, and the maximum score on each subscale was 100 points.

2.5. Statistical analysis

The participants were classified into five subgroups by age: under 40 years old, 40s, 50s, 60s, and over 70 years old, and by KL grades: 0, 1, 2, 3, and 4. The mean KSS2011 and KOOS by age and KL grade were compared among each group using analyses of variance (ANOVAs) with Tukey's post-hoc tests. Mann–Whitney U tests were performed to evaluate differences between females and males within each score. Furthermore, to evaluate the association between the KL grade and both scores, multiple regression analysis was performed. The overall KSS2011 and overall KOOS were assumed to be dependent variables, and age, sex, BMI, and KL grade were assumed to be independent variables. All analyses were performed in SPSS ver. 22.0, and p-values less than 0.05 were considered significant.

3. Results

3.1. Prevalence of knee osteoarthritis

Data were obtained for all 963 participants, which included 368 male and 595 female volunteers with an average age of 54.7 years (range: 20 to 90). The participants who were more than 70 were the oldest age group in this study. Three-hundred-ninety-seven participants (40%) showed radiographic knee OA. The prevalence of knee OA in females was higher than that in males in all age groups and increased with age (Table 1). Most of the participants who had knee OA were classified as KL grade 2 (Fig. 1).

3.2. Age- and sex- related differences in KSS 2011

The overall KSS2011 and each subscale tended to gradually decrease with age (Fig. 2a and Table 2). The score of overall KSS2011 went down by approximately 10 points at over 70 years old from under 40 years old in males and females: 140.9 (95% confidence interval (CI): 138.3 to 143.4), 136.7 (95% CI: 132.4 to 141.1), 135.7 (95% CI: 131.6 to 139.8), 130.3 (95% CI: 126.3 to 134.3), 132.5 (95% CI: 128.1 to 136.7) regarding males under 40 years old, in their 40s, 50s, 60s, and over 70 years old, and 141.5 (95% CI: 139.2 to 143.7), 136.0 (95% CI: 132.4 to 139.7), 132.1 (95% CI: 129.2 to 135.0), 131.5 (95% CI: 128.9 to 134.1), 128.4 (95% CI: 124.5 to 132.2) regarding females. Except for the walking and standing scores in participants older than 70 years, most subscales did not show sex-related

differences (Fig. 2b to f). The change of the symptoms score, standard activities score, and advanced activities score was less than 2 points by age group (Fig. 2b, e, f). The patient satisfaction score declined steadily from under 40 years old to over 70 years old in both sexes. (Fig. 2c and Table 2).

3.3. Age- and sex-related differences in KOOS

The mean overall KOOS and all subscales steadily decreased with age (Fig. 3a to f). The overall KOOS was significantly lower in females beginning in their 50s and in males beginning in their 60s (Table 2). The ADL, QOL, and sports/recreation scores were clearly lower in participants in their 60s and older (Table 2 and Fig. 3d, e, f). In females older than 50, all of the subscale scores except for sport/recreation were lower than the age-matched subscale scores in male participants.

3.4. KL grade related differences in KSS2011 and KOOS

The mean overall KSS2011 gradually decreased with KL grade (Table 3 and Fig. 4a): 137.8 (95% CI: 135.4 to 140.2), 136.4 (95% CI: 133.5 to 139.3), 129.5 (95% CI: 124.1 to 135.0), 130.1 (95% CI: 124.9 to 135.3), 126.2 (95% CI: 103.3 to 149.1) regarding males in KL grade 0, KL grade 1, KL grade 2, KL grade 3, and KL grade 4, and 139.5 (95% CI: 137.2 to 141.7), 134.9 (95% CI: 133.0 to 137.6), 131.7 (95% CI: 129.4 to 133.9), 129.0 (95% CI: 125.0 to 133.0), 123.5 (95% CI: 110.2 to 136.9) regarding females. The symptoms, patient satisfaction score, and walking and standing score declined steadily from under KL grade 0 to KL grade 4 in both sexes (Fig. 4 b to d). The change of the standard activities score and advanced activities score was less than 3 points by KL grade (Fig. 4 e, f).

