Patient Related Outcome Measures

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ORIGINAL RESEARCH

Translation, Cross-Cultural Adaptation and Validation of the Chinese Version of the High Activity Arthroplasty Score

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Background: The High Activity Arthroplasty Score (HAAS) is a validated score that assesses functional outcomes after lower limb arthroplasty, with fewer ceiling effects than other scores. The aim is to translate and cross-culturally adapt the HAAS into a Chinese version (HAAS-C) and to evaluate the psychometric properties of HAAS-C in patients after primary total knee arthroplasty (TKA).
Methods: A total of 104 patients diagnosed with knee osteoarthritis who had undergone TKA at least 12 months prior were recruited. A forward and backward translation procedure was performed for developing a culturally acceptable HAAS-C. Internal consistency was assessed using Cronbach's α, and test-retest reliability was measured using the intraclass correlation coefficient (ICC) within a 10-day interval. Construct validity was assessed by examining the correlations between HAAS-C and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), EuroQoL Group's five-dimension questionnaire (EQ-5D-5L), and Oxford knee score (OKS).
Results: HAAS-C demonstrated adequate Internal consistency reliability, as indicated by Cronbach's α coefficient of 0.75. Test-retest reliability yielded excellent results, with an ICC value of 0.98. Content validity indices were high, with a scale-level validity index of 0.9 and item-level validity indices greater than or equal to 0.8. HAAS-C showed a strong correlation with WOMAC (r = 0.69), a moderate correlation with EQ-5D-5L (r = 0.43), and OKS (r = 0.53) while exhibiting no floor or ceiling effects.
Conclusion: The validated HAAS-C questionnaire is a valid instrument for assessing patients undergoing TKA in mainland China.
Keywords: high activity arthroplasty score, total knee arthroplasty, Chinese validation, reliability, validity

Background

Knee osteoarthritis (KOA) is a prevalent degenerative joint disease that leads to knee pain, stiffness, and functional impairment.[1] The annual prevalence of KOA in China has been significantly increasing, with a trend towards affecting a younger population.[2] The socioeconomic burden associated with KOA has also grown, with an estimated 42 million KOA patients in China.[3,4] Total knee arthroplasty (TKA) is the most common surgical procedure for severe end-stage KOA.[5] Recently, there has been a rise in TKA among younger patients (<65 years old) and an increased focus on persistent dissatisfaction following TKA.[6–8] Postoperative dissatisfaction is often attributed to patients' unmet expectations, particularly regarding their desire to engage in low-impact exercise and maintain participation in intermediate- to high-impact activities.[9–11]

In response to patients' heightened expectations of physical activity after TKA, there is a growing need to determine the appropriate level of physical activity and acceptable types of activities for these patients.[12,13] Traditional physician-provided outcomes alone may not sufficiently address these questions, highlighting the importance of incorporating patient-reported outcome measures (PROMs).[14] PROMs allow for the subjective evaluation of health status and

Received: 25 November 2023
Accepted: 17 April 2024
Published: 29 April 2024

treatment effect to be transformed into relatively objective numerical data, providing valuable information for clinical decision-making.[15] While PROMs for TKA patients have been developed and validated in multiple countries, they often fall short when applied to younger, more active patients, as they may lack the ability to differentiate functional levels and tend to exhibit ceiling effects.[16]

The High Activity Arthroplasty Score (HAAS), developed by a New Zealand research group in 2010 for high-activity patients after hip or knee arthroplasty, offers improved discriminative ability in functional assessment with fewer floor or ceiling effects.[17,18] In contrast to prevailing health-related quality of life (HRQoL) instruments, which primarily address pain and low-demand daily activities after hip and knee arthroplasty, HAAS comprehensively evaluates patients' functional capabilities, encompassing a broader spectrum of physical and sports activities alongside traditional pain symptoms, with each dimension designed to assess the patient's maximum capacity.[19] Previous studies have demonstrated the cultural adaptability, reliability, and effectiveness of the HAAS in English, French, Italian, Dutch, and German-speaking countries.[16,18,20–22] However, a reliable and valid Chinese version of HAAS (HAAS-C) is currently unavailable. Given the increasing prevalence of KOA among a younger population in China and the growing number of TKA procedures, there is a need to adopt the HAAS questionnaire. This questionnaire is essential for several reasons. Firstly, it allows for the assessment of patients' specific functional needs and activity levels, particularly in the context of the younger demographic. Moreover, the HAAS questionnaire exhibits improved discriminative ability and reduced floor or ceiling effects, making it more suitable for evaluating functional outcomes in active TKA patients. Hence, it becomes imperative to translate and culturally adapt the HAAS into a Chinese version and assess the psychometric properties of HAAS-C for Chinese-speaking patients who have undergone TKA.

