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VALIDATION STUDIES

# Cross-cultural adaptation and validation of the Saudi Arabic version of the Knee Injury and Osteoarthritis Outcome Score (KOOS)

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## Abstract

The Knee Injury Osteoarthritis Outcome Score (KOOS) is a widely used joint-specific measure employed to evaluate pain, symptoms, activities of daily living, recreational activities, and quality of life in patients with knee osteoarthritis (OA). Although the original KOOS has been translated into many languages, a Saudi Arabic version is not available. This study aimed to culturally adapt and evaluate the psychometric properties of the Saudi Arabic version of the KOOS in patients with knee OA. The original KOOS was translated and adapted into Saudi Arabic version over six stages according to the guidelines suggested by Beaton and recommended by the American Association of Orthopedic Surgeons Outcome Committee. Patients diagnosed with knee OA ($n = 136$) were recruited to examine the psychometric properties, such as internal consistency that was tested using Cronbach's alpha, test–retest reliability that was analyzed using the intra-class correlation coefficient ($ICC_{2,1}$), and construct validity that examined by testing the correlations between the new version subscales, Form 36 Health Survey subscales, and the Visual Analog Scale, Spearman's correlation coefficient ($r_s$) was used to measure the correlations. A total of 122 (89.7%) of the 136 participants with knee OA completed the second re-test of new Saudi Arabic version. Excellent internal consistency (Cronbach's alpha = 0.87–0.92) was detected in the subscales of the adapted version, as well as excellent test–retest reliability ($ICC_{2,1} = 0.92$–$0.94$). The pattern of correlation between the subscales of the Saudi Arabic version of the KOOS, SF-36 domains and the Visual Analog Scale for pain supported the construct validity of the adapted version. The Saudi Arabic version of the KOOS was well accepted and exhibited excellent reliability, internal consistency, and construct validity in Saudi patients with knee OA.

**Keywords** Osteoarthritis · Knee · Reliability · Validity · Psychometric

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## Introduction

Knee osteoarthritis (OA) is one of the most common prevalent disease affecting millions of people worldwide [1]. The prevalence of knee OA is high and has increased as populations grow older [2]. Its primary causes impairment in activities of daily living (ADL) and functional disability [3]. The interplay between physical function disability and knee OA symptoms, such as pain, aching or stiffness lead to a reduced quality of life (QOL) [4]. In Saudi Arabia, knee OA prevalence (90%) in the older population is higher than the prevalence (50%) in other older people from different countries [5, 6]. Due to its high prevalence of advancing age, knee OA is a significant impact on patient's social and health status [7, 8]. Therefore, accurate and precise outcome measures are essential for clinicians and researchers to assess symptoms, recreational activities, ADL, and QOL in patients with knee OA [9].

The Knee injury and Osteoarthritis Outcome Score (KOOS) is a joint-specific measure that was developed to evaluate pain, stiffness, ADL, recreational activities, and QOL domains [10, 11]. Validation studies reported that it is exhibited better psychometric properties compared to other outcome measures [12, 13]. For example, it is more responsive and sensitive than the Western Ontario and McMaster Universities Index and designed to measure long-term outcomes for patients with total knee replacement [14].

Among more than 40 languages and cultures, the original KOOS was translated and adapted into Arabic for the Egyptian population [15]. In this version, most of the items were translated using an Egyptian dialect rather than the Saudi Arabic language, which is understandable to all Arabic speaking countries. Therefore, some items within the Egyptian version may not be understandable to the Saudi Arabian population, and it was validated only for patients with knee injuries [16]. The purpose of this study was to translate and evaluate the psychometric properties of the Saudi Arabic version of the KOOS in patients with knee OA.

## Methods

### Translation and crosscultural adaptation

Permission was obtained from the developer of KOOS to use the original English version. The Saudi Arabic version of the KOOS was cross-culturally adapted in the following six stages (Fig. 1) according to guidelines suggested by Beaton et al. [17], and recommended by the American Association of Orthopedic Surgeons Outcome Committee.