The mean overall KOOS and all its subscales were clearly decreased with increased KL grade (Table 3 and Fig. 5a to f). In particular, a distinct decrease was observed from KL grades 2 to 4. In KL grade 3, there were sex-related differences in all components. The score of KL grade 4 was lower than those in the smaller grade groups for all components. The score of KL grade 4 was lower than those in the smaller grade groups for all components.

3.5. Association with KL grade in KSS2011 and KOOS

The overall KSS2011 was significantly correlated with age and KL grade. On the other hand, the overall KOOS was significantly correlated with sex, age, BMI, and KL grade (Table 4). The KL grade was more strongly associated with the KOOS ($\beta = -0.42$, $p < 0.001$) than with the KSS2011 ($\beta = -0.13$, $p = 0.001$).

Table 4
Correlations of individual factors with the overall KOOS and KSS2011 assessed by multiple linear regression analysis.

Factors	Overall KOOS			Overall KSS				
	β	95% CI		p-Value	β	95% CI		p-Value
		lower	upper			lower	upper	
Sex	-0.07	-16.91	-1.17	0.024	0.01	-2.10	2.46	0.877
Age	-0.08	-0.64	-0.05	0.020	-0.16	-0.27	-0.10	<0.001
BMI	-0.14	-3.99	-1.75	<0.001	0.03	-0.15	0.49	0.306
KLg	-0.42	-30.48	-21.85	<0.001	-0.13	-3.35	-0.85	0.001

The dependent variables were total KOOS and KSS2011, and the independent variables were sex, age, BMI, and KLg.
 β : regression coefficient; 95% CI: 95% confidence interval; BMI: body mass index; KLg: Kellgren–Lawrence grade.

4. Discussion

The aim of this study was to determine population-based reference data for the KSS2011 and KOOS and to correlate those scores with the severity of knee OA using large-scale epidemiological data from the general Japanese population. The overall KSS2011 decreased with age regardless of sex. Differences between the sexes were more distinct in the KOOS than in the KSS2011. In addition, radiographic knee OA was more strongly associated with the KOOS than the KSS2011. To our knowledge, this is the first study to evaluate knee complaints across the entire adult population as measured with both the KSS2011 and KOOS.

Knee function and physical activities vary among patients and are influenced by age and sex. As expected, the overall KSS2011 and KOOS decreased with age in the current study, as has been previously reported in other populations [19–21]. The results reported here are consistent with those previous findings. Almost none of the KSS2011 subscales showed differences by sex, and the decrease with age was subtle. In contrast, the KOOS significantly decreased with age, and there were

Table 3
KSS2011 and KOOS reported as mean and 95% confidence interval for males (M) and females (F) by KL grade.

