Knee injury and osteoarthritis outcome score (KOOS) – National record-based reference values

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Knee injury and osteoarthritis outcome score (KOOS) – National record-based reference values

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ABSTRACT

Background: Knee Injury and Osteoarthritis Outcome Score (KOOS) and the short form KOOS-12 are commonly used in clinical practice and research but there are no national record-based reference values to aid interpretation. The aim of this study was to establish national record-based reference values for the KOOS and its short form KOOS-12.

Patients and methods: A national record-based representative sample of 9996 adult citizens were derived from the Danish Civil Registration System. The selection of citizens was based on seven predefined age groups with an equal sex distribution across each age strata. The KOOS questionnaire was sent to all participants, together with two supplemental questions regarding previous knee problems and body mass index (BMI).

Results: A total of 2842 participants completed the KOOS, 1463 women (51.4%) and 1379 men (48.6%). The mean KOOS subscale scores were: pain 85.3 (95% confidence interval (CI): 84.6–85.9), symptoms 85.1 (95% CI: 84.5–85.8), activities of daily living (ADL) 86.7 (95% CI: 86.0–87.3), sport and recreation function 70.9 (95% CI: 69.8–72.0), quality of life (QOL) 74.9 (95% CI: 73.9–75.8). Age- and sex-specific reference values showed small differences in mean scores between the five KOOS subscales and all were below the threshold for clinically relevant improvement (10 points). Knee problems were associated with worse KOOS scores across all subscales. The difference in the mean subscale scores between the lowest (<24.9) and highest (>40) BMI groups ranged from 12.9 to 24.1. Comparable results were observed for KOOS-12.

Conclusion: KOOS and KOOS-12 reference values can, in most situations, be used without stratification for age and sex. Sport/recreation reference values stratified for age and BMI may be of importance.

1. Introduction

In recent years, healthcare systems have moved toward a more patient-centered and value-based clinical practice that emphasizes the use of patient-reported outcome instruments [1]. Instruments that investigate both general and body-region specific self-reported health status have become a central part of investigating treatment outcomes in clinical practice

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[2]. Patients' perspectives regarding topics such as pain, symptoms, function, and quality of life (QOL) are commonly included.

In orthopedics, body region-specific patient-reported outcomes are widely used to capture the baseline status of the patient or as repeated questionnaires to describe the changes in a patient's self-report status. These scores are often used in combination with radiological and functional measurements for clinical decision making.

The Knee Injury and Osteoarthritis Outcome Score (KOOS) and its short form KOOS-12 are widely used in both clinical practice and as a research instrument evaluating knee-specific change and effect of treatment [3,4]. The KOOS was developed utilizing patient input during the 1990 s as a patient-reported knee-specific instrument to evaluate knee and associated problems. Several randomized controlled trails use the KOOS as primary outcome and during the last decades the KOOS has been used in numerous studies evaluating a wide range of different knee related injuries or diseases [5,6].

Several studies have provided reference values for the KOOS [7–10]. Three studies included selected populations of healthy individuals [8–10] and one study included a random selected population based on a single region of southern Sweden [7]. At present there is a lack of KOOS reference values derived from a randomly selected large-scale national population across different age ranges and sex strata. Such reference values of the KOOS and KOOS-12 would offer a much-needed reference for discussing patient outcomes and supporting researchers in estimating expected outcomes.

The present study aimed to establish national record-based reference values for the five KOOS subscales, and the short form KOOS-12 based on a randomly selected representative sample of adults across age and sex strata.

2. Methods

2.1. Study design

The study design was a population record-based sample including a national representative sample of all citizens of Denmark.

At birth or emigration to Denmark, a Civil Registration Number (CPR) is given to all residents and registered in the Civil Registration System. Prospective information regarding emigration and death is recorded in this registry [11]. The Civil Registration System includes individual information of the entire population of Denmark [11].

The Danish Data Protection Agency approved the study (J. nr. 2021 Id: 114). The reporting of the study complies with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [12].

