

Structural relationships among osteoporosis knowledge, health beliefs, self-efficacy and activities of daily living in patients with knee osteoarthritis: a cross-sectional structural equation modelling study

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Abstract

Background

Osteoporosis knowledge is clinically relevant for patients with knee osteoarthritis (KOA), because pain, functional limitation and reduced activity may affect bone-health behaviour and fall-prevention capacity. This study examined the structural relationships among osteoporosis knowledge, osteoporosis-related health beliefs, osteoporosis self-efficacy and activities of daily living (ADL) in patients with KOA.

Methods

This cross-sectional questionnaire study was conducted from February to June 2026 among 214 patients with KOA recruited by convenience sampling from the Department of Joint Surgery, Qilu Hospital of Shandong University. The questionnaires included a general information form, the Osteoporosis Knowledge Test (OKT), Osteoporosis Health Belief Scale (OHBS), Osteoporosis Self-Efficacy Scale (OSES) and an ADL instrument. Group differences were assessed with Wilcoxon rank-sum or Kruskal-Wallis tests, univariable linear regression was used to explore associations with knowledge dimensions, and structural equation modelling (SEM) was used to estimate the specified paths. The study is reported in accordance with STROBE.

Results

The sample included 83 men and 131 women, with a mean age of 66.99 +/- 5.38 years. The mean total osteoporosis knowledge score was 9.35 +/- 3.66, the mean health-belief score was 115.57 +/- 18.68, the mean self-efficacy score was 62.86 +/- 3.63 and the mean ADL score was 85.51 +/- 12.41. Osteoporosis knowledge was positively correlated with health belief (Spearman $r = 0.791$), self-efficacy ($r = 0.709$) and ADL ($r = 0.427$). Osteoporosis-knowledge dimensions did not differ significantly across the assessed sociodemographic and clinical groups. The supplied AMOS output showed mixed or suboptimal model fit: chi-square = 181.282, df = 57, chi-square/df = 3.180, GFI = 0.878, CFI = 0.883, TLI = 0.840 and RMSEA = 0.101. AMOS also reported negative error variances, indicating a possible Heywood case. Within this model, health belief showed positive paths to ADL, self-efficacy and osteoporosis knowledge, whereas self-efficacy showed an unexpected negative path to osteoporosis knowledge.

Conclusions

Osteoporosis-related health belief was positively associated with osteoporosis knowledge among patients with KOA, but the SEM results require cautious interpretation because the design was cross-sectional and the supplied AMOS output showed suboptimal fit and negative variance estimates. Longitudinal and multicentre studies with fully reported SEM diagnostics are required to confirm the direction and robustness of these relationships.

Introduction

Knee osteoarthritis (KOA) is a chronic, progressive and heterogeneous joint disorder involving structural changes in cartilage, subchondral bone, synovium, ligaments and periarticular soft tissues. Clinically, KOA commonly manifests as pain, stiffness, reduced mobility and progressive functional limitation [1, 2]. With population ageing and increasing obesity, KOA has become a major contributor to disability and health-service use worldwide [3, 4]. Current management emphasizes patient education, exercise therapy, weight management, analgesic strategies and, in advanced disease, reconstructive procedures such as total knee arthroplasty [5–8].

Osteoporosis (OP) is a systemic skeletal disease characterized by reduced bone mass, deterioration of bone microarchitecture, increased bone fragility and susceptibility to fracture [9–12]. Because early OP is often asymptomatic, delayed recognition may lead to fragility fracture, loss of independence, reduced quality of life and substantial family and socioeconomic burden. KOA and OP are both common age-related musculoskeletal disorders and may coexist in older adults. Bone mass, subchondral bone remodelling, physical inactivity, pain-related disuse, falls and sarcopenia may jointly influence the clinical course and functional prognosis of patients with KOA and impaired bone health [13–20].

Improving osteoporosis knowledge in patients with KOA is clinically relevant because KOA-related pain and mobility limitation may reduce outdoor activity, resistance exercise and fall-prevention capacity. The Health Belief Model (HBM) and self-efficacy theory provide useful frameworks for understanding health-related cognition and behaviour. HBM emphasizes perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers and health motivation, whereas self-efficacy reflects confidence in performing specific preventive behaviours [21, 22]. Osteoporosis knowledge, health beliefs and self-efficacy have been assessed in different populations using the OKT, OHBS and OSES [23–30].