The objective of this study was to translate, cross-culturally adapt, and assess the psychometric properties of HAAS-C in patients who had undergone TKA at least 12 months ago.

Methods

Translation and Cross-cultural Adaptation

In accordance with established guidelines, the HAAS questionnaire underwent a five-step process for translation and cross-cultural adaptation into Chinese.[23] During Stage I, two bilingual authors, including a professional translator and a senior orthopedic doctor, independently translated the English version of HAAS into Chinese. In Stage II, a consensus version was achieved by integrating their opinions and resolving any discrepancies between the two translations. In Stage III, the synthesized version was then translated back into English by two different bilingual authors, neither of whom had a medical background. Stage IV involved a consensus committee consisting of psychologists, orthopedic surgeons, nursing specialists, physiotherapists, and four translators who reviewed all versions of HAAS and incorporated diverse opinions to reach a final consensus. Finally, in Stage V, the pre-final version of HAAS was administered to a group of 30 TKA patients through individual interviews to collect feedback. The review panel discussed and revised the final version of HAAS-C based on the comments received, as provided in Additional File 1.

Patients and Data Collection

Considering the guidance from a previous study, it is suggested that a sample size of at least 100 patients is adequate for evaluating validity, and a minimum of 50 patients is sufficient for evaluating reliability.[24] 104 consecutive patients were enrolled from our department between January 2022 and December 2022 for this study. The inclusion criteria encompassed the following: (1) patients diagnosed with knee osteoarthritis (KOA) who had undergone total knee arthroplasty (TKA) at least 12 months prior; (2) adults aged 65 years or younger; (3) fluent in the Chinese language; (4) capable of independently completing questionnaires. Exclusion criteria were established as follows: (1) patients with severe visual, auditory, or physical impairments that hindered cooperation with researchers; (2) patients with severe cognitive impairment or mental illness; (3) patients who underwent surgical procedures, possessed significant medical conditions, or exhibited relevant comorbidities that could potentially influence physical activity. Our study adheres to the Helsinki Declaration[25] and has received approval from the Medical Ethics Committee of our hospital (ID: 202212004). Written informed consent has been obtained from all participants. Patients expressed their interest in participating and registered for the study upon contacting the research team through the recruiter's advertisement.

Participant demographics and clinical characteristics were obtained following the initial screening. All participants completed the four questionnaires (HAAS-C, WOMAC, EQ-5D-5L, and OKS) by themselves during their hospital visit.

Instruments

The HAAS questionnaire is a self-reported assessment tool used to evaluate the functions of patients who have undergone lower limb arthroplasty. The questionnaire comprises four items, namely walking (0–5 points), running (0–4 points), stair climbing (0–3 points), and activity level (0–6 points).[16] To complete the questionnaire, respondents must provide a response to every item, as each item has a specified option. The total score of the questionnaire ranges from 0 (indicating poor function) to 18 (indicating good function).

WOMAC is a self-reported questionnaire that measures OA-caused constraints experienced by the patient in function and degree of pain and stiffness when performing daily activities.[26] It comprises 24 items classified into three dimensions: pain, stiffness, and activities of daily living.[27] A higher WOMAC score corresponds to a greater level of pain intensity, increased difficulty in performing various daily activities, and more pronounced stiffness in the hip or knee joints. In this study, the Chinese version of WOMAC was employed,[28] wherein each of the 24 items ranged from 0 to 10 points. The EQ-5D-5L questionnaire is a multidimensional instrument for measuring HRQoL.[29] By employing EQ-5D-5L, a broader perspective on patients' HRQoL was obtained, facilitating comparative analysis and aiding clinical decision-making. It is important to acknowledge that while EQ-5D-5L has its limitations in capturing specific functional outcomes in highly functioning TKA patients, its use enriched the assessment. OKS was mainly used for KOA patients who need to accept TKA treatment.[30] Comprising 12 items, OKS evaluates knee joint pain and function, with higher scores indicating poorer health status. All aforementioned scales have been accurately translated into Chinese and have been confirmed as reliable and valid measurement tools.[28,31,32]

