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Original Article

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ABSTRACT

Objective: To test the validity, reliability, and acceptability of the Oxford Knee Score (OKS) Mandarin Chinese version for measuring knee pain and function among Chinese breast cancer survivors.
Methods: This validation study was a secondary analysis of a cross-sectional survey that was conducted at the Affiliated Hospital of Southwest Medical University, Sichuan, China. Recruited from a larger arthralgia-related survey cohort, those who experienced knee arthralgia and completed the OKS Chinese version were selected for the current analysis. The Cronbach's alpha coefficient was calculated to identify the internal consistency reliability of the OKS. Spearman's correlations were adopted to identify the concurrent validity of the OKS. The discriminate performance of the OKS via subgroup analysis of breast cancer survivors with or without arthritis, as well as different exercise levels, cancer stages, chemotherapy protocols, and occupations, was also conducted.
Results: One hundred and fifty-nine breast cancer survivors were included. There were significant correlations between the OKS and the FACT-B, the SF-36, and the BPI in measuring knee pain symptoms and their impact on daily living activities. The Cronbach's alpha for the OKS total scores was 0.90. The participants with arthritis reported significantly lower OKS scores than those without arthritis ($P = 0.040$). The difference in OKS total scores between the participants with different exercise levels ($P < 0.001$) and the participants with different occupations ($P = 0.006$) was statistically significant. Considerable ceiling effects (>15%) of the OKS Chinese version were found in 11 of 12 items.
Conclusions: The OKS Mandarin Chinese version is a short, valid, reliable, and sensitive tool for knee pain and function assessment among breast cancer survivors.

Introduction

Hormone receptor-positive (HR+) breast cancer, including progesterone receptor-positive (PR+) and estrogen receptor-positive (ER+), accounts for about 80% of breast cancer survivors.[1] Aromatase inhibitors (AIs) therapy has been recommended as routine adjuvant treatment for females diagnosed with HR+ breast cancer.[2] Five years of AIs therapy increases disease-free survival by 10%–40% and decreases cancer recurrence rates among breast cancer survivors.[3–5] Joint symptoms such as pain, aches, and stiffness in the knee, hand, and wrist affect 20%–74% of breast cancer survivors receiving AIs therapy.[6] Furthermore, a study reported that the knee is the most prevalent location (61.0% of survivors) of joint symptoms, followed by the wrist (36.0%), the hand (36.0%), and the shoulder (25.5%).[7] Previous studies have supported the finding that joint symptoms can significantly worsen the quality of life (QoL) in all domains[8,9] and lead to nonadherence and early discontinuation of AIs treatment[10] among breast cancer survivors. Moreover, knee pain was associated with a substantial reduction in lower-extremity physical performance.[11] Knee pain affects every aspect of individuals' lives, including struggling through daily living activities.[12] A proper measurement of

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knee symptoms is essential for developing a tailored management plan for knee pain and dysfunction in breast cancer survivors.

Commonly used tools for joint or knee symptoms in breast cancer survivors include the Rheumatoid Arthritis Symptom Questionnaire (RASQ),[13] the Functional Assessment of Cancer Therapy Endocrine Subscale (FACT-ES),[14] the Nordic Musculoskeletal Questionnaire (NMQ),[9] the Brief Pain Inventory (BPI),[15–17] survivors' reports of symptoms (e.g., 'yes' or 'no' polar questions about the presence of symptoms),[18–21] and the Visual Analogue Scale (VAS).[22] However, the RASQ, the FACT-ES, the NMQ, and the BPI are not specifically for knee symptom assessment, and small and specific changes in knee pain and function may not be captured.[9,13–17] Survivors' reports of symptoms (e.g., 'yes' or 'no' polar question for the presence of symptoms) and the VAS are unidimensional instruments that do not capture the whole picture of knee pain and its impacts on functional status.[22] A multidimensional assessment is necessary to obtain a comprehensive understanding of knee pain and function to guide clinical decision-making and the planning of knee symptom management. No psychometrically sound and specific measurement to assess knee pain and function in breast cancer survivors is available.[6] Therefore, instruments that reliably and consistently measure knee symptoms would be welcomed in the therapeutic assessment battery.