However, existing evidence has not sufficiently clarified how osteoporosis-related health beliefs, self-efficacy, ADL and knowledge are structurally related in patients with KOA. Most prior studies have used single-factor or correlational analyses and have rarely examined these psychological and functional variables simultaneously. Therefore, this study specified a cross-sectional SEM framework in which osteoporosis-related health belief was treated as an upstream predictor, osteoporosis self-efficacy and ADL were treated as path variables, and osteoporosis knowledge was treated as the outcome. We hypothesised that osteoporosis-related health beliefs would be associated with osteoporosis knowledge both directly and indirectly through self-efficacy and ADL.

Methods

Study design and reporting guideline

This was a single-centre cross-sectional questionnaire study conducted from February to June 2026. The manuscript was revised to follow the STROBE Statement for cross-sectional studies. Participants were recruited from the Department of Joint Surgery, Qilu Hospital of Shandong University, Jinan, Shandong, China.

Participants and setting

A convenience sample of 214 patients with KOA from the joint-surgery ward was included. Inclusion criteria were: (1) diagnosis of KOA according to the American College of Rheumatology criteria; (2) age $> = 50$ years; (3) clear consciousness and ability to complete the questionnaire independently; and (4) voluntary participation with signed informed consent. Exclusion criteria were: (1) concomitant severe diseases, such as malignant tumours or severe cardiovascular or cerebrovascular disease; (2) cognitive impairment or psychiatric disorder; and (3) fracture within the previous 3 months.

Sample size

The study protocol used Kendall's rule of thumb, which recommends a sample size five to ten times the number of independent variables. Based on 16 independent variables, the estimated sample size was 80–160, and 96–192 participants were required after allowing for a 20% attrition or invalid-response rate. The protocol also considered the recommendation by Lomax that SEM studies commonly require 200–500 participants. The target sample size was therefore set at 200, and 214 valid questionnaires were included in the final analysis.

Data collection procedure

Eligible patients were invited to complete questionnaire measures during the study period after informed consent. According to the supplied protocol, trained investigators administered the questionnaires face to face, checked questionnaires for completeness, and used double data entry with logic checks to reduce entry errors. The final analysis dataset contained 214 valid participant records.

Variables and measurement instruments

General and clinical characteristics

The general information form collected age, sex, ethnicity, occupation, educational level, monthly income, payment method, daily living area and living arrangement. Disease-related variables included joint-disease type, joint-pain duration, analgesic-use duration, calcium-supplement-use duration, hypertension duration, antihypertensive-use duration, diabetes duration, hypoglycaemic-drug-use duration, menopausal age, confirmed OP diagnosis and falls during the previous year. Height and weight were available in the raw text spreadsheet, but implausible values were detected and were therefore not summarised in this manuscript version pending author verification.

Osteoporosis Knowledge Test

The OKT was used to assess osteoporosis-related knowledge. The revised OKT has documented reliability and validity [24, 31]. The supplied protocol and questionnaire include three domains: risk-factor knowledge (items 1–11), exercise knowledge (items 12–18) and calcium knowledge (items 19–26). The protocol describes a total possible score of 0–26 for women and 0–24 for men, with higher scores indicating better osteoporosis-related knowledge; Cronbach's alpha in the supplied protocol was reported as 0.83–0.87, with test-retest reliability of 0.82.

Osteoporosis Health Belief Scale

The OHBS was developed by Katherine Kim and colleagues within the HBM framework and revised by Zheng Cuihong et al. as a multidimensional Chinese health-belief questionnaire [23, 32]. The current study dataset contained seven OHBS dimensions: perceived susceptibility, perceived seriousness, health motivation, perceived benefits of exercise, perceived barriers to exercise, perceived barriers to calcium intake and perceived benefits of calcium intake. Higher summed scores indicate stronger osteoporosis-related health beliefs. The protocol describes a 31-item, 5-point Chinese version, whereas the earlier Chinese manuscript described a 42-item, 6-point version; the submitted version should therefore confirm the exact questionnaire version and theoretical score range.

Osteoporosis Self-Efficacy Scale

The OSES measures confidence in performing osteoporosis-preventive behaviours, particularly exercise and calcium-intake behaviours [25–30, 33]. The supplied Chinese validation article by Hu et al. reported a 19-item Chinese OSES after item reduction, with two subscales and good reliability [33]. The questionnaire and data files supplied for the present study appear to contain 21 self-efficacy items and two subscale scores: exercise self-efficacy and calcium-intake self-efficacy. Higher scores indicate stronger osteoporosis-related self-efficacy.