2.2. Data retrieval

An invitation to participate in the project was mailed to all participants using the mandatory online system E-boks. E-boks is mandatory for almost all Danish citizens and is based on the Danish Civil Registration System. The invitation includes an online link to the KOOS questionnaire and contact information for the research group in case of questions. After finishing the KOOS questionnaire, participants were also asked to submit their height and weight. Furthermore, one supplemental question was asked: "Within the last five years, have you been in contact with a health professional due to a knee problem? Answer: yes/no".

In case of no response within 14 days, participants received a second and final request to participate.

2.3. Study population

A representative sample of 9996 citizens of Denmark was derived from the Danish Civil Registration System. By 2021, the population of Denmark constituted 5.8 million citizens. Included was a representative sample of all Danish citizens above the age of 18 years. Excluded were all participants without online contact information (E-boks).

The sample was selected based on seven predefined age groups (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80 + years) and an equal sex distribution across all age-strata. A sample of 9996 citizens was included to allow adequate power for subgroup analyses based on both age and sex. We expected a response rate of around 30% giving approximately 200 citizens in each age and sex group.

2.4. The KOOS and short form KOOS-12

The KOOS is a patient-reported knee-specific questionnaire including 42 items in five subscales evaluating pain, symptoms, function of daily living, sport and recreation function (sport/rec), and QOL [13]. The KOOS is available in more than 45 languages [13].

The short form, named KOOS-12, was introduced in 2019 including seven items in three subscales: pain, function, and quality of life (QOL) together with an impact score [14,15]. The short form KOOS-12 is reported to reduce respondent burden by about 70%, making the routine use in clinical practice more efficient and affordable [14,15].

The outcome of KOOS and KOOS-12 is calculated based on a standardized scoring algorithm given a score between 0 and 100 for each of the subscales. The KOOS-12 impact scorer is calculated as an average of the three subscales [13]. A score of

100 indicates the best possible results and 0 the worst outcome. The KOOS and KOOS-12, including scoring manuals, is freely available for academic users. For information on, or permission to use, please contact Mapi Research Trust at https://eprovide.mapi-trust.org

2.5. Statistical analysis

The KOOS and KOOS-12 scores were given as mean, median, and standard deviation (SD), 95% confidence intervals, minimum, maximum, and number in each age group. If the number of missing values in the KOOS items was more than 50% in each subscale, the result of the subscale was omitted, in accordance with the KOOS scoring manual.

Continuous variables were reported by mean and SD and categorical variables by frequencies. A two-way analysis of variance (ANOVA) was used to analyze the difference between predefined age groups and sex. If significant ANOVA factors or interactions were found, multiple pairwise analyses with post hoc test (Bonferroni) corrections were used.

One-way ANOVA was used to analyze the difference between KOOS and KOOS-12 subscales and reporting of knee problems (yes/no) and between body mass index (BMI) groups (18–24.9, 25–29.9, 30–34.9, 35–39.9, 40–44.9 and > 45), where BMI > 40 indicates super obesity. If significant ANOVA factor was found, multiple pairwise analyses with post hoc test (Bonferroni) corrections were used. Response versus non-response was evaluated regarding age by the unpaired *t*-test and sex by the Chi-squared test. A *P*-value of < 0.05 was considered significant. The statistical analysis was performed by STATA (version 27).

KOOS thresholds for clinical relevant improvement in the different KOOS subscales range from 8 to 18, and from 8 to 22 for the KOOS-12 subscales [16–19]. In this paper, we considered thresholds of 10 for all KOOS and KOOS-12 subscales and the KOOS-12 impact score to represent a clinically relevant difference between age, sex and BMI groups.

3. Results

A total of 9996 nationally representative persons were included in the study population. Of these, 986 were excluded due to exemption from the E-boks system. A total of 2842/9010 (32%) participants completed the KOOS questionnaire, 1463 women (51%) and 1379 men (49%). Detailed information regarding the study is presented in Figure 1.

3.1. KOOS and KOOS-12 subscale scores

The KOOS and KOOS-12 subscale scores for the total sample and divided by age and sex groups are presented in Tables 1 and 2 and Figure 2.

3.2. Impact of self-reported knee problems within five years on KOOS/KOOS-12 subscale scores

A total of 676 participants (24%) reported a knee problem within the last 5 years. The mean age of participants reporting a knee problem was 60.2 years, and 55% were women compared with the total sample with a mean age of 60.5 years and 51% women.