The Oxford Knee Score (OKS) is a 12-item joint-specific, convenient, self-reported instrument.[23] This questionnaire was developed for the measurement of knee pain and function in individuals with knee osteoarthritis or after total knee replacement.[23] The OKS includes knee pain severity items and items about how individuals have been affected by knee pain and its impact on their daily living activities (e.g., laundry, transport, walking, and shopping) during the previous four weeks.[23] Although the OKS was originally developed for the measurement of knee pain and function in individuals with knee osteoarthritis or after total knee replacement,[23] it might be appropriate for evaluating joint pain and functions in breast cancer survivors receiving AI treatment given that knee osteoarthritis is associated with estrogen deprivation[24] and the development of AI-induced arthralgia is suspected to be analogous to the development of osteoarthritis at menopause.[25]

The OKS might be an ideal tool for knee pain and function assessment among breast cancer survivors, given that it is a knee-specific unidimensional tool that informs a comprehensive understanding of knee pain and function. The OKS has demonstrated reliability and validity in knee osteoarthritis[26–28] and total knee arthroplasty,[29,30] but its psychometric properties have not yet been established in breast cancer survivors receiving cancer treatments and experiencing arthralgia. This validation study, therefore, aimed to test the validity, reliability, and acceptability of the OKS Mandarin Chinese version for measuring knee pain and function in breast cancer survivors.

Methods

This validation study was a secondary analysis of a larger cross-sectional survey that assessed arthralgia after cancer treatments in breast cancer survivors. Oxford University Innovation Ltd approved the use of the OKS Mandarin Chinese version in this study. This validation study did not include the translation process as the OKS Mandarin Chinese version was validated previously[26,31] and is available from Oxford University Innovation Ltd.

The survey, alongside a subsequent trial, was approved by the Clinical Trial Research Ethics Committee at the Affiliated Hospital of Southwest Medical University (KY2018004), the Research Ethics Committee of School of Nursing, The Hong Kong Polytechnic University (HSEARS20180509004), and the Human Research Ethics Committee at Charles Darwin University (H19011).

Overview of the cross-sectional survey

The study setting was the Affiliated Hospital of Southwest Medical University, Sichuan, China. The large cross-sectional survey aimed to explore the prevalence of joint symptoms and the impact of joint symptoms on breast cancer survivors. Inclusion criteria: (1) female adults with breast cancer at stage I, II, or IIIA; (2) completed chemotherapy and currently receiving AI therapy for at least three months; (3) can communicate in Chinese Mandarin or Sichuanese with at least a primary school education. A self-designed demographic and clinical characteristics questionnaire, the Nordic Musculoskeletal Questionnaire (NMQ), the Brief Pain Inventory (BPI), the Functional Assessment of Cancer Therapy-Breast (FACT-B), and the RAND 36-Item Health Survey (SF-36) were completed by participants. The participants were also asked to complete other questionnaires to assess specific joint symptoms, such as the knee, hip, hand, and foot, based on the NMQ's initial assessment results. This validation study only analyzed data from breast cancer survivors who reported knee arthralgia and completed the OKS.

Study instruments

This validation study selected the following instruments from the cross-sectional survey to test the validity, reliability, and acceptability of the OKS Mandarin Chinese version among breast cancer survivors.

Self-designed demographic and clinical characteristics questionnaire

This questionnaire collected data on the participants' demographic characteristics, such as age, education level, body mass index (BMI), occupation, and marital status, and clinical information, such as cancer stage, chemotherapy protocol, and other health conditions.

Oxford Knee Score (OKS)

The OKS is a patient-reported joint-specific instrument, and each of the 12 items has five ordered categories of responses.[23] This questionnaire has proven to be valid, reliable, and responsive to knee pain and function changes.[32] The OKS total score ranges from 0 to 48, with a higher score indicating lower knee pain severity and better knee function.[33] The Chinese version of the OKS reported very good psychometric properties among individuals with knee osteoarthritis.[31]

Functional Assessment of Cancer Therapy-Breast (FACT-B)

This study utilized version 4.0 of the Mandarin Chinese version of the FACT-B for data collection. The FACT-B version 4.0 is a disease-specific QoL assessment tool for use in breast cancer survivors. The FACT-B version 4.0 includes the FACT-General (FACT-G) scale, with 27 items among four subscales: Physical (GP), Social/Family (GS), Emotional (GE), and Functional Well-Being (GF), and the Breast Cancer Subscale (BCS), with another 10 items.[34,35] Each question is rated on a 5-point Likert scale, and the FACT-B total score ranges from 0 to 148, with a higher score demonstrating a better QoL.[34] The Mandarin Chinese version of the FACT-B has demonstrated excellent reliability and validity.[36]