Activities of Daily Living

ADL was assessed using a 10-item functional scale covering feeding, bathing, grooming, dressing, bowel control, bladder control, toilet use, bed-chair transfer, walking on level ground and stair climbing. Higher scores indicate better self-care and functional independence. The item structure is consistent with the Barthel Index framework [34]. The supplied dataset contained ADL total scores ranging from 0 to 90; the exact version and theoretical score range require author confirmation.

Statistical analysis

Continuous variables were described using means and standard deviations, and categorical variables were described using frequencies and percentages. Spearman correlation coefficients were recalculated from the supplied SPSS-format spreadsheet for the main study variables. Group differences in the three osteoporosis-knowledge dimensions were examined with Wilcoxon rank-sum tests for two-group variables and Kruskal-Wallis tests for variables with more than two groups. Bonferroni-adjusted pairwise

Wilcoxon tests were planned after significant Kruskal-Wallis tests, but no group comparison in the supplied output reached statistical significance.

The supplied R script fitted separate univariable linear regression models for each combination of knowledge dimension and predictor. Dependent variables were calcium knowledge, risk-factor knowledge and exercise knowledge. Predictors were the seven health-belief dimensions, exercise self-efficacy, calcium-intake self-efficacy and ADL total score. Analyses used complete cases per model; no missing values were present in the four core scale totals in the supplied SPSS sheet. A two-sided P value < 0.05 was considered statistically significant.

SEM was used to test the specified paths and to estimate direct, indirect and total effects. The supplied IBM SPSS Amos output file was generated on 5 May 2026 and used a recursive model with a sample size of 214; the software version and estimation method were not clearly reported in the output. Fit indices extracted from the AMOS output included chi-square, degrees of freedom, chi-square/df, RMR, GFI, AGFI, NFI, IFI, TLI, CFI, RMSEA with 90% CI, PCLOSE and FMIN. SRMR and bootstrap confidence intervals for indirect effects were not available in the supplied output.

Ethical considerations

The study was approved by the Research Ethics Committee of Qilu Hospital of Shandong University (approval no. KYLL-2026-02-047; review date: 12 February 2026). All participants provided written informed consent before enrolment. The study was conducted in accordance with the Declaration of Helsinki and relevant Chinese ethical requirements for life-science and medical research involving human participants.

Results

Participant Characteristics

The final analysis set included 214 patients with KOA. The mean age was 66.99 +/- 5.38 years, with a range of 58–95 years. The sample comprised 83 men (38.8%) and 131 women (61.2%). All participants in the supplied dataset were Han Chinese and had knee-joint disease recorded as the joint-disease type. Additional baseline characteristics are summarised in Table 1.

Table 1
Demographic and clinical characteristics of the participants

Characteristic	n (%) or mean +/- SD
Age, years	66.99 +/- 5.38; range 58–95
Sex	
Male	83 (38.8)
Female	131 (61.2)
Ethnicity	
Han	214 (100.0)
Occupation	
Farmer	119 (55.6)
Other	43 (20.1)
Worker	26 (12.1)
Professional/technical staff	8 (3.7)
Teacher	7 (3.3)
Manager	6 (2.8)
Civil servant	5 (2.3)
Educational level	
Junior middle school	62 (29.0)
Primary school	59 (27.6)
Senior high/technical secondary/vocational school	38 (17.8)
College or above	30 (14.0)
Illiterate	25 (11.7)
Monthly income, Chinese yuan	
< 3000	131 (61.2)
3000–5000	49 (22.9)
5000–7000	20 (9.3)
7000–10000	11 (5.1)
> 10000	3 (1.4)
Payment method	

Characteristic	n (%) or mean +/- SD
Resident medical insurance	69 (32.2)
Cross-region medical insurance	64 (29.9)
Employee medical insurance	52 (24.3)
Self-pay	23 (10.7)
Other	6 (2.8)
Daily living area	
Rural	145 (67.8)
Urban	69 (32.2)
Living arrangement	
With spouse	143 (66.8)
With children	33 (15.4)
Alone	27 (12.6)
Other	11 (5.1)
Type of joint disease	
Knee joint	214 (100.0)
Confirmed osteoporosis	
No	151 (70.6)
Yes	63 (29.4)
Falls in the previous year	
No	190 (88.8)
Yes	24 (11.2)

Note: Percentages use N = 214 as the denominator. Height and weight are not shown because implausible raw entries were detected and require cleaning or author confirmation.