Psychometric Assessments and Statistical Analysis

Patients were given the opportunity to provide comments on the scale or offer feedback to the institute when submitting the questionnaire, in case they encountered any issues with HAAS-C. Additionally, we recorded the time taken by each participant to complete the questionnaire. To evaluate test-retest reliability, all participants were reassessed 10 days later.[24]

Internal consistency was assessed using the coefficient α, with a value greater than 0.7 indicating adequate internal consistency.[33] Test-retest reliability was assessed using the ICC, which was categorized as follows: values ranging from 0.5 to 0.75 denoted moderate reliability, values between 0.75 and 0.90 indicated good reliability, and values ≥ 0.90 were indicative of excellent reliability.[34] To analyze absolute validity, Bland and Altman analyses be used. The standard error of measurement (SEM) was used as an indicator of absolute reliability.[24] The most commonly used calculation method for this statistic involves the formula: $SEM = SD\sqrt{(1-R)}, SD$ = the sample standard deviation, and R = the calculated intraclass correlation coefficient.[35] Additionally, we calculated the smallest detectable change (SDC), which represents the smallest value change on the scale that can be considered a true change rather than a measurement error. This was calculated using the following formula: $SDC_{(95\%\ CI)} = 1.96\sqrt{2}\ SEM$.[24]

The expert panel, consisting of 10 individuals with over 5 years of experience in Orthopedic Surgery, employed the scale level content validity index (S-CVI) and the item level content validity index (I-CVI) to assess the content validity of the HAAS-C. The relevance of HAAS-C was assessed by the experts using a 4-point scale. A score of 1 represented "not relevant", a score of 2 denoted "somewhat relevant", a score of 3 indicated "very relevant", and a score of 4 signified "highly relevant". The Index of Content Validity (I-CVI) was determined by quantifying the ratio of experts who assigned a rating of 3 or 4 to the total number of experts involved. In order to guarantee an acceptable level of content validity, it is advisable to achieve a minimum Scale-level Content Validity Index (S-CVI) of 0.8, along with an Item-level Content Validity Index (I-CVI) of at least 0.78.[36]

The assessment of construct validity for the HAAS-C was performed using the Pearson correlation coefficient (*r*) in conjunction with the WOMAC, EQ-5D-5L, and OKS measures. The correlation coefficients were categorized into distinct levels of strength as follows: very strong (> 0.80), strong (0.61–0.80), moderate (0.41–0.60), weak (0.21–0.40), or none or very weak (< 0.20).[37] Before this analysis, based on assessment of the content of the items on the scales, we hypothesized that the HAAS-C scores correlated moderately with the total scores of the EQ-5D, WOMAC, and OKS.

In order to examine the potential occurrence of floor and ceiling effects, the proportion of participants who attained the lowest or highest score on the HAAS-C was computed. Floor effects were deemed present if more than 15% of participants obtained the lowest possible score, while ceiling effects were considered present if more than 15% of participants achieved the highest possible score.[24]

Reverse scoring was implemented for the HAAS-C in the current study. The scoring for specific items was converted according to the following rules: Item 1 (5=0, 4=1, 3=2, 2=3, 1=4, and 0=5), Item 2 (4=0, 3=1, 0=4, and 1=3), Item 3 (3=0, 2=1, 0=3, and 1=2), and Item 4 (6=0, 5=1, 4=2, 2=4, 1=5, and 0=6). The statistical analysis employed SPSS 26.0 (Chicago, IL). Demographic and clinical characteristics of the participants were presented as means and standard deviations (SD) for continuous variables, while categorical variables were reported as frequencies (percentages). A *p*-value below 0.05 was considered statistically significant.