Reporting knee problems was associated with worse KOOS and KOOS-12 mean subscale scores. The difference in KOOS mean subscale scores between patients with and without self-reported knee problems ranged from 17.7 in activities of daily

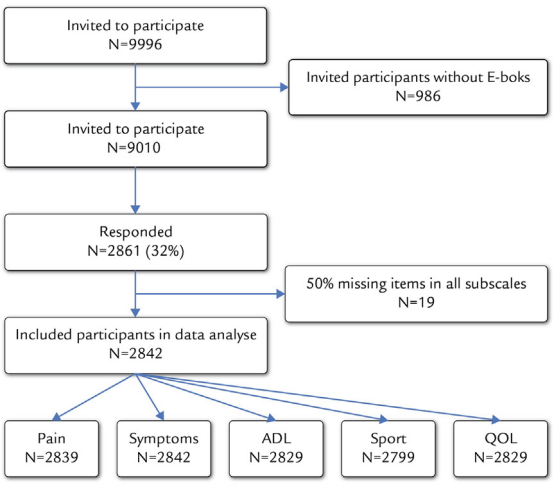

Figure 1. Flow diagram for the study. ADL, activities of daily living; QOL, quality of life.

Table 1
Knee Injury and Osteoarthritis Outcome Score (KOOS) and KOOS-12 subscale scores for the total sample.

KOOS						KOOS-12		
	Pain	Symptoms	ADL	Sport/Rec	QOL	Pain	Function	QOL
Mean	85.3	85.1	86.7	70.9	74.9	82.7	82.8	74.9
SD	18.2	16.8	17.5	30.3	25.4	20.3	20.8	25.4
95% CI	84.6–85.9	84.5–85.8	86.0–87.3	69.8–72.0	73.9–75.8	81.9–83.4	82.1–83.6	73.9–75.8
Median	94	90	96	80	81	94	94	81
Min	0	0	9	0	0	0	0	0
Max	100	100	100	100	100	100	100	100
Number	2839	2842	2829	2799	2829	2825	2825	2829

ADL, activities of daily living; CI, confidence interval; QOL, quality of life; SD, standard deviation.

Table 2
Knee Injury and Osteoarthritis Outcome Score (KOOS) and KOOS–12 subscale scores by age–groups (total sample).