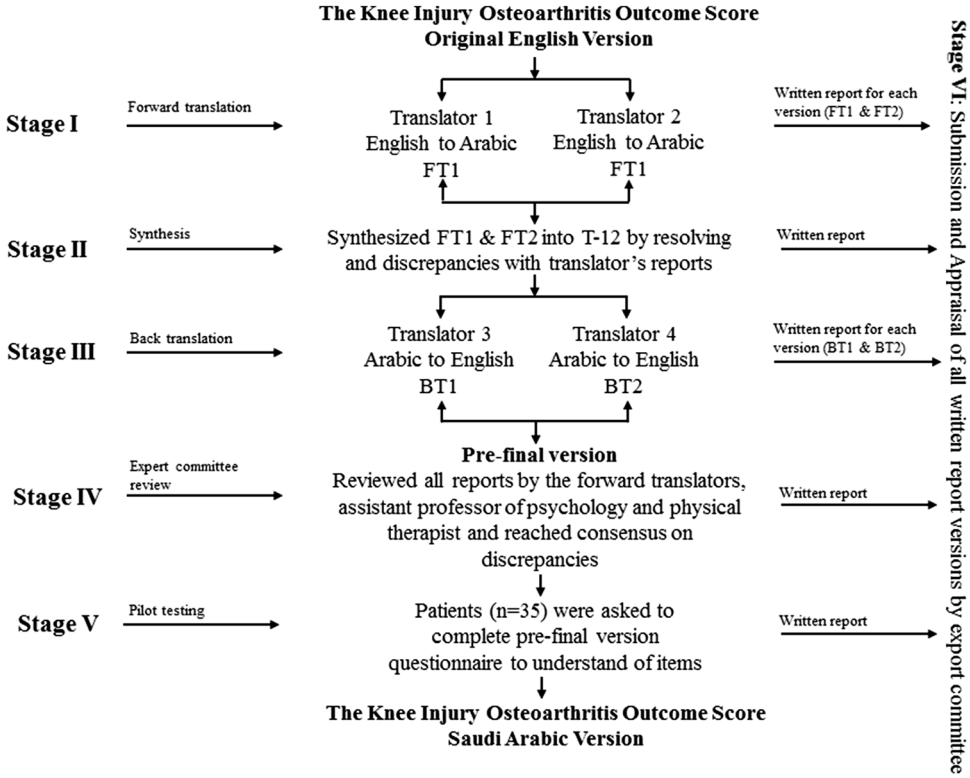


**Fig. 1** The flowchart of the translation and cross-cultural adaptation process

#### Stage I forward translation

Two bilingual translators with Arabic as their mother language independently completed two forward translations of the original English version into the Saudi Arabic version. The translators aimed for a conceptual rather than a literal translation. A written report with their comments on any difficulties and the rationale for their choices for problematic questions was completed.

#### Stage II synthesis

A meeting between the forward translators, was arranged, and the two translators compared both translated documents. The translators synthesized both translated documents into one Arabic version by resolving any discrepancies on their reports.

#### Stage III backward translation

Two native English speakers with no medical background independently back-translated the Arabic version into the English. The two back translation versions were then compared. The discrepancies were discussed and resolved by consensus.

#### Stage IV expert committee

An expert committee consisting of forward translators, an assistant professor of psychology and a physical therapist reviewed all translated versions and reached a consensus on all discrepancies, which resulted in the pre-final Saudi Arabic version of the KOOS. The committee personally communicated with the original KOOS construction team to clarify minor misunderstandings. The pre-final version was compared to the original English version to ensure semantic, idiomatic, experiential and conceptual equivalences.

#### Stage V pilot study

The pre-final version was tested on a sample of 35 Saudi patients with knee OA. Patients were asked about the clarity of the items, the relevance of the items to their condition and any difficulties encountered in completing the questionnaire. The committee reviewed patients' notes and suggestions, and minor changes to the pre-final version were performed.

