Insight in the role of lipids and other systemic factors in hand and knee osteoarthritis: lessons from clinical studies

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Application of the Knee Injury and Osteoarthritis Outcome Score percentile curves for longitudinal data of patients undergoing total knee arthroplasty: the LOAS study

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Journal of Arthroplasty. 2021;36(8):2779-2787

Abstract

Background We aimed to investigate the application of the Knee Injury and Osteoarthritis Outcome Score (KOOS) percentile curves, using pre- and postoperative data of patients with knee osteoarthritis (OA) undergoing total knee arthroplasty (TKA).

Methods We used Longitudinal Leiden Orthopaedics Outcomes of Osteo-Arthritis study (LOAS) data of patients between 45 and 65 years and undergoing primary TKA. KOOS scores (0-100) were obtained preoperatively and 6, 12 and 24 months after TKA. Preoperative knee radiographs were assessed according to Kellgren-Lawrence (KL) in a subset (37%) of patients. Comorbidities were self-reported using a standardized questionnaire. The median (interquartile range) population-level KOOS scores were plotted on previously developed population-based KOOS percentile curves. Additionally, we assessed the application of the curves on patient-level, and investigated differences in scores between patients with preoperative KL-scores ≤2 and ≥3, and presence (versus absence) of comorbidities.

Results The study population consisted of 853 patients (62% women, mean age 59 years, BMI 30 kg/m^2) with knee OA undergoing primary TKA. Preoperatively, median KOOS scores of all subscales were at or below the 2.5th percentile. Scores increased to approximately the 25th percentile 12 months postoperatively. Greater improvements were observed in pain, and less improvements in sport and recreational function and quality of life. Patients with higher preoperative KL scores and without comorbidities showed greater improvements.

Conclusion The KOOS percentile curves provided visual insights in knee complaints of patients relative to the general population. Furthermore, the KOOS percentile curves give insight in how preoperative patient characteristics are correlated with postoperative results.

Introduction

Patient-reported outcome measures (PROMs) have been vastly incorporated in clinical research, and are nowadays increasingly used in daily clinical practice [1]. PROMs enable capturing the patients' health status in a standardized way, and support a more comprehensive understanding of outcomes and effectiveness. There are various ways in which PROMs can be used. Individual, patient-level PROM data can be routinely used to aid shared-decision making and patient-centred care by facilitating patient-clinician and multidisciplinary communication [2,3]. In addition, PROMs can be used for monitoring of disease progression and treatment effects. On population-level, PROMs can be used to identify patient groups that benefit most from treatment, assess treatment (cost-)effectiveness, or compare performance of health organizations [4–6]. However, the interpretation of PROMs can be difficult if benchmarks are lacking and if there is uncertainty about which level of change in score is clinically meaningful.

Knee complaints, such as pain and functional disability, are estimated to occur in 32.1 per 1000 persons per year in the Dutch population. Knee osteoarthritis (OA) is one of the most important causes of knee complaints [7]. Due to the absence of disease modifying drugs for OA, knee OA is treated symptomatically until progression to end-stage disease warrants a total knee arthroplasty (TKA). In the Netherlands, the annual number of TKAs has tripled in the last decade to over 25 thousand TKAs in 2018 [8]. The Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire is a condition-specific PROM developed to investigate the patients' burden due to knee complaints [9]. The KOOS consists of five subscales, measuring different knee-specific domains: symptoms, pain, activities of daily living (ADL) function, sport and recreational function, and quality of life (QOL). The items of these domains are transformed to subscale scores ranging from 0 to 100. By itself, these scores can be difficult to interpret, as suboptimal scores may be unrelated to musculoskeletal pathology [10–12]. Therefore, we have previously developed KOOS percentile curves in a middle-aged population-based cohort of Dutch men and women [13], to provide a benchmark for comparison of patient scores with the general population. Alternative ways to show PROMs data can optimise the interpretation of PROMs both by clinicians and patients, to support patient-clinical communication and making well-informed shared treatment decisions.

The aim of the present study was to investigate the application of the KOOS percentile curves to compare the pre- and postoperative KOOS scores of patients with knee OA undergoing primary TKA, with the distribution of KOOS scores in the Dutch general population. Furthermore, we compared KOOS scores between specific patient groups to gain insight in possible differences in treatment benefit.