Results

Patient Characteristics

A total of 104 patients, consisting of 28 males and 76 females, were included in this study, with an average age of 61.3 ± 3.4 years (range: 51 to 65 years). The participants had an average BMI of 25.7 ± 3.7 kg/m2 (range: 15.2 to 36.5 kg/m2). Among them, 83% were farmers, while only a small proportion of patients (18%) had received education beyond high school. Additionally, all participants returned to the hospital for follow-up evaluations. The baseline characteristics of the participants can be found in Table 1.

Cross-Cultural Adaptation

The forward and backward translations of the HAAS did not encounter any significant issues. However, due to cultural differences between China and Western countries, certain sports listed in the questionnaire, such as golf, light gardening, low-impact aerobics, doubles tennis, skiing, jogging < 10km, single tennis, running > 10km, and cycling > 80km, were found to be less popular among Chinese individuals. In addition, within the prevailing demographic of individuals undergoing TKA in China, there exists a notable dearth of access to secondary and tertiary education, with a predominant engagement in manual labor among the majority. After careful consideration and discussion by the panel, the fourth item

Table 1 Demographic and Clinical Characteristics of Participants

		Participants (*n*=104)
Age (SD, range)		61.3 years (3.4, 51 to 65)
Body mass index (SD, range)		25.7 kg/m^2 (3.7, 15.2 to 36.5)
Sex	Male	28 (27%)
	Female	76 (73%)
Occupation	Heavy physical worker	2 (2%)
	Light physical worker	7 (7%)
	Retired	9 (9%)
	Farmer	86 (83%)
Residence status	Living alone	3 (3%)
	With spouse	66 (63%)
	With children	35 (34%)
Education	Primary school or below	51 (49%)
	Middle school	35 (34%)
	High school	10 (10%)
	University or above	8 (8%)

Abbreviations: SD, standard deviation; n, number.

(activities) of the HAAS was modified to better align with the activity preferences of the Chinese population. Please refer to Additional file 2 for more details regarding this modification.

Acceptability

The HAAS-C was well received, and all participants reported no difficulty in understanding its content during their initial completion. All the returned questionnaires were not missing or incorrectly filled in. The average time required to complete the HAAS-C was 2.1 minutes (SD 0.61, range 1.2 to 6.53).

Reliability

The internal consistency of the HAAS-C was found to be adequate, with a Cronbach's α coefficient of 0.75. The initial assessment occurred at an average of 17.0 ± 3.3 months after primary TKA, with a 10-day interval between the first and second assessments. The test-retest reliability was excellent, with an ICC of 0.98 (95% CI 0.98 to 0.99). The SEM was 0.25 points, and the SDC was 0.69. The 95% limits of agreement of the HAAS-C for TKA cases were −1.15 to 1.05. The Bland–Altman plots are shown in Figure 1.

Content Validity

Table 2 presents the results of the content validity analysis. In this study, all experts assigned a score of 3 (very relevant) or 4 (highly relevant) to 36 out of 40 items. However, for the dimensions of "Running" and "Activity level", two experts each marked 2 (somewhat relevant). The S-CVI (ave) was 0.9, and the I-CVI was ≥ 0.8, indicating good content validity.

Construct Validity

Table 3 displays the correlation between HAAS-C and other PROMs. Our a priori hypotheses were confirmed. The results revealed a strong correlation between HAAS and WOMAC (r = 0.69), as well as a moderate correlation between HAAS and WOMAC activities of daily living (r = 0.65). HAAS also showed a moderate correlation with all other PROMs (r, 0.43–0.56).