Distribution and Correlations of Study Variables

The mean total osteoporosis knowledge score was 9.35 +/- 3.66. The mean scores for risk-factor knowledge, exercise knowledge and calcium knowledge were 3.16 +/- 1.95, 2.59 +/- 1.59 and 3.59 +/- 1.62, respectively. Spearman correlations among the main study variables were all positive (Table 2).

Table 2

Descriptive statistics and Spearman correlations among osteoporosis knowledge, health beliefs, self-efficacy and ADL

Variable	Possible range	Observed range	Mean +/- SD	1	2	3	4
1. Osteoporosis knowledge total	0–26	0–17	9.35 +/- 3.66	1.000			
Risk-factor knowledge	0–11	0–9	3.16 +/- 1.95				
Exercise knowledge	0–7	0–6	2.59 +/- 1.59				
Calcium knowledge	0–8	0–7	3.59 +/- 1.62				
2. Osteoporosis health belief total	Version range requires verification	59–188	115.57 +/- 18.68	0.791	1.000		
3. Osteoporosis self-efficacy total	Version range requires verification	53–74	62.86 +/- 3.63	0.709	0.786	1.000	
4. ADL total	ADL range requires verification	0–90	85.51 +/- 12.41	0.427	0.389	0.411	1.000

Note: Correlations were recalculated from the supplied SPSS-format spreadsheet. P values for the correlation matrix were not available in the supplied analysis files and should be verified before submission if the journal requires them.

Differences in Osteoporosis Knowledge Across Participant Characteristics

No statistically significant differences were found in calcium knowledge, risk-factor knowledge or exercise knowledge across the assessed sociodemographic and clinical characteristics (all $P > 0.05$). Ethnicity and joint-disease type were not tested because all participants were in the same recorded category.

Table 3
Non-parametric group comparisons for osteoporosis-knowledge dimensions

Outcome	Grouping variable	Method	Statistic	P
Risk-factor knowledge	Sex	Wilcoxon rank-sum	W = 5491	0.9015
Risk-factor knowledge	Occupation	Kruskal-Wallis	H = 4.711	0.5814
Risk-factor knowledge	Educational level	Kruskal-Wallis	H = 4.048	0.3994
Risk-factor knowledge	Monthly income	Kruskal-Wallis	H = 1.676	0.7952
Risk-factor knowledge	Payment method	Kruskal-Wallis	H = 2.885	0.5774
Risk-factor knowledge	Daily living area	Wilcoxon rank-sum	W = 4827	0.6914
Risk-factor knowledge	Living arrangement	Kruskal-Wallis	H = 1.014	0.7978
Risk-factor knowledge	Confirmed osteoporosis	Wilcoxon rank-sum	W = 4507.5	0.5376
Risk-factor knowledge	Falls in previous year	Wilcoxon rank-sum	W = 2279	0.9990
Exercise knowledge	Sex	Wilcoxon rank-sum	W = 5700	0.5619
Exercise knowledge	Occupation	Kruskal-Wallis	H = 4.477	0.6125
Exercise knowledge	Educational level	Kruskal-Wallis	H = 6.015	0.1981
Exercise knowledge	Monthly income	Kruskal-Wallis	H = 1.623	0.8048
Exercise knowledge	Payment method	Kruskal-Wallis	H = 6.083	0.1930
Exercise knowledge	Daily living area	Wilcoxon rank-sum	W = 5146.5	0.7265
Exercise knowledge	Living arrangement	Kruskal-Wallis	H = 6.842	0.0771
Exercise knowledge	Confirmed osteoporosis	Wilcoxon rank-sum	W = 4084	0.1033
Exercise knowledge	Falls in previous year	Wilcoxon rank-sum	W = 2406	0.6144
Calcium knowledge	Sex	Wilcoxon rank-sum	W = 5148.5	0.5084
Calcium knowledge	Occupation	Kruskal-Wallis	H = 3.680	0.7199
Calcium knowledge	Educational level	Kruskal-Wallis	H = 2.020	0.7321
Calcium knowledge	Monthly income	Kruskal-Wallis	H = 3.551	0.4701
Calcium knowledge	Payment method	Kruskal-Wallis	H = 6.404	0.1719
Calcium knowledge	Daily living area	Wilcoxon rank-sum	W = 5281	0.4795
Calcium knowledge	Living arrangement	Kruskal-Wallis	H = 1.143	0.7668
Calcium knowledge	Confirmed osteoporosis	Wilcoxon rank-sum	W = 4345	0.3278
Calcium knowledge	Falls in previous year	Wilcoxon rank-sum	W = 2573	0.3382

Note: Statistics were extracted from the supplemental file

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Univariable Linear Regression Analyses

In the supplied R output, each knowledge dimension was modelled separately with one predictor at a time. All displayed associations between health-belief dimensions, self-efficacy dimensions, ADL and osteoporosis-knowledge dimensions were positive and statistically significant (Table 4 and Fig. 1). These models are univariable analyses and should not be interpreted as mutually adjusted regression estimates.