Materials and methods

Study population

The Longitudinal Leiden Orthopaedics Outcomes of Osteo-Arthritis (LOAS) study (Trial ID NTR3348) started in June 2012, and is an ongoing, observational, multicentre, longitudinal cohort study designed to determine long-term outcomes of TKA and total hip arthroplasty. Patient recruitment has been described previously [14]. Briefly, patients were eligible if they had a diagnosis of OA, an age of 18 years or older, were listed for total hip arthroplasty or TKA, and were fluent in the Dutch language. Patients were recruited consecutively from eight hospitals in The Netherlands: Leiden University Medical Center (LUMC), Alrijne Hospital

Leiderdorp, Alrijne Hospital Leiden, Groene Hart Hospital Gouda, LangeLand Hospital Zoetermeer, Reinier de Graaf Groep Delft, Albert Schweitzer Hospital Dordrecht, Waterland Hospital Purmerend [15]. Informed consent was obtained according to the declaration of Helsinki. The Medical Ethical Committee of the LUMC approved the design of the study. The current analyses are comprised of patients who have been included from June 2012 until June 2017, who were between 45 and 65 years of age, and undergoing primary TKA. Supplementary figure S1 presents a flowchart of included and excluded patient numbers.

Demographic data and comorbidities
Patient characteristics including age, sex, bodyweight (kg) and height (m) were collected by questionnaire and verified with data from the Landelijke Registratie Orthopedische Implantaten (LROI). Weight and height were used to calculate body mass index (BMI) (kg/m^2). A comorbidity questionnaire provided by the Dutch Central Bureau of Statistics (CBS) was used to determine the presence of comorbidities in the past year [16].

Patient reported outcomes
Patients completed the KOOS [9,17] preoperatively and at 6, 12 and 24 months after surgery. Patient numbers at each timepoint are presented in supplementary table S2. The KOOS is a knee-specific instrument consisting of five subscales: pain (nine items), symptoms (seven items), ADL function (17 items), sport and recreation function (five items) and knee-related QOL (four items). Items were scored considering the previous week from 0 (no problems) to 4 (extreme problems), on a 5-point Likert scale. Subscale scores were calculated according to the KOOS user's guide [18] as the sum of the items included, and subsequently transformed to a 0–100 scale, with zero representing extreme knee problems and 100 representing no knee problems.
Patient treatment satisfaction was assessed at 6 and 12 months postoperatively using the Friends and Family Test phrasing [19], asking patients if they would recommend the surgery to friends or family members if they would have the same complaints.
The Short Form Health Survey (SF-12) was used to measure patients' health-related quality of life. This questionnaire consists of 12 questions covering 8 different dimensions (General Health, Physical Functioning, Role Physical, Role Emotional, Bodily Pain, Vitality, Social Functioning, and Mental Health). We calculated summary scores for the physical component (PCS), and mental component (MCS). The MCS and PCS scores range from 0 (worst QOL) to 100 (best QOL) [20]. Average scores of the United States population were used to derive norm-based scores with a mean of 50 and a standard deviation of 10.

Radiographic knee osteoarthritis severity
Weight-bearing anteroposterior knee radiographs of the affected knee were obtained in all patients prior to surgery as part of routine care. The radiographs were retrieved from five of the local hospitals (Leiden University Medical Center (LUMC), Alrijne Hospital Leiderdorp, Alrijne Hospital Leiden, Groene Hart Hospital Gouda, LangeLand Hospital Zoetermeer, Albert Schweitzer Hospital Dordrecht), and therefore available in a subset (37%) of patients. The radiographs were centrally scored by an experienced musculoskeletal radiologist. The Kellgren and Lawrence (KL) grading system was used to assess radiographic OA severity on a 0-4 scale (grade 0: no OA; grade 1: doubtful OA; grade 2: minimal OA; grade 3: moderate OA and grade 4: severe OA) [21]. Ten percent of radiographs was scored twice for assessment of an intraobserver reliability, which was 98% (97-99%) [14]. A comparison of baseline

characteristics between patients with and without radiographs showed no differences (supplementary table S1).

Reference population

The reference population consisted of middle-aged individuals included in the population-based Netherlands Epidemiology of Obesity (NEO) study. The NEO study is a prospective cohort study that included Dutch men and women between 45 and 65 years of age living in the greater are of Leiden (The Netherlands) between 2008 and 2012. Detailed study design and data collection have been described elsewhere (20). Briefly, individuals with a self-reported body mass index (BMI) ≥ 27 kg/m^2 were eligible to participate resulting in an oversampling of overweight or obese individuals. In addition, all inhabitants aged between 45 and 65 years from one municipality (Leiderdorp) were invited to participate irrespective of their BMI, allowing for a reference BMI distribution comparable to the general Dutch population (21). To correctly represent associations in the general population, adjustments were made for the oversampling of individuals with BMI ≥27 kg/m^2 (36). This was done by weighting individuals towards the BMI distribution of participants from the Leiderdorp municipality (n=1671), whose BMI distribution was similar to the BMI distribution in the general Dutch population (21). Consequently, results apply to a population-based study without oversampling of participants with BMI ≥27 kg/m^2. The Medical Ethical Committee of the LUMC approved the design of the study and all participants gave written informed consent.