	KL grade 0		KL grade 1		KL grade 2		KL grade 3		KL grade 4	
	M	F	M	F	M	F	M	F	M	F
Overall KSS2011	137.8 135.4 to 140.2	139.5 137.2 to 141.7	136.4 133.5 to 139.3	134.9 132.3 to 137.6	129.5* 124.1 to 134.9	131.7* 129.4 to 133.9	130.1 124.9 to 135.3	129.0*† 125.0 to 133.0	126.2 103.3 to 149.1	123.5* 110.2 to 136.9
Symptoms	23.5 23.1 to 24.0	23.8 23.4 to 24.2	23.5 22.9 to 24.1	23.1 22.5 to 23.7	22.5 21.5 to 23.5	22.5* 21.9 to 23.1	22.6 21.0 to 24.2	22.0* 21.2 to 22.8	17.4*†‡§ 11.2 to 23.6	20.7* 17.8 to 23.7
Patient satisfaction	34.2 33.1 to 35.3	34.7 33.5 to 35.9	32.6 31.1 to 34.0	32.8 31.6 to 34.0	31.3 29.2 to 33.5	30.7* 29.6 to 31.7	29.4* 26.5 to 32.2	30.3* 28.7 to 32.0	30.0 20.2 to 39.8	30.0 25.6 to 34.4
Walking and standing	28.4 27.8 to 29.0	28.0 27.2 to 28.8	27.9 27.1 to 28.8	27.5 26.7 to 28.2	26.4* 24.9 to 27.8	27.4 26.8 to 28.1	26.9 24.9 to 28.9	26.1* 24.9 to 27.2	26.4 21.5 to 31.3	26.2 22.8 to 29.6
Standard activities	28.7 28.3 to 29.2	29.2 28.8 to 29.6	29.1 28.6 to 29.5	28.6 28.1 to 29.2	27.5*† 26.4 to 28.5	28.4 28.0 to 28.9	28.6 27.8 to 29.4	28.2 27.4 to 29.0	28.6 24.7 to 32.5	26.9*† 24.3 to 29.4
Advanced activities	23.0 22.4 to 23.6	23.7 23.2 to 24.2	23.4 22.7 to 24.0	23.0 22.3 to 23.6	21.8 20.5 to 23.2	22.6 22.0 to 23.2	22.6 21.2 to 23.9	22.3 21.3 to 23.4	23.8 20.5 to 27.1	19.7 15.6 to 23.9
Overall KOOS	486.9 483.5 to 490.3	483.3 478.4 to 488.2	468.3* 458.7 to 477.9	471.0 464.0 to 478.0	458.6*‡ 443.7 to 473.4	448.9*† 440.7 to 457.1	422.1*†‡ 386.4 to 457.8	379.8*†‡ 361.2 to 398.3	285.4*†‡§ 211.5 to 359.3	275.1*†‡§ 217.9 to 332.3
Pain	98.5 97.9 to 99.1	97.8 96.9 to 98.8	95.1* 93.3 to 96.9	95.8 94.5 to 97.0	93.1* 90.4 to 95.8	91.9*† 90.3 to 93.5	88.1*†‡ 81.6 to 94.6	80.6*†‡ 77.1 to 84.0	58.9*†‡§ 44.8 to 73.0	61.7*†‡§ 48.4 to 75.0
Symptoms	96.5 95.8 to 97.3	95.1 94.0 to 96.2	94.2 92.3 to 96.1	94.7 93.5 to 96.0	92.7* 89.9 to 95.5	91.9 90.4 to 93.5	88.9*†‡ 82.9 to 95.0	82.5*†‡ 79.3 to 85.7	62.1*†‡§ 51.0 to 73.3	61.4*†‡§ 49.3 to 73.5
ADL	99.4 99.2 to 99.7	99.4 99.0 to 99.7	97.5 96.3 to 98.7	97.7 96.8 to 98.6	96.5* 94.6 to 98.4	96.1* 95.0 to 97.3	90.8*†‡ 84.9 to 96.6	86.9*†‡ 83.9 to 89.9	74.1*†‡§ 54.9 to 93.3	69.6*†‡§ 58.7 to 80.5
Sports/recreation	97.7 96.6 to 98.8	98.2 97.0 to 99.4	93.0 90.1 to 95.8	94.5* 92.6 to 96.4	90.8*† 86.5 to 95.1	89.1 86.5 to 91.7	78.6*†‡ 68.3 to 89.0	67.9*† 62.0 to 73.9	44.0*†‡§ 20.2 to 67.8	38.7*†‡§ 18.7 to 58.6
QOL	94.8 93.0 to 96.5	92.8 90.6 to 95.0	88.5 85.4 to 91.7	88.3* 85.6 to 90.9	85.4*†‡ 80.5 to 90.4	79.9*† 77.2 to 82.5	75.6‡ 65.4 to 85.9	61.8*†‡ 56.4 to 67.2	46.3*†‡§ 26.0 to 66.5	43.8*†‡§ 31.5 to 56.0