RAND 36-Item Health Survey (SF-36)

The Mandarin Chinese version of the SF-36 was used in this study. The SF-36 is a commonly used tool for QoL assessment.[37] The SF-36 has 36 items that measure "physical functioning", "bodily pain", "role limitations due to physical health problems", "role limitations due to personal or emotional problems", "emotional well-being", "social functioning", "energy/fatigue", and "general health perception".[37] A higher SF-36 score reflects a better QoL.[38] The SF-36 Mandarin Chinese version has shown good reliability and validity.[39]

Brief Pain Inventory (BPI)

The BPI has become one of the most commonly used tools for measuring pain symptoms. The BPI includes two main domains—pain intensity and pain interference in general activities.[40] A higher score demonstrates more severe pain symptoms and pain interference.[40] The Chinese version of the Brief Pain Inventory (BPI–C) has proven to be a valid and reliable tool for cancer pain assessment.[41]

Psychometric assessment

Reliability

The Cronbach's alpha coefficient was calculated to identify the internal consistency reliability of the OKS. Item-to-total correlations for each of the OKS items were computed to identify the correlations between one single OKS item score and the OKS total score excluding that item. A Cronbach's alpha of 0.8 or above is identified as having very good internal consistency and reflects a strong relationship among the instrument's items.[42] Once the item-to-total correlation value reaches 0.4 or more, the item is determined to be adequate.[43]

Validity

Validity for the OKS was demonstrated by concurrent validity, which reflects the extent to which a tool is associated with measures of similar content.[44] Relationships between the OKS and the FACT-B domains (physical and functional well-being), the SF-36 domains (bodily pain, physical functioning, and role-physical), and the BPI were identified to examine the concurrent validity of the OKS. The total scores of the OKS, the FACT-B domain scores (physical well-being and functional well-being), the SF-36 domain scores (bodily pain, physical functioning, and role-physical), and the BPI domain scores were hypothesized to be significantly correlated with each other, given that these instruments and domains measure very similar concepts. In addition, correlation coefficients between the OKS and SF-36 bodily pain, physical functioning and role-physical domains were hypothesized to be higher than correlations with the other SF-36 domains,[45] correlation coefficients between the OKS and FACT-B physical well-being and functional well-being domains were hypothesized to be higher than correlations with the other FACT-B domains. A correlation coefficient of more than 0.30 or more than 0.50 is considered a moderate or strong correlation, respectively.[46]

Floor and ceiling effects and acceptability

The floor and ceiling effects of the OKS were estimated by computing the percentages of the participants who reported the lowest and highest OKS total score and item score, respectively. The percentage of missing data across all the OKS items was computed to estimate the acceptability of the OKS. The presence of floor and ceiling effects is defined as 15% of the participants achieving the maximum or minimum score of the scale.[47]

Invariance and discriminate performance

The invariance of the OKS was evaluated by multigroup analysis, and BMI and age were chosen for analysis, as previous studies have demonstrated that BMI[10] and age[21] were correlated with AIs-induced joint symptoms. The OKS total score was hypothesized to be significantly correlated with BMI and age. The discriminate performance of the OKS was determined via subgroup analysis of breast cancer survivors with or without arthritis,[48] as well as survivors with different exercise levels,[49] cancer stages,[6] chemotherapy protocols,[50] and occupations[21] given that these factors were associated with greater AI-related arthralgia based on existing research evidence.

Data analysis

Data analyses were performed using IBM SPSS Statistics version 26.0. Descriptive statistics were computed for all variables. Spearman's correlations were adopted to identify the associations between the OKS total scores and the FACT-B, the SF-36, and the BPI domain scores based on the results of a normality test, which indicated that most of the OKS, FACT-B, SF-36, and BPI scores in this study sample violated the assumption of normal distribution. Group differences in knee pain and function were assessed by an Independent *t*-test/Mann–Whitney *U* test

Table 1
Demographic and clinical information ($N = 159$).