Population-based outcomes

Participant characteristics and KOOS scores were collected cross-sectionally at baseline. The NEO study reference population consisted of 6,643 participants. Mean age of the population was 56 years, with a mean BMI of 26 kg/m^2, and 56% were women. Clinical knee OA was defined using the American College of Rheumatology classification criteria, 15% of the population was classified with clinical knee OA. KOOS scores were handled according to the KOOS user's manual similar to the LOAS study. The majority of this middle-aged general population showed a lack of pain and other knee-related problems, with KOOS subscale scores (median; IQR) of: pain (100; 94-100), symptoms (96; 86-100), ADL function (100; 96-100), sport and recreation function (100; 80-100), and quality of life (100; 75-100). Among investigated patient characteristics we showed that sex and BMI were most strongly associated with KOOS scores. Hence, sex and BMI-specific percentile curves were developed using quantile regression with fractional polynomials [13]. The curves can be interpreted as follows: the 50th percentile is equal to the median. A score at the 25th percentile means that 25% of the scores in the (reference) population are at or below this score and 75% of the population has a higher score. A similar interpretation applies to the other percentiles.

Statistical analysis

Patient characteristics, radiographic knee OA severity and presence of comorbidities were analysed using descriptive statistics. In previous analyses by our group KOOS scores were influenced by sex and BMI, therefore reference curves have been developed stratified for these variables. Therefore, we provided the LOAS patient characteristics stratified by sex. We plotted the preoperative and postoperative KOOS scores of patients with knee OA included in the LOAS cohort on the KOOS percentile curves for comparison of patient scores with the Dutch general population, as well as to visualize the score trajectories following TKA. We assessed the application of the reference curves on both patient-level and population-level.

To get more insight in the differences of TKA treatment effect, KOOS scores of patients with preoperatively low (≤2) and high (≥3) KL scores were compared, as well as KOOS scores of patients with at least one comorbidity of any kind, and without comorbidities. Stata V16.0 (StataCorp LP, College Station, TX, USA) was used for all analyses.

Data availability

The data underlying this article were provided by the LOAS study group by permission. The data will be shared on reasonable request to the corresponding author, with permission of the LOAS study group.

Results

Patient characteristics

The study population consisted of 853 patients, with a mean age of 59.1 years, a mean BMI of 30 kg/m^2, and predominantly women (62%). Overall, 75% of the LOAS population had one or more comorbidities; patients reported more often non-musculoskeletal (68%) than musculoskeletal (23%) comorbidities. Mean MCS and PCS scores were 54 and 31, respectively. While 74% of the population had moderate to severe radiographic OA, a subset had no (4%), doubtful (6%) or minimal (17%) radiographic OA (table 1).

Table 1. Baseline patient characteristics of the LOAS study, stratified by sex

	Overall	**Men**	**Women**
	853	321 (36%)	532 (64%)
Patient characteristics			
Age, year	59.1 (4.7)	59.6 (4.4)	58.8 (4.9)
BMI, kg/m^2	30.4 (5.0)	29.8 (4.4)	30.8 (5.3)
Any comorbidities, n (%)	636 (75)	230 (72)	406 (76)
Kellgren & Lawrence score*			
0, n (%)	13 (4)	3 (3)	10 (5)
1, n (%)	18 (6)	5 (5)	13 (6)
2, n (%)	52 (17)	16 (15)	36 (17)
3, n (%)	163 (52)	59 (55)	104 (50)
4, n (%)	68 (22)	24 (22)	44 (21)
SF-12^			
MCS	54.1 (10.2)	54.4 (10.2)	53.9 (10.2)
PCS	31.1 (8.7)	33.2 (8.7)	29.7 (8.5)

Numbers represent mean (SD) unless otherwise specified. KOOS subscale scores are transformed to a 0–100 scale, with zero representing extreme knee problems and 100 representing no knee problems. *Knee radiographs were scored in a random subset of n = 314 (37%) patients. ^SF-12 scores were missing in 101 patients. Abbreviations: ADL = activities daily living, BMI = body mass index, KOOS = Knee Injury and Osteoarthritis Outcome Score, n = number, SD = standard deviation.

Treatment satisfaction

At 12 months postoperatively, 92% of patients (90% of men, 92% of women) replied that they would recommend the surgery to friends or family if they would have the same complaints, reflecting treatment satisfaction in the great majority of patients.