Values of KSS2011 and KOOS are shown as the mean and 95% confidence interval. Comparisons between the total scores and each subscale among the Kellgren–Lawrence grade (grade 0, grade 1, grade 2, grade 3, and grade 4) were analyzed using ANOVAs with Tukey's post-hoc tests. Mann–Whitney U tests were used to compare the males and females in each subscale and age group. p-Values less than 0.05 are shown as *: $p < 0.05$ vs KL grade 0. †: $p < 0.05$ vs KL grade 1. ‡: $p < 0.05$ vs KL grade 2. §: $p < 0.05$ vs KL grade 3. ¶: $p < 0.05$ between males and females. ADL: activities of daily living; QOL: quality of life; overall KOOS: the total KOOS summed from the individual subscale scores.

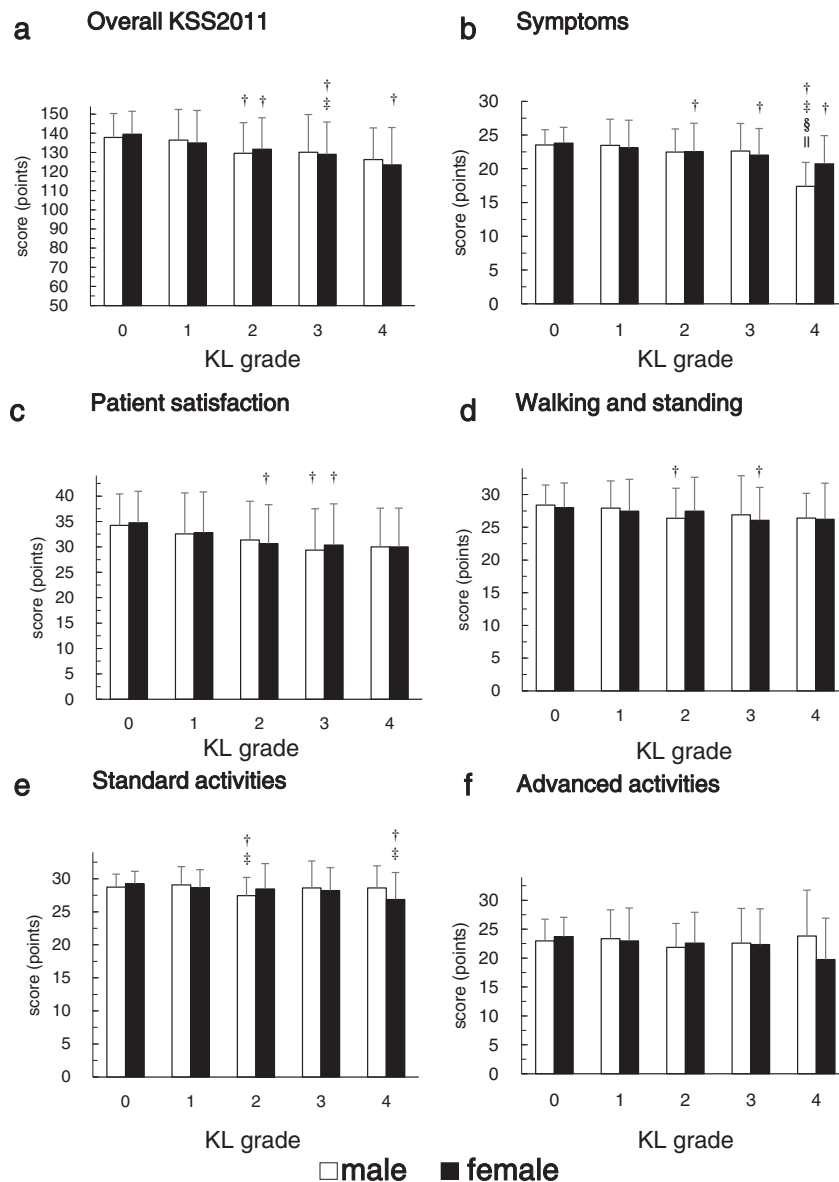


Fig. 4. The mean overall KSS2011 and KSS2011 subscales for males and females divided by Kellgren–Lawrence (KL) grade, including (a) overall KSS2011, (b) symptoms, (c) patient satisfaction, (d) walking and standing, (e) standard activities, and (f) advanced activities. The overall KSS2011 and each subscale tended to gradually decrease with KL grade. The advanced activities did not show KL grade-related differences. P-values less than 0.05 are shown as *: $p < 0.05$ between males and females. †: $p < 0.05$ vs KL grade 0. ‡: $p < 0.05$ vs KL grade 1. §: $p < 0.05$ vs KL grade 2. ||: $p < 0.05$ vs KL grade 3. Overall KSS: the total KSS2011 summed from the individual subscales.

clear differences between male and female participants. Elderly females reported more knee-related complaints in all of the KOOS subscales than the age-matched males in this study cohort. Therefore, these characteristics of the KSS2011 and KOOS should be considered when evaluating patients. Furthermore, elderly patients typically set lower goals after knee operations than younger patients.