#### Stage VI submission and approval

All of the translation versions were sent to the KOOS developer for approval of the final Saudi Arabic version of the KOOS.

### Participants and data collection

Patients with knee OA were recruited from outpatient physical therapy departments and orthopedic clinics at King Khalid University Hospital and King Saud Medical City between April and September 2016. Two of the 138 recruited participants withdrew from the study, and the remaining 136 participants represent the study cohort that was used in the analysis. The investigator or other physical therapists called potential participants to participate in this study. Patients who accepted the invitation were briefed about the purposes and procedures of the study and were asked to read and sign a written consent form. Inclusion criteria were as follows (1) male and female aged 45 years or old with knee OA confirmed by a physician according to the criteria of the American College of Rheumatology [18] and graded according to Kellgren–Lawrence Classification [19], (2) read and understand the basic Arabic language. Patients with inflammatory arthritis such as rheumatoid arthritis and psoriatic arthritis were excluded, fractures, major surgery of the lower limbs or who received an intra-articular injection in the last 6 months were excluded from the study.

All study participants ($n = 136$) were asked to complete a questionnaire containing the Saudi Arabic version of the KOOS, Arabic Short Form 36 Health Survey (SF-36), and Visual Analog Scale (VAS) for pain intensity. A total of 122 (89.7%) of the 136 participants completed the Saudi Arabic version for a second time within 1 week of the first completion of the test–retest reliability part of the study. The patient provided demographic and clinical information, such as age, gender, education, occupation, living in the country of the region, knee involvement with OA, duration, and severity.

### Questionnaire

The KOOS consists of five subscales, including Pain (9 items), Symptoms (7 items), ADL (17 items), Sport and recreation (5 items) and Knee-related QOL (4 items). The total number of items is 42, and each item is rated from 0 to 4. Each subscale score is represented on 0–100 scale using the following formula (100−mean of subscale items scores/$4 \times 100$), and higher scores indicate a better health status [10]. Each subscale score was calculated using the official KOOS scoring file (Excel 97-2003, Redmond,

Washington, United States). Missing data were treated according to developer guidelines [15].

The SF-36 is a generic health-related outcome measure that consists of 36 items and measures eight domains: physical functioning (PF), role-physical (RP), bodily pain (BP), vitality (VT), general health (GH), social functioning (SF), role-emotional (RE) and mental health (MH). Items within the SF-36 also yield a physical component summary (PCS) and a mental component summary (MCS). The official scoring software was used to calculate scores for the SF-36 domains and components [20]. The Saudi Arabic version of the SF-36 is a reliable and valid measure [21].

VAS for pain intensity was used in the current study. It was represented by a horizontal line, 100-mm in length, anchored by two descriptive words at each edge, no pain and very severe pain. VAS assessed the intensity of knee pain, and patients were asked to estimate their average pain intensity in the last week. VAS is a reliable and valid measure to assess pain in patients with knee conditions [22].

## Psychometric measurements and statistical analysis

### Sample size estimation

Subject to item ratio is a frequently used to estimate sample size with vary range (2–20) patients per item [23]. On the other hand, Anthoine et al. [23] literature review revealed that about 90% articles (more than 100/114) of validation studies had a sample size greater than or equal to 100 patients. To conform to those criteria, we decided the ratio to be three patients per item. Therefore, a sample size of this study was estimated to be at least 126 patients.

### Floor and ceiling effects

Floor and ceiling effects refer to the number of participants scoring the lowest or the highest possible subscale score. Floor and ceiling effects are present when greater than 15% of the participants score the lowest or highest possible subscales scores [24].

### Reliability

Test–retest reliability was assessed by calculating the intraclass correlation coefficient ($ICC_{2,1}$) with a 95% confidence interval (CI). An ICC value equal to or greater than 0.70 indicated an acceptable level of reliability. A 1-week period between the first and second administrations of the Saudi Arabic version of the KOOS was used because this time interval was considered sufficiently long to prevent answer recall and sufficiently short to minimize clinical changes in participants' conditions [24].