Knee-specific outcomes up to 2 years after total knee arthroplasty
Preoperatively, KOOS scores were very poor across all subscales, and were lower in women compared to men. All subscale scores increased to a great extent 6 months after surgery, and showed further improvement between 6 and 12 months. Twelve months after surgery, KOOS scores stabilized. With exception of sport and recreational function, which remained lower in women, postoperative KOOS subscale scores were similar between men and women (supplementary table S2).

Using the KOOS percentile curves for population-level comparison of patients' KOOS scores with the general population
For comparison of population-level patient KOOS scores with the Dutch general population, the median (interquartile range) preoperative and 12-month postoperative KOOS scores of all five subscales were plotted on the KOOS percentile curves (figures 1, 2 and 3). By example, pain scores of all postoperative timepoints are shown in supplementary figure S2. All subscale scores showed notable inter-patient variability, as can be seen from the wide range of the boxplots and accompanying error bars. Visual comparison of the graphs in figure 1 and 2 showed that prior to TKA, median KOOS pain scores were worse in women compared to men. In comparison to the general population, preoperative median KOOS pain scores were below the 2.5th percentile (solid blue line) in both men and women. At 12 months postoperatively, median pain scores were around the 25th percentile (dotted yellow line) in men, and between the 25th and 50th percentile (striped navy line) in women. Pre-operatively, median scores of the other subscales varied from below the 2.5th percentile, to around the 5th percentile (dotted maroon line) in patients with a higher BMI. Median symptom and ADL function scores increased to around the 25th percentile postoperatively in both men (figure 1) and women (figure 2). Similarly, postoperative QOL scores were around the 25th percentile in men (figure 3). In women, somewhat higher postoperative scores were observed, approaching the 50th percentile in women with a higher BMI. A flooring effect was observed preoperatively in the sport and recreational function scores (figure 3). Postoperatively, sport and recreation scores increased; however, they remained around the 10th percentile (striped green line) of the general population.

Applying the KOOS percentile curves for follow-up of patient-level KOOS scores after total knee arthroplasty
To show the use of the KOOS percentile curves on a patient-level, for illustrative purposes five randomly selected men and women with knee OA were selected, and the preoperative and postoperative KOOS pain scores were plotted alongside the distribution in the general population (supplementary figure S3). A clear inter-patient variability in preoperative pain status, as well as at postoperative time points was observed. Despite that all depicted patients start with a preoperative KOOS pain score at or below the 2.5th percentile of the general population, some improve to (almost) the 50th percentile already at 6 months postoperatively, while others improve more gradually or to a lesser extent.