Demographic and clinical information		*n* (%)
Age (years)	20–29	1 (0.6%)
	30–39	6 (3.8%)
	40–49	29 (18.2%)
	50–59	83 (52.2%)
	60–69	36 (22.6%)
	70–79	4 (2.5%)
Educational background	Primary school	61 (38.4%)
	Secondary school	58 (36.5%)
	High school/vocational school	19 (11.9%)
	College diploma	10 (6.3%)
	University degree or above	11 (6.9%)
Marital status	Single/Unmarried	12 (7.5%)
	Married	146 (91.8%)
	Not recorded	1 (0.6%)
Occupation	Professional and technical personnel	4 (2.5%)
	Manual worker	21 (13.2%)
	Housewife	48 (30.2%)
	Clerical or administrative worker	8 (5.0%)
	Unemployment	8 (5.0%)
	Retired	37 (23.3%)
	Other	32 (20.1%)
	Not recorded	1 (0.6%)
Household income (RMB)	Less than 3000	57 (35.8%)
	3000–6000	48 (30.2%)
	6001–10000	32 (20.1%)
	More than 10000	13 (8.2%)
	Not recorded	9 (5.7%)
Source of healthcare insurance	NCMS	73 (45.9%)
	URBMI	29 (18.2%)
	UEBMI	52 (32.7%)
	Self-paid	2 (1.3%)
	Other	1 (0.6%)
	Not recorded	2 (1.3%)
BMI (kg/m^2)	Mean (SD)	24.1 (3.3)
	Underweight (<18.5)	4 (2.5%)
	Normal/healthy weight (18.5–22.9)	61 (38.4%)
	Overweight (23–24.9)	25 (15.7%)
	Obese (≥25)	68 (42.8%)
	Not recorded	1 (0.6%)
Cancer stage	I	33 (20.8%)
	IIA	62 (39.0%)
	IIB	37 (23.3%)
	IIIA	27 (17.0%)
Menopausal status	Postmenopausal	132 (83.0%)
	Years of menopause, Mean (SD)	8.2 (6.2)
	Premenopausal	25 (15.7%)
	Perimenopause	2 (1.3%)
Insomnia	Yes	115 (72.3%)
	No	43 (27.0%)
	Not recorded	1 (0.6%)
Exercise (Hour/week)	0–2	29 (18.2%)
	3–4	12 (7.5%)
	5–6	13 (8.2%)
	More than 6	101 (63.5%)
	Not recorded	4 (2.5%)
Smoking	Never smoked	159 (100%)
Use of alcohol	Yes	10 (6.3%)
	No	149 (93.7%)
Obesity history	Yes	23 (14.5%)
	No	132 (83.0%)
	Not recorded	4 (2.5%)
Arthritis	Yes	21 (13.2%)
	No	132 (83.0%)
	Not recorded	6 (3.8%)
Lymphedema	Yes	12 (7.5%)
	No	146 (91.8%)
	Not recorded	1 (0.6%)
Completed paclitaxel chemotherapy	Yes	134 (84.3%)
	No	24 (15.1%)
	Detailed chemotherapeutic agents not specified	1 (0.6%)

(*continued on next page*)

Table 1 (*continued*)

Demographic and clinical information		*n* (%)
Current physiotherapy treatments	Yes	21 (13.2%)
	No	136 (85.5%)
	Not recorded	2 (1.3%)

SD, standard deviation; NCMS, the rural new cooperative medical scheme; UEBMI, the urban employee-based basic medical insurance; URBMI, urban resident-based basic medical insurance scheme; BMI, body mass index; AI, aromatase inhibitor.

and one-way Analysis of Variance (ANOVA)/Kruskal–Wallis *H* test according to the normality test results. Statistical significance was set at $P < 0.05$.

Results

Demographic and clinical information of the patient sample

One hundred and fifty-nine breast cancer survivors were included in this study. The mean age of the participants was 54.4 years (SD 8.4 years), and the mean chemotherapy duration was 4.4 months (SD 1.2 months). All the participants were receiving AIs treatment, and the mean duration of the AIs treatment was 28.6 months (SD 23.0 months). The participants' demographic and clinical characteristics are summarized in Table 1.

Floor and ceiling effects and acceptability

Missing values were identified in OKS items 2, 6, 7, and 9 (one participant), with the percentage of missing values ranging from 0% to 0.6% (1 of 159), see Table 2. No missing values were detected for the other OKS items. For the whole questionnaire, four missing values were identified in the OKS total scores, which contributed to the missing data rate of 2.51% (4 of 159). The percentage of subjects with the lowest (0) and highest (48) scores of the OKS total score was 0.0% (0 of 159) and 3.77% (6 of 159), respectively. However, 11 of 12 items showed a considerable ceiling effect (more than 15% of the participants achieved the maximum score of the item). See Table 2.