Measurement error in the study is reported as the standard error of measurement (SEM) and defined as $=\times\sqrt{1}-$, where SD is the standard deviation. SEM was converted into the minimal detectable change (MDC), which reflects the smallest change in the score above measurement error. $MDC_{95}$ was computed using the formula, $MDC = SEM \times 1.96 \times \sqrt{2}$, where 1.96 was derived from the 0.95% CI [25].

### Internal consistency

Internal consistency measures the extent to which items within the subscales were correlated and homogenous. Examination of internal consistency is used in validation studies to ensure that all items of subscales measure the same construct. Internal consistency in this study was estimated by calculating Cronbach's alpha. Alpha values within 0.70 to 0.95 indicated acceptable internal consistency [24].

### Construct validity

Construct validity refers to the extent to which a score of an instrument measures what it purports to measure [24, 26]. Spearman's correlation coefficient ($r_s$) measured the expected correlations between the Saudi Arabic version of the KOOS, SF-36, and VAS. Correlation coefficient values $> 0.50$, $0.50 - 0.35$, and $< 0.35$ were considered fair, weak, and little or no correlations, respectively [27]. Fair correlations values $> 0.50$ considered as acceptable correlation based on the proposed quality criteria of measurement properties of health status questionnaires [24]. Statistical analyses were performed using statistical analysis software (SAS) version 9.2 (SAS Institute, Cary, NC).

# Results

## Patients' data

The mean age of patients was $58.77 \pm 9.1$ years. Most of the participants were females (91; 67%) who had an intermediate or lower educational level (74; 54%). Most patients were self-employed or retired (103; 76%) and resided in the central region (104; 76%). 70 patients (52%) had severe knee OA, followed by 45 (33%) and 21 (15%) patients with moderate and mild knee OA, respectively. Most patients (113; 83%) were diagnosed with bilateral knee OA with mean disease duration of $5.91 \pm 5.3$ years (Table 1).

## Translation and cross-cultural adaptation

Forward and backward translation went smoothly. However, some patients misunderstood the "None" response option. Therefore, the final Saudi Arabic version of the

**Table 1** Characteristics of patients in testing the psychometric properties

| Characteristics | ($N=136$) |
|---|---|
| Age in years, mean ± SD | 58.77 ± 9.1 |
| Female, *n* (%) | 91 (67) |
| Education, *n* (%) | |
| Intermediate school or less | 74 (54) |
| High school or more | 62 (46) |
| Occupation, *n* (%) | |
| Employed | 33 (24) |
| Self-employed or retired | 103 (76) |
| Region, *n* (%) | |
| Central | 104 (76) |
| Eastern | 4 (3) |
| Western | 8 (6) |
| Northern | 7 (5) |
| Southern | 13 (10) |
| Body mass index (kg/m$^2$), mean ± SD | 32.7 ± 5.4 |
| Involved knee (knee osteoarthritis), *n* (%) | |
| Right | 12 (9) |
| Left | 11 (8) |
| Both | 113 (83) |
| Knee osteoarthritis duration in years, mean ± SD | 5.91 ± 5.3 |
| Knee osteoarthritis severity, *n* (%) | |
| Mild | 21(15) |
| Moderate | 45 (33) |
| Severe | 70 (52) |

*KOOS* the knee injury osteoarthritis outcome score, *SD* standard deviation

KOOS added a word to the "None" response options. This word connected the reply with the instructions and improved response clarity. This version was used as the final version in the subsequent validation phase without any further change.

## Internal consistency

Descriptive and internal consistency for the Saudi Arabic version of the KOOS is presented in Table 2. The highest average score for the new version scale was 52.9 for the Symptoms subscale, and the lowest average score was 17.7 for the Sport and recreation subscale. None of the Saudi Arabian KOOS subscales exhibited ceiling or floor effects, except the Sport and recreation subscale, which presented a floor effect in which 26.5% of the participants scored the lowest possible score. Excellent internal consistency (Cronbach's alpha = 0.87–0.92) was found in the subscales of the new version. The highest Cronbach's alpha was 0.92 for the Sport and recreation subscale, and the lowest value was 0.87 for the Pain subscale.