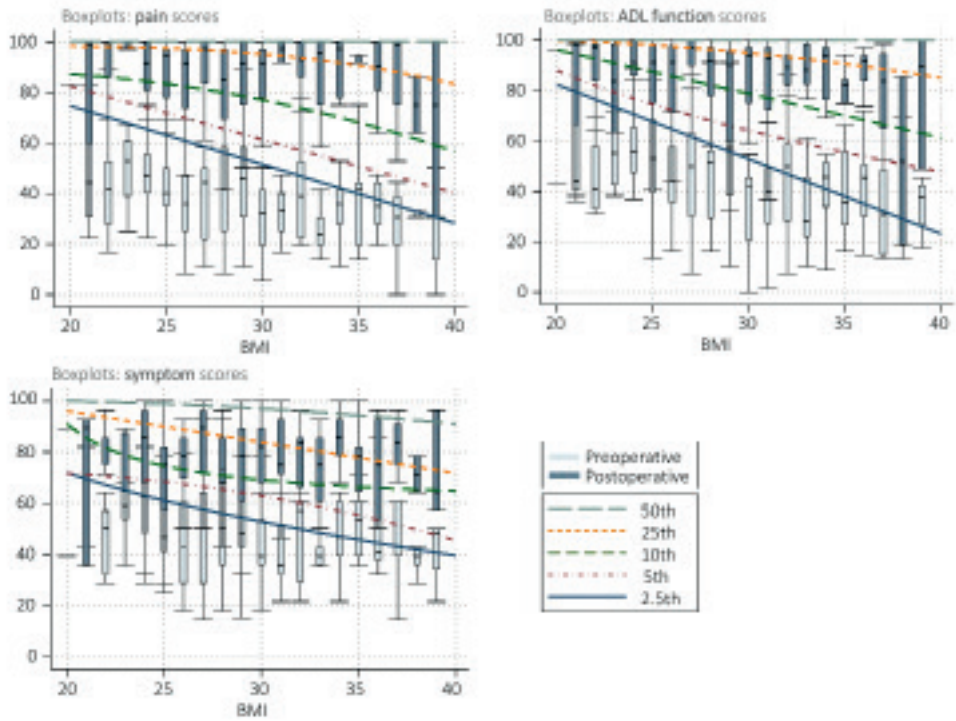

Figure 1. Comparison of the preoperative and 12 months postoperative KOOS pain, symptom and ADL scores in men undergoing primary total knee arthroplasty, with KOOS scores in the general population. The KOOS scores (Y-axis) are given over BMI (X-axis). The preoperative KOOS scores are represented by the light grey boxplots, and the postoperative scores are given in dark grey boxplots. The boxplots represent the median (horizontal line) and interquartile range. The KOOS score distribution of the general population is depicted with the coloured percentile lines.

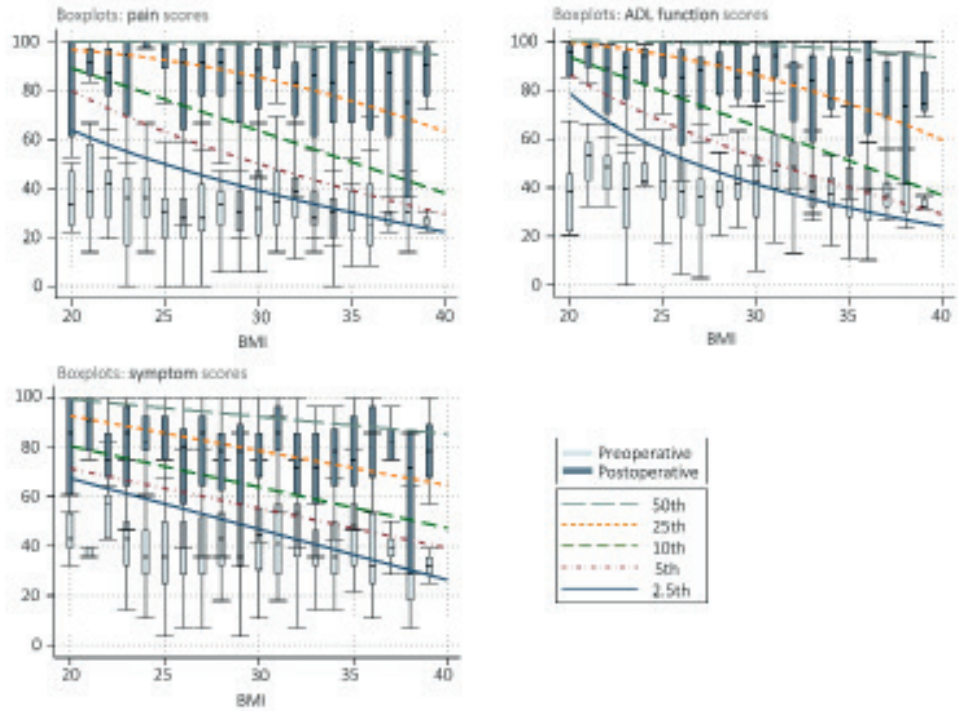

Figure 2. Comparison of the preoperative and 12 months postoperative KOOS pain, symptom and ADL scores in women undergoing primary total knee arthroplasty, with KOOS scores in the general population. The KOOS scores (Y-axis) are given over BMI (X-axis). The preoperative KOOS scores are represented by the light grey boxplots, and the postoperative scores are given in dark grey boxplots. The boxplots represent the median (horizontal line) and interquartile range. The KOOS score distribution of the general population is depicted with the coloured percentile lines.

Comparison of KOOS score trajectories between specific patient groups

KOOS pain scores from patients with preoperative KL scores below or equal to 2 points were compared with scores from patients with preoperative KL scores of 3 points or higher (figure 4). In men, patient numbers were too low to give conclusive results. In women, median preoperative pain scores did not differ with respect to KL score. Postoperatively, pain scores improved to a greater extent in women with preoperative moderate to severe radiographic OA compared with women with preoperative no to mild radiographic OA.

Figure 5 shows the KOOS pain scores of patients included in the LOAS study without any comorbidity and with at least one comorbidity. Preoperatively, across both sexes median pain scores were below the 2.5th percentile, with no differences between study group patients with and without comorbidities. At 12 months postoperatively, in both groups of LOAS patients median pain scores were about the 25th percentile in men. In women, median pain scores were at, or just below the 50th percentile in patients without comorbidities, while median pain scores were about the 25th percentile in women who had at least one comorbidity.