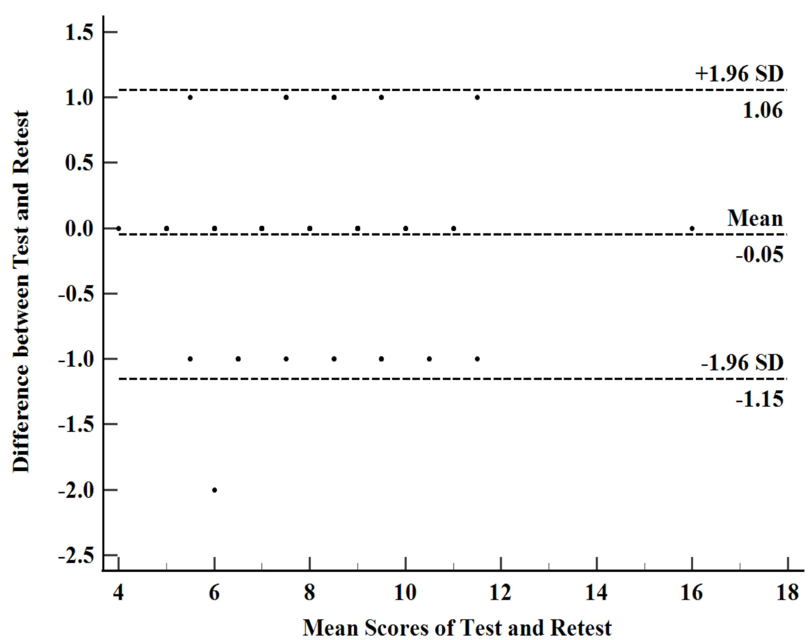

Figure 1 Bland–Altman plot of HAAS-C for TKA patients.

Table 2 Ratings on a 4-Item Scale for HAAS-C by ten Doctor (Rated 3 or 4)

Item	Walking	Running	Stair Climbing	Activity Level	S-CVI (un)
Expert1	3	4	3	4	1
Expert2	4	4	3	2	0.75
Expert3	4	4	4	4	1
Expert4	4	3	3	2	0.75
Expert5	4	3	3	3	1
Expert6	3	2	3	3	0.75
Expert7	3	4	4	4	1
Expert8	3	2	4	3	0.75
Expert9	3	4	4	4	1
Expert10	3	3	3	3	1
No.In Agreement	10	8	10	8	S-CVI (ave) = 0.9
I-CVI	1	0.8	1	0.8	

Abbreviations: S-CVI (un), scale level content validity index (universal); S-CVI (ave), scale content validity index (average).

Table 3 PROMs with Mean, SD, Range, Floor and Ceiling Effects and Correlation to HAAS-C

Scales	Score			
	Mean ± SD (range)	**Floor/ceiling effects in %**	**Spearman's rho**	**Correlation**
HAAS	7.8 ± 1.9 (4–16)	0/0	–	–
WOMAC	39.1 ± 25.5 (11–165)	0/0	0.69*	Strong
Pain	4.9 ± 4.9 (0–28)	13.5/0	0.56*	Medium
Stiffness	4.5 ± 3.2 (0–16)	13.5/0	0.48*	Medium
ADL	21.9 ± 17.7 (1–109)	0/0	0.65*	Strong
EQ-5D-5L	0.9 ± 0.1 (0.1–1)	40.4/0	0.43*	Medium
OKS	19.3 ± 5.7 (12–43)	1/0	0.53*	Medium

Note: *p < 0.001.
Abbreviations: HAAS, Chinese version of High-Activity Arthroplasty Score; WOMAC, Western Ontario and McMaster University index; ADL, Activities of Daily Living; EQ-5D-5L, Five-level EuroQoL Group's five-dimension questionnaire; OKS Oxford knee score.

Floor and Ceiling Effects

As shown in Table 3, the presence of floor and ceiling effects in all PROMs is reported. The total score distribution of HAAS-C is shown in Figure 2, and no floor or ceiling effects were observed in HAAS-C, indicating that there were no lowest or highest scores recorded.

Discussion

In this study, we found that the cross-culturally adapted HAAS-C demonstrated widespread acceptance and exhibited good reliability, content validity, and construct validity. Notably, no instances of floor or ceiling effects were observed. The questionnaire is reliable and valid in individuals with KOA patients for at least 12 months after TKA.