Reliability of the OKS

The mean OKS total score was 40.46 (range: 20 to 48; SD: 6.19) (see Table 3). The OKS showed excellent internal consistency, with a Cronbach's alpha of 0.90. Cronbach's alpha coefficients were slightly lower (0.89) after removing items 1, 2, 3, 5, 6, 7, 9, or 12. Very good item-to-total correlations were reported, with the value ranging from 0.45 to 0.76 for each item and with eight of the 12 item-to-total correlations more than 0.60 (see Table 3).

Concurrent validity of the OKS

The OKS total scores were positively and significantly correlated with the FACT-B total and subscale scores and the SF-36 subscale scores ($P < 0.01$) except the mental health subscale ($P > 0.01$) the association was deemed weak to strong, with an r range of 0.27–0.64. Correlation coefficients between the OKS and SF-36 bodily pain ($r = 0.60$), physical

Table 3
Reliability of the Oxford Knee Score (Chinese version).

Question number and content		*N*	Mean score	SD	Corrected item–total correlation	Cronbach's alpha if item deleted
1	Usual level of knee pain	159	2.20	0.96	0.67	0.89
2	Trouble with washing and drying	158	3.54	0.70	0.65	0.89
3	Trouble with transport	159	3.25	0.76	0.76	0.89
4	Walking time before severe pain	159	3.79	0.47	0.45	0.90
5	Pain on standing up from sitting	159	3.37	0.76	0.68	0.89
6	Limping when walking	158	3.41	0.79	0.74	0.89
7	Difficulty with kneeling	158	3.28	0.93	0.67	0.89
8	Pain in bed at night	159	3.33	0.95	0.51	0.90
9	Work interference due to pain	158	3.23	0.73	0.73	0.89
10	Sense of knee instability	159	3.75	0.52	0.54	0.90
11	Doing household shopping alone	159	3.84	0.49	0.54	0.90
12	Trouble with walking downstairs	159	3.55	0.67	0.61	0.89
Total score		155	40.46	6.19		

SD, standard deviation; Each question is scored from 0 to 4 with 4 being the best outcome. This method, when summed, produces overall scores running from 0 to 48 with 48 being the best outcome.

Table 2
Item analysis ($N = 159$).

	No. of participants responded to the item	No. of participants not responded to the item	Missing value (%)	Floor effect (%)	Ceiling effect (%)
OKS item 1	159	0	0.0%	4.4%	7.5%
OKS item 2	158	1	0.6%	0.0%	64.2%
OKS item 3	159	0	0.0%	0.6%	41.5%
OKS item 4	159	0	0.0%	0.0%	81.1%
OKS item 5	159	0	0.0%	3.1%	50.9%
OKS item 6	158	1	0.6%	0.0%	57.9%
OKS item 7	158	1	0.6%	2.5%	50.9%
OKS item 8	159	0	0.0%	0.0%	61.0%
OKS item 9	158	1	0.6%	0.0%	38.4%
OKS item 10	159	0	0.0%	0.0%	78.6%
OKS item 11	159	0	0.0%	0.6%	86.8%
OKS item 12	159	0	0.0%	0.0%	64.2%
	No. of participants responded to all the items	No. of participants not responded to one or more of the items			
OKS total	155	4	2.51%	0.0%	3.77%

Table 4
Correlation between knee pain and function, QoL and BPI scores.