	KOOS Pain							KOOS Symptoms						
Age group (years)	18–29	30–39	40–49	50–59	60–69	70–79	80+	18–29	30–39	40–49	50–59	60–69	70–79	80+
Mean	85.6	89.4	87.2	84.2	83.3	84.8	86.5	82.0	86.3	85.5	83.7	83.6	85.9	88.8
SD	18.2	15.3	17.1	19.0	19.3	18.1	17.8	18.1	14.7	16.3	17.3	17.3	16.8	15.3
95% CI	82.7–88.5	87.4–91.4	85.4–89.0	82.5–85.9	81.8–84.7	83.4–86.2	84.7–88.3	79.1–84.9	84.4–88.3	83.7–87.2	82.2–85.3	82.3–84.9	84.6–87.3	87.2–90.4
Median	94	97	94	92	92	92	97	90	90	90	90	90	93	95
Min	17	25	8	19	6	22	25	10	15	20	0	25	15	25
Max	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number	153	218	351	473	640	634	370	153	218	351	473	640	634	373
	KOOS ADL							KOOS Sport/Rec						
Age group (years)	18–29	30–39	40–49	50–59	60–69	70–79	80+	18–29	30–39	40–49	50–59	60–69	70–79	80+
Mean	91.3	93.0	90.4	85.9	84.8	85.0	84.2	77.8	81.2	77.7	71.1	66.5	67.7	68.1
SD	14.1	12.5	15.3	18.4	18.1	17.8	18.6	27.1	25.1	27.3	29.9	31.4	30.9	31.8
95% CI	89.0–93.5	91.3–94.7	88.8–92.0	84.3–87.6	83.4–86.2	83.6–86.4	82.3–86.1	73.5–82.2	77.9–84.6	74.9–80.6	68.4–73.8	64.0–68.9	65.3–70.1	64.8–71.4
Median	97	99	97	94	93	93	92	85	90	90	80	75	80	80
Min	24	31	12	18	9	21	15	0	0	0	0	0	0	0
Max	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number	152	217	350	473	639	632	366	152	217	348	469	631	624	358
	KOOS QOL							KOOS–12 Pain						
Age group (years)	18–29	30–39	40–49	50–59	60–69	70–79	80+	18–29	30–39	40–49	50–59	60–69	70–79	80+
Mean	76.9	80.8	78.5	73.8	71.2	73.8	76.0	82.5	86.6	84.9	81.9	80.4	82.0	84.0
SD	25.0	23.2	23.0	25.9	26.4	25.3	26.2	20.7	18.3	18.9	20.7	21.1	20.3	20.3
95% CI	72.8–80.9	77.7–83.9	76.1–80.9	71.5–76.1	69.2–73.3	71.8–75.8	73.3–78.7	79.2–85.8	84.1–89.0	83.0–86.9	80.0–83.7	78.8–82.1	81.9–86.1	81.9–86.1
Median	88	94	88	81	75	81	88	88	94	94	88	88	94	94
Min	6	6	6	6	0	0	0	25	13	13	19	0	25	25
Max	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number	152	217	351	473	640	628	368	153	218	351	473	640	634	370
	KOOS–12 Function							KOOS–12 QOL						
Age group (years)	18–29	30–39	40–49	50–59	60–69	70–79	80+	18–29	30–39	40–49	50–59	60–69	70–79	80+
Mean	88.1	90.4	87.4	82.0	80.1	80.8	80.5	76.9	80.8	78.5	73.8	71.2	73.8	76.0
SD	17.4	15.7	18.5	21.3	21.5	21.3	22.2	25.0	23.2	23.0	25.9	26.4	25.3	26.2
95% CI	85.3–90.9	88.3–92.5	85.5–89.4	80.1–84.0	78.4–81.8	79.1–82.4	78.2–82.7	72.8–80.9	77.7–83.9	76.1–80.9	71.5–76.1	69.2–73.3	71.8–75.8	73.3–78.7
Median	94	100	94	94	88	88	88	88	94	88	81	75	81	88
Min	13	19	13	13	0	19	13	6	6	6	6	0	0	0
Max	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number	152	217	350	473	639	633	370	152	217	351	473	640	628	368

ADL, activities of daily living; CI, confidence interval; QOL, quality of life; SD, standard deviation.