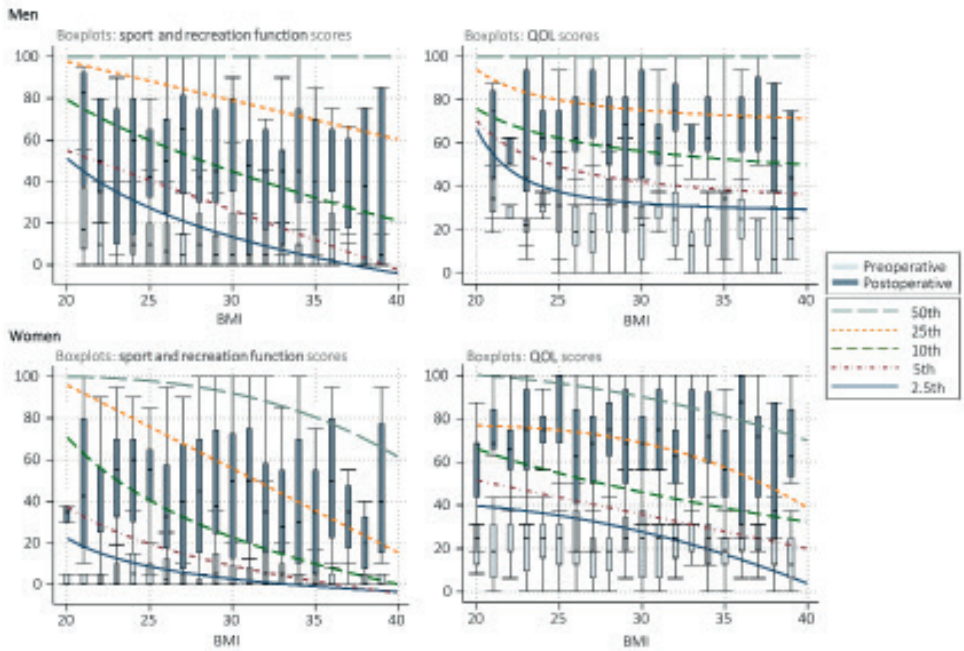

Figure 3. Comparison of the preoperative and 12 months postoperative KOOS sport and recreation, and QOL subscale scores in patients undergoing primary total knee arthroplasty, with KOOS scores in the general population. The KOOS scores (Y-axis) are given over BMI (X-axis). The preoperative KOOS scores are represented by the light grey boxplots, and the postoperative scores are given in dark grey boxplots. The boxplots represent the median (horizontal line) and interquartile range. The KOOS score distribution of the general population is depicted with the coloured percentile lines.

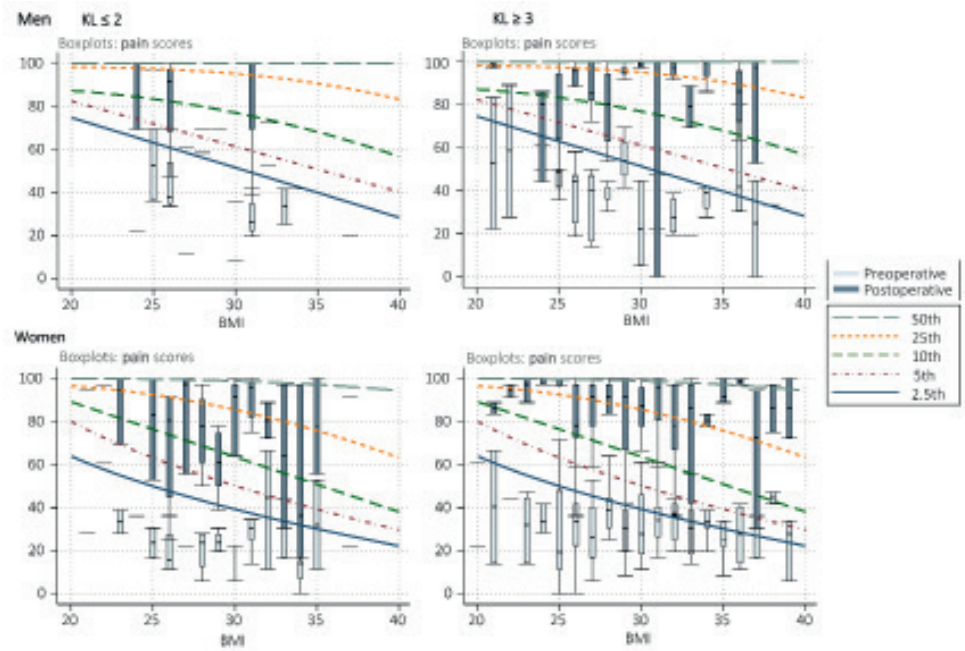

Figure 4. Comparison of the preoperative and 12 months postoperative KOOS pain scores in patients with low versus high preoperative radiographic OA severity. Preoperative and 12 months postoperative KOOS pain scores were stratified by Kellgren-Lawrence (KL) scores, comparing patients with a preoperative KL score ≤ 2 with patients with a preoperative KL score ≥ 3. The KOOS scores (Y-axis) are given over BMI (X-axis). The preoperative KOOS scores are represented by the light grey boxplots, and the postoperative scores are given in dark grey boxplots. The boxplots represent the median (horizontal line) and interquartile range. The KOOS score distribution of the general population is depicted with the coloured percentile lines.