The internal consistency of the HAAS-C, as measured by Cronbach's α, was found to be 0.75, higher than the values reported for the French (0.58)[21] and German (0.749)[18] versions but lower than the values reported for the original,[16] Dutch (0.838)[20] and Italian (0.91)[22] versions. Nevertheless, a value greater than 0.7 indicates adequate internal consistency for HAAS-C. Additionally, the test-retest reliability of HAAS-C was excellent, with an ICC of 0.98. Among all versions of HAAS, only the German version reported SEM. The SEM of HAAS-C was lower than the value of the German version (0.54).[18] The Bland-Altman plots for the 2 measurements showed no systematic error. The

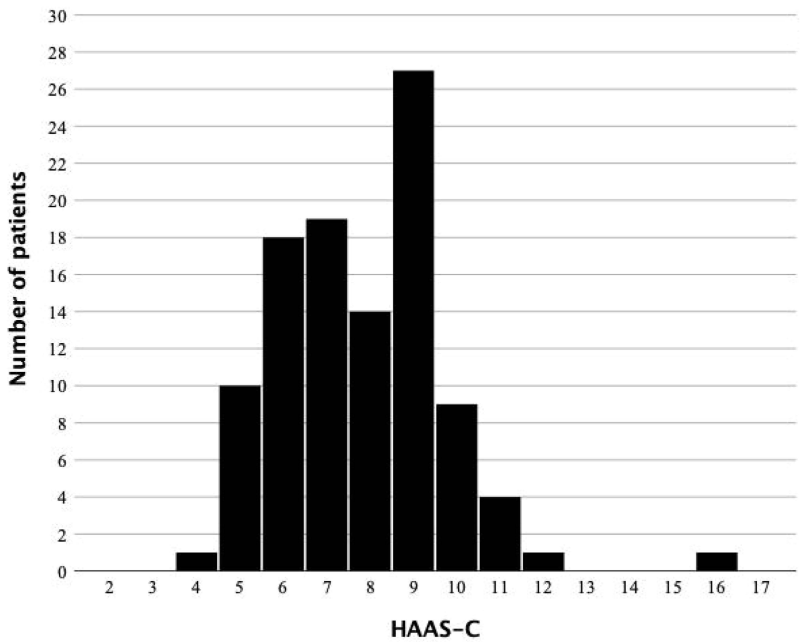

Figure 2 Distribution of the HAAS-C.

SDC results indicated that no measurement error would occur if an individual showed a change of more than 0.69 points after a given intervention. Compared with other studies, our result was lower than the values of the Italian (1.8)[22] and German version (1.5).[18] These results demonstrate the qualified absolute reliability of HAAS-C.

HAAS-C has been shown to have good content validity. The content validity assessment of the Chinese version demonstrated an S-CVI (Ave) of 0.9 and I-CVI values ≥ 0.8, indicating high content validity of the scale. Moreover, the content validity of HAAS was confirmed in both the Italian and German versions.[18,22] Therefore, the items of HAAS-C accurately reflect the high functional evaluation ability of patients after TKA.

Regarding construct validity, we found moderate to strong correlations between HAAS-C and all WOMAC subscales. A Strong correlation between HAAS-C and the total score of the WOMAC was found (r = 0.69). The correlation with WOMAC activities of daily living (r = 0.65) was higher than with WOMAC pain (r = 0.56) and WOMAC stiffness (r = 0.48). The construct validity assessment of the Italian version of HAAS in subjects with total hip arthroplasty found very similar correlations with WOMAC pain (r = 0.66), WOMAC stiffness (r = 0.50), and WOMAC activities of daily living (r = 0.70). Although different countries use different scales for HAAS construct validity, all the results suggest that HAAS specificity is more relevant to physical activity than symptoms and pain.[18,22] This study reveals moderate validity for HAAS only in comparison to WOMAC and OKS. This can be attributed to HAAS being tailored for higher-level functionality, distinct from the broader functional outcomes observed within subsets of WOMAC and OKS. The study also found a moderate correlation between HAAS-C and EQ-5D-5L (r = 0.43), consistent with the findings reported in the German and Dutch versions of HAAS, where the correlation coefficients were found to be 0.427 and 0.447,[18,20] respectively. This consistency aligns with our findings of a moderate correlation between HAAS-C and EQ-5D-5L. Additionally, a moderate correlation was also found between HAAS-C and the OKS (r = 0.53). A similar result was reported by a French research group (r = 0.436).[21] These results indicate that HAAS-C has qualified construct validity. Our study showed that the total scores of HAAS-C did not demonstrate any floor or ceiling effects, indicating its strong discriminatory ability as a questionnaire.