Item	OKS	PW	SWB	EWB	FWB	BCS	FACTB	PF	RP	BP	GH	VT	SF	RE	MH	BPIS	BPII
OKS	1.00																
PWB	0.48[a]	1.00															
SWB	0.31[a]	0.26[a]	1.00														
EWB	0.27[a]	0.54[a]	0.42[a]	1.00													
FWB	0.36[a]	0.39[a]	0.47[a]	0.47[a]	1.00												
BCS	0.32[a]	0.58[a]	0.25[a]	0.53[a]	0.17[b]	1.00											
FACTB	0.48[a]	0.74[a]	0.67[a]	0.79[a]	0.70[a]	0.66[a]	1.00										
PF	0.64[a]	0.46[a]	0.19[b]	0.27[a]	0.34[a]	0.37[a]	0.45[a]	1.00									
RP	0.42[a]	0.46[a]	0.17[b]	0.33[a]	0.42[a]	0.23[a]	0.45[a]	0.42[a]	1.00								
BP	0.60[a]	0.61[a]	0.31[a]	0.36[a]	0.41[a]	0.44[a]	0.58[a]	0.49[a]	0.47[a]	1.00							
GH	0.28[a]	0.48[a]	0.32[a]	0.38[a]	0.42[a]	0.31[a]	0.51[a]	0.28[a]	0.51[a]	0.39[a]	1.00						
VT	0.27[a]	0.42[a]	0.39[a]	0.48[a]	0.43[a]	0.25[a]	0.54[a]	0.23[a]	0.44[a]	0.42[a]	0.54[a]	1.00					
SF	0.41[a]	0.50[a]	0.27[a]	0.44[a]	0.41[a]	0.47[a]	0.57[a]	0.37[a]	0.50[a]	0.46[a]	0.46[a]	0.48[a]	1.00				
RE	0.29[a]	0.37[a]	0.24[a]	0.47[a]	0.31[a]	0.36[a]	0.47[a]	0.29[a]	0.54[a]	0.35[a]	0.32[a]	0.55[a]	0.55[a]	1.00			
MH	0.15	0.40[a]	0.21[a]	0.47[a]	0.38[a]	0.33[a]	0.49[a]	0.23[a]	0.35[a]	0.32[a]	0.34[a]	0.65[a]	0.43[a]	0.50[a]	1.00		
BPIS	-0.53[a]	-0.55[a]	-0.13	-0.29[a]	-0.24[a]	-0.35[a]	-0.41[a]	-0.43[a]	-0.22[b]	-0.63[a]	-0.24[a]	-0.27[a]	-0.32[a]	-0.28[a]	-0.33[a]	1.00	
BPII	-0.50[a]	-0.65[a]	-0.12	-0.33[a]	-0.35[a]	-0.37[a]	-0.48[a]	-0.44[a]	-0.42[a]	-0.58[a]	-0.35[a]	-0.34[a]	-0.39[a]	-0.33[a]	-0.38[a]	0.69[a]	1.00

OKS, Oxford Knee Score; PWB, Physical well-being; SWB, Social/Family well-being; EWB, Emotional well-being; FWB, Functional well-being; BCS, Breast cancer subscale; FACTB, Functional Assessment of Cancer Therapy-Breast Total score; PF, Physical functioning; RP, Role-physical; BP, Bodily pain; GH, General health; VT, Vitality; SF, Social functioning; RE, Role-emotional; MH, Mental health; BPIS, Brief Pain Inventory-pain intensity; BPII, Brief Pain Inventory-pain interference.
[a] Correlation is significant at the 0.01 level (2-tailed).
[b] Correlation is significant at the 0.05 level (2-tailed).

functioning ($r = 0.64$) and role-physical ($r = 0.42$) domains, were higher than correlations with the other SF-36 domains. Similarly, correlation coefficients between the OKS and FACT-B physical well-being ($r = 0.48$) and functional well-being ($r = 0.36$) domains were higher than correlations with the other FACT-B domains. Strong and negative correlations were shown between the OKS total scores and the BPI severity and inference scores ($P < 0.01$, $r = -0.53$ and -0.50, respectively). Details are presented in Table 4.

Invariance and discriminate performance of the OKS

Spearman's correlations indicated that the OKS total score and age showed a significant, moderate, and negative association ($P < 0.01$, $r = -0.33$, $n = 155$). The participants with arthritis reported significantly lower OKS scores (indicating higher knee pain and worse knee function) than those without arthritis ($P = 0.040$, $z = 2.052$, $n = 149$, see Table 5). There were statistically significant differences in the OKS total scores between the participants with different exercise levels ($P < 0.001$, $n = 151$, see Table 5) and the participants with different occupations ($P = 0.006$, $n = 154$, see Table 5). The participants with 3–4 h of exercise per week compared with those who had longer weekly exercise levels and professional/technical personnel reported higher knee pain and worse knee function.