It is important to understand the factors that influence patient-reported outcome scales. In the present study, the KSS2011 was significantly correlated with age and KL grade, and the KOOS was correlated with age, BMI, and KL grade. In particular, the KL grade was more strongly correlated with the KOOS than the KSS2011. A few previous studies have examined the association of the KSS2011 with factors in general populations. One prior cross-sectional study in Japan reported that the KSS2011 decreased with age and was associated with the KL grade, BMI, leg muscle strength, and the Timed Up and Go test [20]. Population-based normative data for the KOOS were reported and stratified by age and sex [21]. A previous study found that lower knee extension strength and higher BMI were associated with knee pain [4]. The relationship between

radiographic knee OA and quadriceps strength has also been reported [22]. In that study, the authors found that quadriceps muscle strength decreased in patients after age 50 years and a tendency for muscle strength to decrease with the progression of knee OA grade between grades 0 and 1 in both males and females. The KOOS may more accurately reflect knee muscular strength because we found here that the functional subscales of the KOOS were more greatly decreased with age than those of the KSS2011 in patients older than 50 years. From a clinical perspective, the KOOS may be more useful than the KSS2011 to assess knee complaints from the initial phase to the late phase of radiographic knee OA.

There were several limitations to this study. First, we cannot completely exclude the effects of other systemic diseases. Any physical function-related comorbidity could affect the results. Second, this study was performed in a limited local region, which may not be representative of Japan overall. For example in the Research on Osteoarthritis–osteoporosis Against Disability (ROAD) study, living in a mountainous community was a risk factor for knee OA [23,24]. Third, we used the Japanese version of the KSS2011, for which validation