## Reliability

The results of the test–retest reliability of the Saudi Arabic version of the KOOS subscales with the SEM and MDC for each subscale are shown in Table 3. The Symptoms and ADL subscales exhibited a similar ICC of 0.94, and the Pain and Knee-related QOL subscales also presented a similar ICC value of 0.93. The ICC for Sport and recreation subscale was 0.92. The SEM ranged from 4.55 for the Knee-related QOL subscale to 5.25 for the Sport and recreation subscale. The $MDC_{95}$ ranged from 12.57 for the Knee-related QOL subscale to 14.56 for the Sport and recreation subscale.

## Construct validity

The correlations between the Saudi Arabic version of the KOOS, SF-36 subscales, and VAS are listed in Table 4. The correlations between the new version subscales and the PCS ($r_s = 0.51$–$0.65$) were higher than the correlations with the MCS ($r_s = 0.28$–$0.47$) of the SF-36. The highest fair correlations were observed between the Saudi Arabic version of the KOOS subscales, such as Pain ($r_s = 0.71$), Symptoms ($r_s = 0.56$), ADL ($r_s = 0.71$), Sport and recreation ($r_s = 0.59$),

**Table 2** Distribution and internal consistency for the Saudi Arabic version of the KOOS subscales

| Measure | Mean | SD | % Floor effect | % Ceiling effect | Cronbach's alpha |
|---|---|---|---|---|---|
| KOOS subscales[a] | | | | | |
| Pain | 45.6 | 18.7 | 0.7 | 0.0 | 0.87 |
| Symptoms | 52.9 | 21.2 | 0.0 | 0.7 | 0.91 |
| Activity of daily living | 47.4 | 20.1 | 0.0 | 0.0 | 0.88 |
| Sport and recreation | 17.7 | 18.9 | 26.5 | 0.0 | 0.92 |
| Knee-related quality of life | 31.2 | 16.8 | 3.7 | 0.0 | 0.90 |

KOOS the knee injury osteoarthritis outcome score

[a]Scores for all subscales range from 0 to 100, with higher scores indicating better health status

**Table 3** The test–retest reliability of the Saudi Arabic version of the KOOS subscales

| KOOS subscales[a] (number of items) | Test ($n=136$) Mean ± SD | Retest ($n=122$)[b] Mean ± SD | Difference (retest–test) | ICC (95% CI) | SEM | $MDC_{95}$ |
|---|---|---|---|---|---|---|
| Pain (9) | 45.6 ± 18.6 | 44.3 ± 19.1 | − 1.3 | 0.93 (0.90–0.95) | 5.02 (4.16–5.88) | 13.91 (11.35–16.30) |
| Symptoms (7) | 52.9 ± 21.3 | 50.1 ± 21.2 | − 2.8 | 0.94 (0.92–0.96) | 5.14 (4.26–6.02) | 14.25 (11.81–16.69) |
| Activity of daily living (17) | 47.4 ± 20.1 | 45.4 ± 19.7 | − 2.0 | 0.94 (0.92–0.96) | 4.88 (4.02–5.69) | 13.46 (11.14–15.77) |
| Sport and recreation (5) | 17.7 ± 18.9 | 18.0 ± 20.3 | 0.3 | 0.92 (0.89–0.95) | 5.25 (4.23–6.27) | 14.56 (11.73–17.38) |
| Knee-related quality of life (4) | 31.3 ± 16.8 | 31.6 ± 16.5 | 0.3 | 0.93 (0.90–0.95) | 4.55 (3.76–5.31) | 12.57 (10.42–14.71) |