There was no difference in the OKS total scores between the two BMI groups (group 1, BMI ≥ 23 kg/m^2 [overweight and obesity], and group 2, BMI < 23 kg/m^2 [normal weight and underweight]) ($P > 0.05$, $n = 154$). The participants with different cancer stages (I to IIIA) ($P > 0.05$, $n = 155$) and different chemotherapy protocols (paclitaxel chemotherapy versus other chemotherapy protocols) ($P > 0.05$, $n = 154$) reported similar OKS total scores.

Discussion

The OKS Mandarin Chinese version is a short, valid, reliable, and sensitive tool for knee pain and function assessment among breast cancer survivors. The OKS total score ranged from 0 (worst) to 48 (best), and any change in the OKS total score of more than 7 points (cut-off value) at the individual level can be considered as a clinically important improvement.[51] Participants experienced mild-to-moderate knee pain (mean pain score of item 1 [usual level of knee pain]: 2.20) without significant impact on their knee function, as the mean score of all knee function items of the OKS was more than 3.0 (range 3.23–3.84, with mean OKS total score was 40.46). This might also explain the ceiling effect identified in 11 of 12 items. The ceiling effect of the OKS items in this study was in concordance with previous studies in patients with knee osteoarthritis,[31,52,53] among which one study reported that ceiling effects were identified in up to 57.3% of participants, with a mean OKS total score was 38.37.[31] In this study, considerable ceiling effects of the OKS Chinese version may limit the interpretability of change scores as further enhancement in knee function may occur but cannot be captured by the OKS Chinese version.

This study demonstrated that the OKS Mandarin Chinese version showed high acceptability among Chinese breast cancer survivors based on minimal missing data (2.51%). A high Cronbach's alpha was found for the OKS Mandarin Chinese version, and adequate corrected item-total coefficients (more than 0.4) for all 12 items confirmed that the OKS Mandarin Chinese version is internally consistent. The OKS also showed very good concurrent validity in this study, and the clinical utility of the OKS for breast cancer survivors is promising. These results are consistent with those in previous studies that showed that the OKS Mandarin Chinese version had excellent acceptability and psychometric properties in patients with knee osteoarthritis.[26,31]

The concurrent validity of the OKS Mandarin Chinese version was very good. As hypothesized, the OKS Mandarin Chinese version correlated moderately or strongly with the FACT-B domain scores (physical well-being and functional well-being) and the SF-36 domain scores (bodily pain, physical functioning and role-physical). The FACT-B domains (physical well-being and functional well-being), the SF-36 domains (bodily pain, physical functioning, and role-physical), and the BPI include pain and physical functioning items, and these aspects are also the focus of the OKS.[23] The OKS includes knee pain and function items related to daily living activities,[23] which measure very similar concepts as the two QoL assessments: the FACT-B (e.g., physical well-being and functional well-being domains)[34,35] and the SF-36 (e.g., bodily pain, physical functioning, and role-physical domains).[39] Positive correlations between knee pain and function (measured by the OKS) and QoL were also captured by previous observational studies that reported that breast cancer survivors with joint pain had a low QoL.[8,9] Furthermore, the OKS Mandarin Chinese version correlated strongly with the BPI domains in the expected negative direction. The OKS items also measured very similar concepts as those in the BPI, including pain severity and its impact on daily living activities.[40]

The OKS Mandarin Chinese version demonstrated very good discriminate performance via subgroup analysis with known risk factors for knee pain and function. The study findings showed that the OKS total score and age showed a significant and moderate association. This is

Table 5
Difference in OKS total score between different groups.

Demographic and clinical group		OKS total score, Mean rank	OKS total score Mean, SD	*Z/ Kruskal-Wallis H*	*P value*
Arthritis	Yes ($n = 20$)	56.63	38.25 (6.52)	2.052	0.040
	No ($n = 129$)	77.85	41.07 (5.81)		
Exercise level (Hour/week)	0-2 ($n = 29$)	51.55	37.72 (5.48)	26.28	< 0.001
	3-4 ($n = 12$)	39.50	34.50 (7.76)		
	5-6 ($n = 12$)	67.75	39.42 (6.79)		
	More than 6 ($n = 98$)	88.71	42.26 (5.34)		
Cancer stage	I ($n = 33$)	81.50	40.70 (6.70)	1.45	0.694
	IIA ($n = 61$)	80.69	41.03 (5.83)		
	IIB ($n = 34$)	70.24	39.26 (6.51)		
	IIIA ($n = 27$)	77.43	40.41 (6.08)		
Chemotherapy protocols	Paclitaxel chemotherapy ($n = 130$)	80.10	40.83 (6.02)	1.69	0.091
	Other chemotherapy protocols ($n = 24$)	63.40	38.38 (6.91)		
Occupation	Professional and technical personnel ($n = 4$)	54.63	36.25 (8.58)	17.94	0.006
	Manual worker ($n = 21$)	53.79	36.85 (7.21)		
	Housewife ($n = 44$)	77.58	40.02 (5.04)		
	Clerical or administrative worker ($n = 8$)	84.88	42.13 (4.94)		
	Unemployment ($n = 8$)	86.94	41.25 (7.38)		
	Retired ($n = 37$)	69.24	39.19 (7.09)		
	Other ($n = 32$)	101.16	43.84 (3.18)		