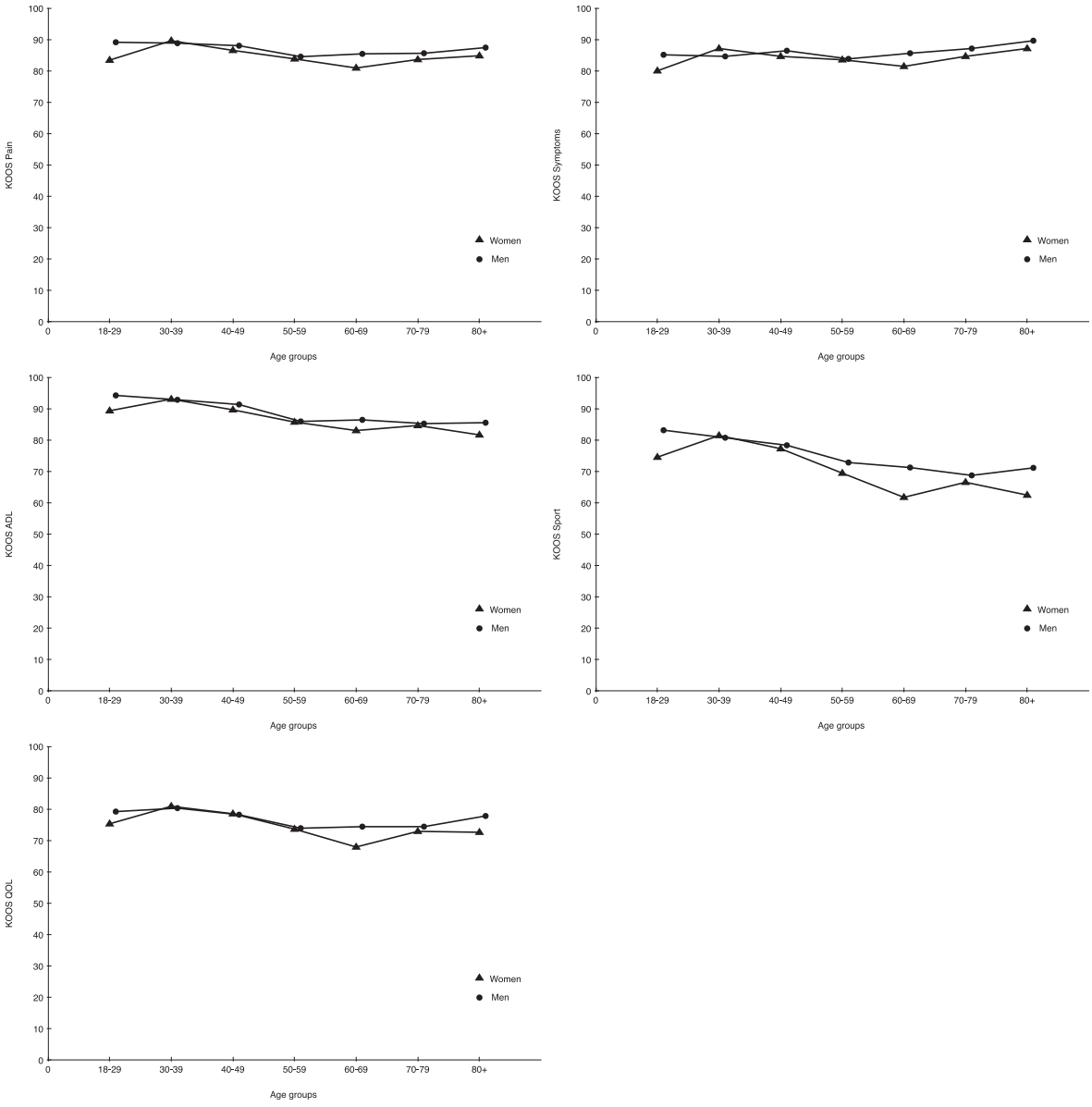

Figure 2. Knee Injury and Osteoarthritis Outcome Score (KOOS) and KOOS12 subscale scores divided by age groups and gender. ADL, activities of daily living; QOL, quality of life.

living (ADL) to 34.1 in sport/recreation and for KOOS-12 mean subscale scores ranged from 21.6 in function to 32.1 in QOL (Table 1 supp.).

3.3. Age- and sex-specific scores for the KOOS and KOOS-12

The age- and sex-specific subscale scores for the KOOS and KOOS-12 are presented in Table 2 and Figure 2.

The differences between men and women on the KOOS subscales were small and none were close to the predefined cut-off (10 points) for clinical relevance. The differences ranged from 1.1 in ADL to 3.7 in sport/recreation, and mean KOOS-12 subscale score differences ranged from 1.6 in function to 2.5 in pain (Figure 2).

The age-specific reference values show small differences in mean KOOS subscale scores between the seven pre-defined age groups. Comparison between all age groups (21 groups) only showed clinically relevant differences (thresholds predefined as 10 points) in mean scores in eight of the 21 possible comparisons in the KOOS subscale sport/recreation and in one of the 21 possible comparisons for the KOOS-12 subscale function. Age-related differences in the mean KOOS subscale scores ranged from a maximum of 6.1 in pain between the age groups 30–39 years and 60–69 years to a maximum of 14.7 in sport/

recreation between the age groups 30–39 years and 60–69 years. Age-related differences in the mean KOOS-12 subscale scores ranged from a maximum of 6.1 in pain between the age groups 30–39 years and 60–69 years to a maximum of 10.2 in function between the age groups 30–39 years and 60–69 years (Table 2).

Excluding patients reporting knee problems did not significantly change the KOOS subscale mean scores when compared with the reference values of the total population.