*KOOS* the knee injury osteoarthritis outcome score, *SD* standard deviation, *CI* confidence interval, *ICC* intraclass correlation coefficient. (Two-way model, single measure), *SEM* standard error of measurement, $MDC_{95}$ minimal detectable change from the 95% confidence interval level

[a]Scores for all subscales range from 0 to 100, with higher scores indicating best health status

[b]Two assessments, separated by a 1-week interval

**Table 4** Correlations between the Saudi Arabic version of the KOOS, SF-36 subscales, and VAS for pain

| Scale | Subscales | KOOS subscales | | | | |
|---|---|---|---|---|---|---|
| | | Pain | Symptoms | Activity of daily living | Sport and recreation | Knee-related quality of life |
| SF-36 | Physical functioning | 0.54* | 0.52* | 0.65* | 0.49** | 0.50* |
| | Role-physical | 0.48** | 0.43** | 0.54* | 0.46** | 0.46** |
| | Bodily pain | 0.71* | 0.56* | 0.71* | 0.59* | 0.63* |
| | General health | 0.57* | 0.43** | 0.55* | 0.39** | 0.50* |
| | Vitality | 0.48** | 0.38** | 0.56* | 0.34** | 0.51* |
| | Social functioning | 0.60* | 0.47** | 0.56* | 0.43** | 0.51* |
| | Role-emotional | 0.37** | 0.40** | 0.43** | 0.24*** | 0.27*** |
| | Mental health | 0.47** | 0.34** | 0.49** | 0.34** | 0.44** |
| | Physical component summary | 0.60* | 0.51* | 0.65* | 0.54* | 0.57* |
| | Mental component summary | 0.46** | 0.37** | 0.47** | 0.28*** | 0.40** |
| VAS | Pain | − 0.71* | − 0.59* | − 0.68* | − 0.56* | − 0.64* |

*KOOS* the knee injury osteoarthritis outcome score, *SF-36* short form 36 health survey, *VAS* visual analog scale

*Fair correlations

**Weak correlations

***Little or none correlations

and Knee-related QOL ($r_s=0.63$), with the BP of the SF-36 subscales. The highest negative correlation was found between the new version Pain subscale and the VAS scale ($r_s=-0.71$).

## Discussion

The current study aimed to translate and evaluate the psychometric properties of the Saudi Arabic version of the KOOS in patients with knee OA. The study results demonstrated that the Saudi Arabic version of the KOOS was understandable, reliable and valid for patients with knee OA.

No major difficulties were encountered in the current study during the translation of the original KOOS into the Saudi Arabic language. A recommended standard guideline for cross-cultural adaptations was used to improve the quality and ensure the equivalence between the Saudi Arabic version of the KOOS and the original English version [17]. The adapted new version passed through all of the recommended standard stages. The committee used simple, standard Arabic in the translation and adaptation process to enhance the use of the Saudi Arabic version of the KOOS across Saudi Arabia and other Arabic-speaking countries where people understand simple standard Arabic.

Committee members discussed all of the translation versions during the first meeting to reach a consensus on all discrepancies and ensure equivalence between the Saudi Arabic version of the KOOS and the original KOOS version. Difficulties encountered were overcome by careful wording

to develop a straightforward and understandable the Saudi Arabic version of the KOOS. Some items and responses were changed. Items S7, P7, A10, Q3 and Q4 and the fifth response of items Q2 and Q3 were modified. Items S7 and A10 were also topics of discussion in the adaptation of the Japanese version [28], and item Q3 was hard to translate in the Italian version [29]. The first response ("None") of some items was modified according to patients' feedback to be more understandable. The final Saudi Arabic version of the KOOS was developed, and the psychometric properties of the adapted version were further examined.

The study results indicated no severe ceiling effects in the scores of the five subscales of the Saudi Arabic version of the KOOS, and a floor effect was exhibited only in the Sport and recreation subscale. This floor effect may be attributed to the significant proportion of patients recruited who had severe knee OA, or it may be related to the age of the participants. These factors generally decrease patients' activities, such as squatting, running, jumping and kneeling. A floor effect in the Sport and recreation subscale was reported in most KOOS versions, such as Dutch [30], Singapore [31], French [27], Japanese [28] and Portuguese [32].