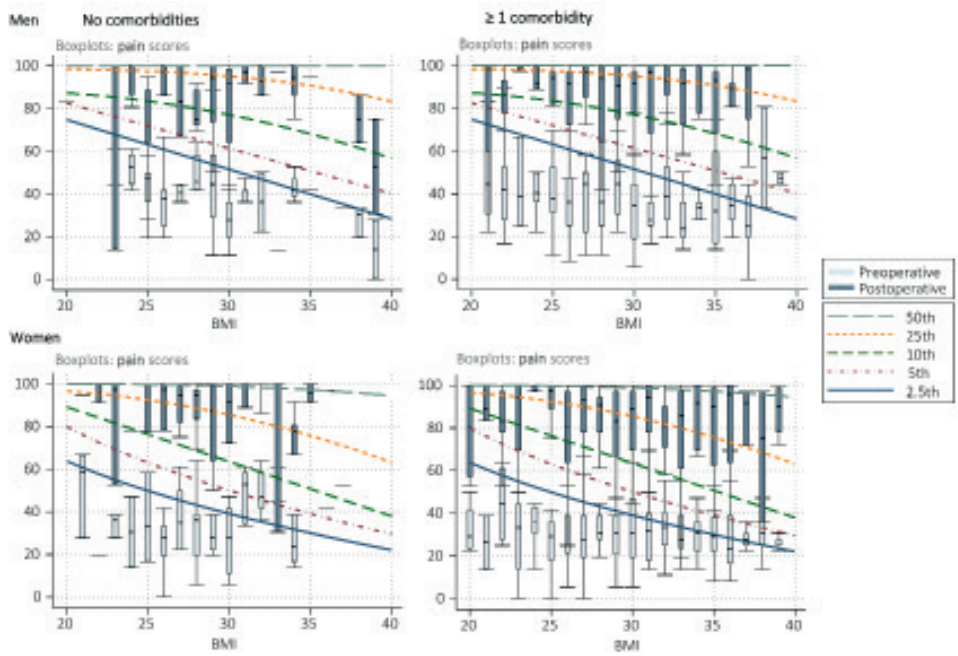

Figure 5. Comparison of the preoperative and 12 months postoperative KOOS pain scores in patients with no comorbidities versus patients with at least one comorbidity. The KOOS scores (Y-axis) are given over BMI (X-axis). The preoperative KOOS scores are represented by the light grey boxplots, and the postoperative scores are given in dark grey boxplots. The boxplots represent the median (horizontal line) and interquartile range. The KOOS score distribution of the general population is depicted with the coloured percentile lines.

Discussion

The increasing routine use of PROMs to evaluate conservative as well as surgical interventions necessitates the development of methodology to optimize the interpretation and evaluation of PROMS across several follow-up moments. Therefore, we aimed to compare the KOOS scores of a large prospective cohort of TKA patients with the KOOS scores of the general population, to show the use of the previously developed population-based percentile curves of the KOOS questionnaire [13] as method to aid the interpretation of the KOOS subscale scores. Applying preoperative and up to two years postoperative KOOS scores of patients with knee OA undergoing TKA to the general population-based percentile curves, allowed to visualize the pre- and postoperative knee-specific health status of these patients relative to the general population. Furthermore, we have shown that the KOOS percentile curves can give insight in the correlation of specific preoperative patient characteristics with postoperative results. We observed that absence of moderate to severe preoperative radiographic OA, as well as the presence of comorbidities, was associated with less improvement after surgery.