OKS, Oxford Knee Score; SD, standard deviation.

consistent with other studies that showed that age-related changes lead to tissue vulnerability and can induce knee dysfunction.[54] The OKS Mandarin Chinese version was sensitive to knee symptom assessment and accurately captured differences in pain across different age groups of breast cancer survivors, which allowed a comparison between age groups. Joint pain and stiffness are the key symptoms of patients with arthritis, and arthritis is one of the significant predictors of joint pain among breast cancer survivors.[48] This was accurately and sensitively captured by the OKS Mandarin Chinese version, as the breast cancer survivors with arthritis reported significantly higher knee pain than those without arthritis in this study.

There was a statistically significant difference in OKS total scores between the participants with different exercise levels and the participants with different types of occupations, which demonstrated that the OKS Mandarin Chinese version sensitively captured differences in knee pain and function in breast cancer survivors with different exercise levels and occupation types. A previous cross-sectional study with 300 participants reported that AIs-related lower-extremity pain and function were associated with self-reported physical activity reductions.[49] After starting AIs treatment, the breast cancer survivors who reported higher lower-extremity pain levels and poorer lower-extremity functioning were more likely to report reduced physical activity.[49] Joint symptoms can interfere with walking or other forms of activity.[55] Participants in this study with lower exercise levels reported lower OKS scores, 19.2% (29/151) of the participants with 0–2 h exercise/week; our findings recommend that tailored interventions targeting higher joint pain levels are needed. With reference to the types of occupations, a previous study reported that heavy lifting in participants' jobs was associated with knee pain.[56] In this study, professional/technical personnel and manual workers reported higher knee pain and worse knee function.

The mean OKS total score was 40.46 in this study, but it is still possible to achieve a clinically important improvement (more than 7 points change) among breast cancer survivors experiencing hormone treatment-related knee dysfunction. Breast cancer survivors who had their last menstrual period (LMP) within the last five years were significantly associated with greater AI-related joint pain, and a short time from LMP was the only significant predictor of AI-related joint symptoms.[21] In this study, 132 (83.0%) participants were postmenopausal, with a mean time of menopause of 8.2 years (SD 6.2 years); this might partially explain the relevantly high OKS total score. Nevertheless, the excellent acceptability and psychometric properties of the OKS Mandarin Chinese version identified in this study encourage the use of the OKS for the assessment of knee pain and function in breast cancer survivors from both research and clinical practice perspectives.

Limitations

Test-retest reliability was not possible as this study was cross-sectional. Another reason for not choosing to conduct test-retest reliability is the poor stability of knee pain symptoms, as knee pain is a dynamically changing symptom in cancer. The sample size across the groups was uneven, and some groups had a small sample size, which may have contributed to type II errors[57] in determining the differences in the OKS scores between the different groups. Six survivors reported they had knee problems in the NMQ, but they received a full score (48) after being assessed with the OKS. The different timeframes of assessment (NMQ: past 12 months and 7 days, OKS: past 4 weeks) may contribute to the inconsistent results between the two instruments.

Conclusions

The OKS Mandarin Chinese version is a short, valid, reliable, and sensitive tool for knee pain and function assessment among breast cancer survivors. Future clinical studies and routine health care are encouraged to use the OKS for the evaluation of knee pain and function in breast cancer survivors.

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Declaration of competing interest

None declared.

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Contributors

Study conception and design: XLL; YYH; TW; AM; LQY; HQH; SLZ; JYT. Data collection: XLL; YYH; TW; LQY; HQH; SLZ; JYT. Data analysis:

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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