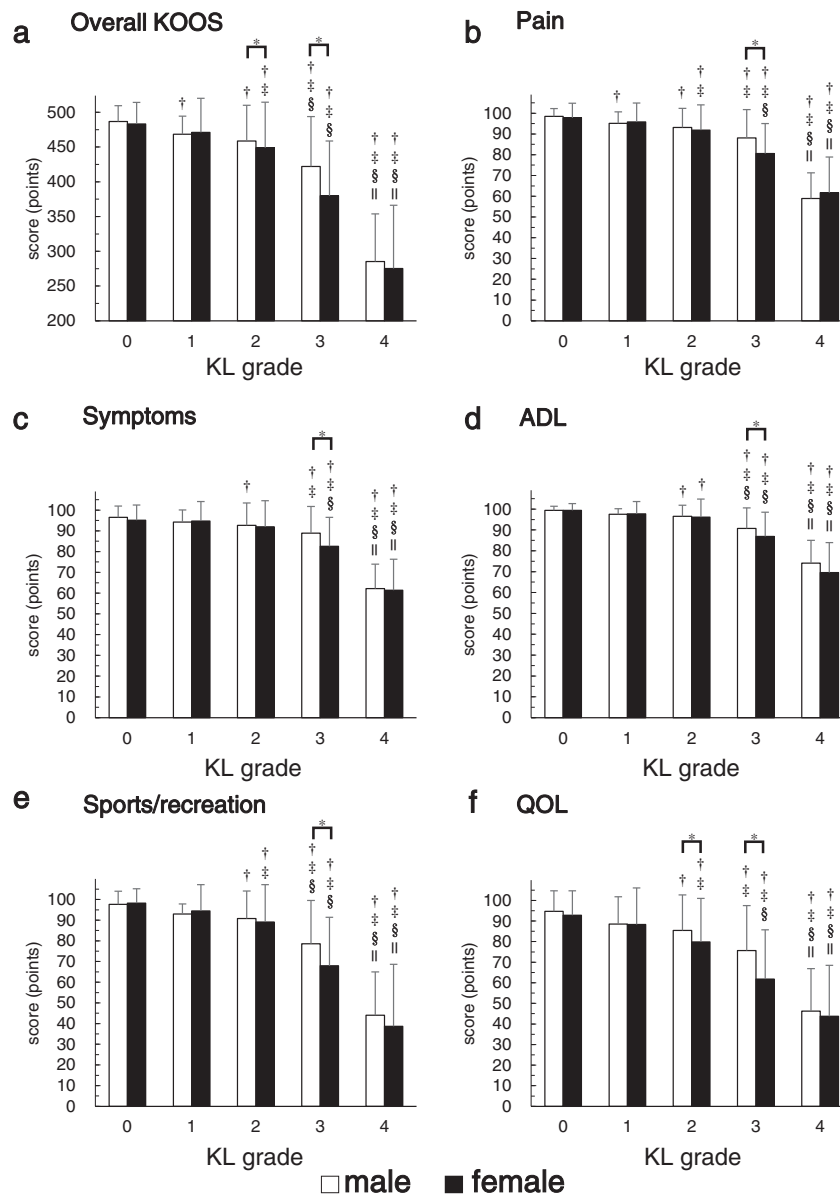


Fig. 5. The mean overall KOOS and KOOS subscales for males and females divided by the Kellgren–Lawrence (KL) grade, including (a) overall KOOS, (b) pain, (c) symptoms, (d) ADL, (e) sports/recreation, and (f) QOL. The mean overall KOOS and all subscales clearly decreased with KL grade. All of the KOOS subscales in patients with KL grades 3 and 4 were lower than those in patients with grades 0 and 1. p-Values less than 0.05 are shown as *: $p < 0.05$ between males and females. †: $p < 0.05$ vs KL grade 0. ‡: $p < 0.05$ vs KL grade 1. §: $p < 0.05$ vs KL grade 2. ||: $p < 0.05$ vs KL grade 3. ADL: activities of daily living; QOL: quality of life; Overall KOOS: the total KOOS summed from the individual subscales.

work using cultural adaptation methods has not yet been performed. For populations with larger cultural differences from Western countries, such as Asian populations, the cultural adaptation may be important [9]. Finally, smaller differences in the results than anticipated may have been caused by selection bias resulting from the use of voluntary participants who may be more health conscientious than the population overall.

5. Conclusion

This is the first study to evaluate knee complaints as measured by both the KSS2011 and KOOS in a large general population in Japan. The three key findings of the present study are: (1) the KSS2011 and KOOS decreased with age and were correlated with the KL grade. (2) Sex differences were more apparent in the KOOS than in the KSS2011. (3) The KOOS was more strongly correlated with the KL grade than KSS2011 across the entire adult population. In the general

population, the KOOS may be more useful than the KSS2011 when evaluating knee complaints in patients with knee OA.

Conflict of interest statement

No benefits in any form have been received or will be received from any commercial party related directly or indirectly to the subject of this article entitled “The Knee injury and Osteoarthritis Outcome Score reflects the severity of knee osteoarthritis better than the revised Knee Society Score in a general Japanese population”.

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