Implementing alternative ways to show PROMs data can support patient-clinician communication about the patients' symptoms and quality of life. Moreover, it may aid managing patients' expectations, making treatment decisions, and improve patient autonomy [3]. In the Netherlands, the number of TKAs has strongly risen in the last decade. The annual

number of TKAs has more than tripled, with a little over 7 thousand TKAs in 2007 to more than 25 thousand TKAs in 2018 [8]. A systematic review has reported that 10-34% of patients are not satisfied after knee replacement surgery [22]. In our patient population, at one year postoperatively, only 8% of patients responded that they would not recommend the surgery to friends or family if they would have the same complaints, which can be interpreted as dissatisfaction with the treatment result. Data on potential underlying factors related to this specific query were not collected in the current study, which prohibited in-depth insight in explanations for (dis)satisfaction after surgery. In addition, we showed that although most patients show great improvements far beyond the minimal important change [23] in all KOOS subscales after surgery, in the majority of patients KOOS scores do not normalize to the median score of the general population. We observed worse preoperative KOOS scores compared to previous studies investigating KOOS scores in TKA populations [24,25]. For example, Lyman et al. observed in a TKA population with a mean age of 74 years mean preoperative KOOS pain and ADL function scores of 51 and 55, respectively (versus 34 and 44 in our population). One year postoperative, KOOS scores were more similar [24]. Vestergaard et al. observed better preoperative KOOS pain and sport and recreation scores compared with ours. Scores on the other KOOS subscales were similar to the scores we observed [25]. The observed differences may be explained by differences in lifestyle and physical activities associated with age, since our population was notably younger than the populations included in previous studies. Our results give insight in the expected postoperative improvements in knee pain, symptoms and function. Therefore, they are important to communicate with patients, as part of the shared decision making process during the preoperative consultation, to manage their expectations, as this may reduce treatment dissatisfaction [26].

Visualizing differences in treatment benefit in different patient groups may help making a well-informed patient-centred (conservative or surgical) treatment decision. In line with others investigating patients undergoing TKA [27,28], we observed a high frequency of comorbidities in our study population. Similarly, we observed less improvement postoperatively in patients having at least one comorbidity compared to patients without comorbidities. Furthermore, we observed greater improvements in patients with preoperatively more severe radiographic OA compared to patient with no to minimal radiographic OA, which is in line with previous findings in the LOAS study [29,30], and with others [31,32]. However, not all previous studies are in agreement [33,34], which could be explained by the inclusion of a limited patient number [33], including only patients with mild radiographic OA in contrast to also including patients with no radiographic OA [33,34], as well as other differences in patient characteristics such as higher age.

Our study has notable strengths. The LOAS study has a multicentre design allowing the inclusion of a diverse patient population from both academic and non-academic hospitals with a low threshold for inclusion, reflecting a real-life care situation and improves the generalizability of the study results. However, as only Dutch hospitals were included, extrapolating our data to other countries, with likely differences in health-care access or insurance, should be done cautiously. In addition, the prospective longitudinal design resulted in a structured data collection at standardized timepoints. Furthermore, the present analyses show a variety of applications for the KOOS percentile curves, which are easy to implement in research and clinical care.

However, our study is also limited in several ways. The age range of the population in which the percentile curves were developed was restricted to persons between 45 and 65 years of age. This makes the percentile curves less ideal for the use of end-stage OA or TKA data, as a considerable number of these patients will be older than 65 years. Restriction of the LOAS population to the required age range resulted in a loss of data from almost two thirds of LOAS patients. However, the age range between 45 and 65 years is well suited for other patient populations, for example to track conservative treatment response in patients with an earlier stage of OA. In addition, the percentile curves may be extrapolated to a broader age range. However, no data is available on accuracy and reliability of extrapolation at this moment. Another limitation is the healthy attendant bias that is inherent to the population-based design in which the percentile curves were developed. This form of selection bias may lead to overly optimistic results. To which extent this might play a role depends on the patient group under investigation, as the patient group may also be subject to a degree of selection. In addition, we observed that a minority of operated patients had no to minimal preoperative radiographic OA. Many factors influence the decision to perform TKA, which may go beyond OA-related health status [35]. Unfortunately, we did not obtain data on which factors drove the orthopaedic surgeon's decision to perform TKA. Furthermore, we did not have data within 3 months after surgery, which could have given information on performance in the time window shortly after surgery when no improvement or even worsening of complaints could be anticipated. In addition, we did not obtain lateral knee X-rays, which might have resulted in underreporting of predominantly patellofemoral knee OA. However, we used one of the most commonly reported radiographic OA scoring methods, the KL grading, which does not include lateral view X-rays. Therefore, current results are well comparable to previous OA literature. Lastly, in our subgroup analyses the patient numbers were rather small, especially for men, which hampered conclusiveness. However, despite the smaller patient number, our results were in line with previous findings [29].

In conclusion, our study showed that the previously developed KOOS percentile curves can be used in research and clinical care to examine the pre- and postoperative knee-related health status of patients with knee OA undergoing TKA. The percentile curves may aid patient-clinician communication, improve management of treatment expectations and support shared-decision making.

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