The HAAS questionnaire is a valuable tool in clinical research, especially for evaluating the high functional status of patients after TKA. Compared with the limited scale assessment tools currently used in China (such as WOMAC scale),[38] the HAAS-C questionnaire provides a more comprehensive and accurate method. By combining the choice of sports types and difficulty levels, it can accurately reflect the performance of patients in various high-function activities.

In light of the growing number of middle-aged patients undergoing TKA and their desire to engage in moderate to high-intensity activities, there is a need to introduce more targeted assessment tools that cater to their specific needs and contribute to clinical research. The internationally recognized and proven HAAS questionnaire introduces the field of musculoskeletal diseases in China, which is expected to promote clinical research and strengthen patient rehabilitation. Moreover, the HAAS-C not only serves as an effective tool for assessing the high functional status of post-TKA patients but also discerns the attainable level of activity for these individuals. According to the results of the questionnaire, the HAAS questionnaire can optimize the rehabilitation strategy, so as to obtain more effective treatment methods and improve the quality of life of patients.

Therefore, the introduction of HAAS questionnaire into China can serve as a valuable guide for clinical practice, supporting healthcare professionals to optimize postoperative high-function recovery and ultimately improve patient prognosis.

The completion time of HAAS-C was only 2.1 minutes, indicating its simplicity for patients. With the tremendous volume of outpatient visits in top-tier hospitals across China, healthcare professionals face significant challenges in evaluating and quantifying the severity of patients' conditions within the constraints of limited clinical time. In this context, the HAAS-C questionnaire assumes paramount importance as a valuable tool for both medical practitioners and patients alike.

Our study still has certain limitations. Firstly, the participants were exclusively recruited from a single medical institution in the northwestern region of China, considering that cultural diversity, varying lifestyle factors, occupations, and educational backgrounds across different regions of the country might influence the choice of postoperative physical activities. In the future, HAAS-C will be updated according to the demographic background. Secondly, we did not assess the risk of bias in regard to gender effects on the psychometric properties of HAAS-C, which may affect the universality of the conclusions. Thirdly, our study exclusively comprises patients who have undergone TKA surgery at least 12 months ago. Consequently, we intend to conduct further assessments to verify the reliability and validity of HAAS-C at different follow-up time points in future investigations.

Conclusions

The HAAS-C demonstrates adequate reliability, good content validity, moderate validity, which support the use of HAAS-C as a reliable instrument for capturing high-intensity activities among KOA patients who have undergone TKA in mainland China.

Abbreviations

HAAS-C, Chinese Version of HAAS; EQ-5D-5L, Five-Level EuroQoL Group's Five-Dimension Questionnaire; HAAS, High Activity Arthroplasty Score; HRQoL, Health-Related Quality of Life; ICC, Intraclass Correlation Coefficient; I-CVI, Item Level Content Validity Index;KOA:Knee Osteoarthritis; OKS, Oxford Knee Score; PROM, Patient-Reported Outcome Measurement; SD, Standard Deviation; SDC, Smallest Detectable Change; SEM, Standard Error of Measurement; S-CVI, Scale Level Content Validity Index; TKA, Total Knee Arthroplasty; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Data Sharing Statement

The dataset used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The study adheres to the Helsinki Declaration and has received approval from the Medical Ethics Committee of the Honghui Hospital, Xi'an Jiaotong University (202212004). Additionally, written informed consent was obtained from all participants.

Acknowledgments

Dongping Wan, Shihang Cao and Xinrui Li are co-first authors for this study. We sincerely thank Yue Wang and Vanessa Pong for their work in translation and cross-cultural adaptation.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by Key Research and Development Program of Shaanxi Province (Grant No. 2023-YBSF-464); General Research Plan of Xi'an Health Commission (Grant No. 2023yb30); the National Natural Science Foundation of China (Grant No. 82173627).

Disclosure

The authors declare that they have no competing interests in this work.

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