Our study demonstrated that the Saudi Arabic version of the KOOS subscales exhibited excellent test–retest reliability ranged from 0.92 to 0.94, which indicates stability over time. The 1-week interval used in the study between test and retest was sufficient to avoid the memory effect and changes in patients' conditions [24]. The new version ICC values were higher compared to the original version developed by Roos et al. [10]. The findings of the current study are consistent with previous studies that validated the KOOS for patients with knee OA using different samples and intervals of test–retest, such as Turkish version [33], French version [27], Dutch version [30], Portuguese version [32], and Japanese version [28]. Reported test–retest reliability for the Japanese version was ranged from 0.86 to 0.90 [28], and they were 0.82–0.94 for the Portuguese version with a 2-day interval [32]. Ornetti et al. [27] reported a good to excellent test–retest reliability were ranged from 0.75 to 0.91 for subscales of the French KOOS version using a 2-week interval, and Paker et al. [33] reported the reliability of Turkish KOOS subscales were ranged from 0.85 to 0.89 in a sample of 50 patients with knee OA. The test–retest reliability of the Dutch version was reported for patients with mild (0.74–0.88) and moderate knee OA (0.87–0.94) [30]. The Singapore KOOS version reported lower test–retest reliability compared to other versions [31]. Xie et al. [31] used 127 English-speaking patients with knee OA and reported test–retest reliability between 0.65 and 0.94 using a 6-day interval. The second group of the study was 131 Chinese-speaking patients with knee OA, and the reported test–retest reliability in this group ranged from 0.60 to 0.87 using a 6-day interval.

The Saudi Arabic version of the KOOS subscales exhibited excellent internal consistency, with Cronbach's alpha values (0.87–0.92) within the recommended range of 0.70–0.95 [24]. This result indicates that items within each subscale were homogenous and not redundant [24]. Comparison between the internal consistency of the Saudi Arabic version of the KOOS subscales against the original KOOS was not possible because Cronbach's alpha coefficients were not reported in the original version [10]. The Japanese KOOS subscales exhibited Cronbach's alpha coefficient values from 0.89 to 0.95 [28], which is consistent with the current study. Other studies that validated the KOOS for patients with knee OA reported lower Cronbach's alphas for some subscales than the current study. Cronbach's alpha ranged from 0.77 to 0.95 for the Portuguese version [32] and from 0.77 to 0.95 and 0.76–0.93 for the French KOOS version [27]. The Singapore English version subscales exhibited Cronbach's alpha coefficients between 0.70 and 0.92, and coefficients for the Chinese version were 0.64–0.88, where the pain and symptoms subscales exhibited the lowest values [31]. Cronbach's alpha values for the Turkish KOOS ranged from 0.66 to 0.95, with the symptoms subscale exhibiting the lowest value [33]. Previous studies that validated the KOOS for patients with knee OA demonstrated that the Dutch version exhibited the lowest internal consistency values. Groot et al. [30] indicated that the internal consistency of the Dutch version ranged from 0.56 to 0.98 for the different subscales. Internal consistency results were acceptable for all subscales, except for the Symptoms subscale, which exhibited a Cronbach's alpha coefficient of 0.56.

The Saudi Arabic version of the KOOS ADL subscale exhibited a fair, positive correlation with SF-36 PF, as hypothesized. The Saudi Arabic version of the KOOS Pain subscale showed a fair, positive correlation with SF-36 BP and a fair negative correlation with pain intensity measured using VAS, which supports the construct validity of the adapted scale. The correlation between the Saudi Arabic version of the KOOS subscales with a PCS was higher than their correlation with the MCS of the SF-36, which further supports the construct validity of the new version scale. The KOOS subscales, such as Pain, ADL, and Knee-related QOL were relatively correlated with the GH and VT subscales of the SF-36. This correlation was higher than the values reported for the original KOOS version and some previous studies that translated and adapted the KOOS for different languages and cultures [10, 27, 28, 30–33]. Similar findings were reported for the KOOS Egyptian version, in which a fair correlation was reported between all KOOS subscales with the GH and VT subscales of the SF-36 [16]. Also, the weighted mean correlation (from 11 studies) reported in a systematic review [34] between KOOS ADL subscale and SF-36 PF domain was 0.65 (95%CI: 0.64–0.66) among patient with knee OA and the correlation reported in the