3.4. Impact of BMI on KOOS and KOOS-12 subscale scores

The mean BMI of the participants was 26.9 (5.7 SD). Participants reporting a BMI of > 30 account for 22% (n = 624). The mean age of participants reporting a BMI of 30 or higher was 59.3 years, and 52% were women. The association between BMI and the KOOS/KOOS-12 subscale scores are presented in Table 3. A higher BMI was associated with lower (worse) KOOS subscale scores and was especially pronounced in the KOOS subscales pain, sport/recreation, and QOL. The difference in mean KOOS subscale scores between the lowest BMI group (<24.9) and super obese (>40) ranged from 13.0 in pain to 24.0 in sport/recreation and KOOS-12 between 14.2 in QOL to 16.1 in function (Table 3).

4. Discussion

This national record-based sample is the first study to report national age-stratified reference values for the KOOS and KOOS-12 questionnaires. We showed that the KOOS and KOOS-12 mean subscale scores in most situations can be used without stratification for age and sex. However, when a clinically relevant threshold of 10 KOOS points is applied, the KOOS subscale sport/recreation may have clinically relevant age-dependent differences. As an example, applying age-specific reference values can be of importance in setting expectations regarding improvements in sport and recreation function following knee surgery in young adults and in older adults. Furthermore, super-obese patients generally have clinically important worse reference values. This information should be considered when evaluating KOOS scores of an individual patient in the clinic, both when evaluating the clinical status of the patient and the potential for treatment effects.

4.1. The impact of sex and age on KOOS and KOOS-12

Age-specific KOOS and KOOS-12 reference values are only relevant in specific situations while sex-specific scores are not needed. For the KOOS subscale sport/recreation, clinically relevant differences were found for the youngest and the oldest age groups indicating it may be clinically relevant to apply age-specific reference scores for young athletes and older adults when considering knee surgeries.

We found statistically significant differences between women and men, but the differences were small and below the clinically relevant difference. Our results indicate that KOOS reference values stratified by sex are not needed. Moreover, statistically significant differences were observed between age strata, but the small differences are unlikely to have a clinical relevance in most situations. Apart from the subscale sport/recreation, with a mean difference of 14.8, the differences in mean KOOS subscale scores between the seven pre-defined age groups were < 9.6.

Previous studies have reported that KOOS subscale scores vary with age and sex [7–9]. Our results are in line with Paradowski et al. [7] who also reported small statistically significant differences between sex and age. Paradowski et al. [7] reported the most pronounced difference between sexes was in the age group 55–74 years, with women reporting worse KOOS scores. The differences ranged between 8.9 in ADL to 11.6 in sport/recreation indicating clinically relevant differences among the subscales symptoms, sport/recreation, and QOL) [7]. Paradowski et al. [7] reported considerably higher (>12.4 points) differences between age strata, indicating the relevance of including age-related reference values for all the KOOS subscales. This finding was not replicated in the current study. However, a direct comparison between studies is difficult due to differences in sample-size, width of confidence interval and different years of data collection.

4.2. The impact of BMI on KOOS and KOOS-12

The study population included 22% with a BMI of 30 or more. Participants with a high BMI had lower KOOS scores, especially in the KOOS subscales pain, sport/recreation, and QOL. The mean KOOS subscale difference between the BMI groups < 24.9 and > 40 was between 12.9 and 24.1. Results indicate the importance of considering BMI-stratified reference values in the interpretation of the KOOS and the KOOS-12 subscale scores. Results from the present study align with Baldwin et al. [9], who reported that a five-point increase in BMI increases the odds of limitations on the KOOS subscale sport/recreation by 85%. The strong association between high BMI and low KOOS scores have been confirmed by several authors and may be caused by the physical impairment caused by obesity [8,20]. For example, a super-obese patient, BMI > 40, scoring a KOOS subscale sport/recreation score of 58 is scoring above the expected reference value. In contrast, a slim person, BMI of 20, scoring 70 is well below the expected reference value.

Table 3
Knee Injury and Osteoarthritis Outcome Score (KOOS) and KOOS-12 subscale scores by body mass index (BMI) groups.