current study was 0.65 falling within the reported 95% CI. The weighted mean correlation (from 11 studies) reported in the same systematic review between KOOS Sport and recreation subscale and SF-36 PF domain was 0.46 (95%CI: 0.44–0.47), and the correlation reported in the current study was 0.49 indicating a higher correlation between similar constructs reported in the present study.

The results supported the expected direction of correlation, and the magnitude of correlation (0.49) was very close to the predefined magnitude (> 0.50), which is considered a fair correlation. A floor effect observed in the Saudi Arabic version of the KOOS Sport and recreation subscale in the current study, which may contribute to the lower than expected correlation between the KOOS Sport and recreation subscale and SF-36 PF. The KOOS original version and other KOOS versions that validated the KOOS for patients with knee OA reported relatively weaker correlations between the Sport and recreation subscale and SF-36 physical function subscale [10, 27, 30, 31], which is similar to current findings.

Several limitations of the current study must be acknowledged. The current study limited participation to individuals 45 years of age or older diagnosed with knee OA. Therefore, the results of the present study may be not generalizable to younger patients with different knee conditions and injuries. The responsiveness of the Saudi Arabic version of the KOOS to detect change over time was not examined in the current study. Another limitation of this study was both native translators have a medical background. According to the guidelines, one of the two translators should have no medical experience.

However, the current study followed the recommended guidelines by Beaton et al. [17] for the translation and cultural adaptation of the Saudi Arabic version of the KOOS to ensure quality and equivalence with the KOOS original version. Translation of the KOOS to simple standard Arabic would enhance the utilization of the Saudi Arabic version of the KOOS for all populations across Saudi Arabia and other Arabic-speaking countries. The psychometric properties of the Saudi Arabic version of the KOOS were investigated with adequate sample size.

Adaptation and validation of the KOOS into different languages and cultures provides a standardized measure for quantitative and qualitative studies. The Saudi Arabic version of the KOOS is a reliable and valid instrument that enables researchers to compare local research results with the results of international studies. The adapted scale also enables clinicians and researchers to quantify critical health-related domains, including physical function, Symptoms, Pain, ADL and QOL in Saudi patients with knee OA. The Saudi Arabic version of the KOOS is a patient-reported and functional assessment measure to assist clinicians in physical therapy, orthopedics and others healthcare providers in tracking changes in health-related domains during the intervention in patients with knee OA and aid in determining the effect of interventions to improve different health-related aspects.

## Conclusions

The Saudi Arabic version of the KOOS was well accepted and easily understood by participants. It exhibited excellent reliability, internal consistency, and construct validity in patients with knee OA. Additional validation studies are needed to examine the Saudi Arabic version of the KOOS psychometric properties in younger patients with different knee injuries. Further studies are necessary to investigate to what extent the Saudi Arabic version of the KOOS is applicable and valid in other Arab countries and cultures.

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### Compliance with ethical standards

**Conflict of interest** Alfadhel SA, Vennu V, Alnahdi AH, Omar MT, Alasmari SH, AlJafri Z, Bindawas SM declared that they have no conflict of interest.

**Ethical approval** The Research Ethics Committee and Institutional Review Board at the following institutions authorized this study: College of Applied Medical Sciences (No: 098-36/37), King Saud University Medical City (No: 16/0169/IRB), and King Saud Medical City (No: H-01-R-053). All patients involved in the present study had thoroughly read and signed the informed consent.

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