KOOS Pain				
BMI group	Mean	95% CI	SD	No.
18–24.9	89.2	88.3–90.1	15.4	1128
25–29.9	84.2	83.1–85.4	18.4	988
30–34.9	80.4	78.5–82.4	20.2	408
35–39.9	77.4	73.8–81.0	21.2	138
40–44.9	76.2	69.1–83.4	22.5	40
over 45	78.7	71.8–85.6	19.4	33
KOOS Symptoms				
BMI group	Mean	95% CI	SD	Number
18–24.9	88.7	87.9–89.5	14.4	1131
25–29.9	84.2	83.2–85.3	17.3	988
30–34.9	80.6	78.9–82.3	17.8	498
35–39.9	78.4	75.2–81.7	19.4	138
40–44.9	80.0	74.4–85.6	17.6	40
over 45	84.4	78.9–89.9	15.5	33
KOOS ADL				
BMI group	Mean	95% CI	SD	No.
18–24.9	91.0	90.1–91.8	14.3	1124
25–29.9	85.2	84.0–86.3	18.1	984
30–34.9	81.7	79.9–83.6	19.0	407
35–39.9	79.3	76.0–82.6	19.7	138
40–44.9	75.9	68.2–83.6	24.2	40
over 45	81.6	74.0–89.2	21.4	33
KOOS Sport/Rec				
BMI group	Mean	95% CI	SD	No.
18–24.9	79.0	77.5–80.6	26.1	1117
25–29.9	68.0	66.0–69.9	30.7	978
30–34.9	60.9	57.7–64.1	32.2	401
35–39.9	59.3	53.6–65.0	33.0	132
40–44.9	55.0	43.9–66.1	34.3	39
over 45	63.2	50.1–76.3	35.6	31
KOOS QOL				
BMI group	Mean	95% CI	SD	No.
18–24.9	80.8	79.5–82.1	22.7	1125
25–29.9	72.7	71.1–74.3	25.5	983
30–34.9	67.7	65.0–70.3	26.9	407
35–39.9	65.0	60.3–69.6	27.6	138
40–44.9	66.7	57.2–76.2	29.7	40
over 45	66.3	55.7–76.9	29.8	33
KOOS12 Pain				
BMI group	Mean	95% CI	SD	No.
18–24.9	87.1	86.1–88.2	17.4	1128
25–29.9	81.5	80.3–82.8	20.4	987
30–34.9	77.0	74.8–79.2	22.6	408
35–39.9	73.8	70.0–77.6	22.5	138
40–44.9	73.1	65.0–81.3	25.4	40
over 45	74.6	67.2–82.0	20.9	33
KOOS–12 Function				
BMI group	Mean	95% CI	SD	No.
18–24.9	88.1	87.1–89.1	17.2	1126
25–29.9	80.9	79.5–82.2	21.3	987
30–34.9	76.4	74.2–78.7	23.3	407
35–39.9	74.7	71.0–78.5	22.4	138
40–44.9	72.0	64.3–79.8	24.3	40
over 45	77.5	67.8–87.1	27.2	33
KOOS12 QOL				
BMI group	Mean	95% CI	SD	No.
18–24.9	80.8	79.5–82.1	22.7	1125
25–29.9	72.7	71.1–74.3	25.5	983
30–34.9	67.7	65.0–70.3	26.9	407
35–39.9	65.0	60.3–69.6	27.6	138
40–44.9	66.7	57.2–76.2	29.7	40
over 45	66.3	55.7–76.9	29.8	33

ADL, activities of daily living; CI, confidence interval; QOL, quality of life; SD, standard deviation.

4.3. Strengths and limitations

A major strength of the present study is the inclusion of a randomly selected national age and sex representative sample with more than 2800 responders making this the largest reference material available for the KOOS and KOOS 12.

Missing responders were spread evenly among age groups and sex ($P < 0.001$), minimizing the risk of a selection bias between age and sex groups. However, we were unable to evaluate any other differences not related to age and sex.

5. Conclusion

KOOS and KOOS-12 reference values can, in most situations, be used without stratification for age and sex. Sport/recreation reference values stratified for age and BMI may be of importance when interpreting both the baseline status and room for improvement in a clinical setting with a single patient or when interpreting results from a group of patients primarily representing a single age strata or BMI group.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.knee.2023.06.004.

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