Table 4
Univariable linear regression results for osteoporosis-knowledge dimensions

Outcome	Predictor	Estimate	SE	t	P
Calcium knowledge	Perceived susceptibility	0.101	0.034	2.983	0.003
Calcium knowledge	Perceived seriousness	0.155	0.034	4.589	< 0.001
Calcium knowledge	Health motivation	0.097	0.025	3.859	< 0.001
Calcium knowledge	Exercise benefits	0.098	0.025	3.930	< 0.001
Calcium knowledge	Exercise barriers	0.098	0.024	4.124	< 0.001
Calcium knowledge	Calcium-intake barriers	0.131	0.024	5.495	< 0.001
Calcium knowledge	Calcium-intake benefits	0.127	0.026	4.800	< 0.001
Calcium knowledge	Exercise self-efficacy	0.196	0.039	5.018	< 0.001
Calcium knowledge	Calcium-intake self-efficacy	0.171	0.039	4.402	< 0.001
Calcium knowledge	ADL total	0.048	0.008	5.800	< 0.001
Risk-factor knowledge	Perceived susceptibility	0.267	0.037	7.193	< 0.001
Risk-factor knowledge	Perceived seriousness	0.203	0.040	5.016	< 0.001
Risk-factor knowledge	Health motivation	0.156	0.029	5.293	< 0.001
Risk-factor knowledge	Exercise benefits	0.217	0.027	7.942	< 0.001
Risk-factor knowledge	Exercise barriers	0.150	0.028	5.361	< 0.001
Risk-factor knowledge	Calcium-intake barriers	0.119	0.030	4.019	< 0.001
Risk-factor knowledge	Calcium-intake benefits	0.222	0.030	7.398	< 0.001
Risk-factor knowledge	Exercise self-efficacy	0.247	0.047	5.299	< 0.001
Risk-factor knowledge	Calcium-intake self-efficacy	0.199	0.047	4.238	< 0.001
Risk-factor knowledge	ADL total	0.048	0.010	4.639	< 0.001
Exercise knowledge	Perceived susceptibility	0.164	0.032	5.141	< 0.001
Exercise knowledge	Perceived seriousness	0.206	0.032	6.477	< 0.001
Exercise knowledge	Health motivation	0.123	0.024	5.118	< 0.001
Exercise knowledge	Exercise benefits	0.114	0.024	4.717	< 0.001
Exercise knowledge	Exercise barriers	0.119	0.023	5.189	< 0.001
Exercise knowledge	Calcium-intake barriers	0.105	0.024	4.407	< 0.001
Exercise knowledge	Calcium-intake benefits	0.125	0.026	4.810	< 0.001

Outcome	Predictor	Estimate	SE	t	P
Exercise knowledge	Exercise self-efficacy	0.191	0.038	4.989	< 0.001
Exercise knowledge	Calcium-intake self-efficacy	0.186	0.038	4.948	< 0.001
Exercise knowledge	ADL total	0.036	0.008	4.252	< 0.001

Note: Estimates, standard errors and t values were extracted from the supplemental raw-data workbook. Confidence intervals, R2 values and model diagnostics were not included in the supplied output.

Structural Equation Model

The supplied AMOS output reached a minimum for the default model. However, the fit indices indicated mixed or suboptimal fit: chi-square = 181.282, df = 57, chi-square/df = 3.180, GFI = 0.878, CFI = 0.883, TLI = 0.840 and RMSEA = 0.101 (90% CI 0.085–0.118). These values differ from the more favourable fit indices reported in the earlier source manuscript and should be checked against the final AMOS output before submission.

Table 5
Structural equation model fit indices extracted from the
supplied AMOS output

Index	AMOS output value
Sample size	214
chi-square	181.282
df	57
P value	< 0.001
chi-square/df	3.180
RMR	2.233
GFI	0.878
AGFI	0.805
NFI	0.841
IFI	0.885
TLI	0.840
CFI	0.883
RMSEA	0.101
RMSEA 90% CI	0.085–0.118
PCLOSE	0.000
FMIN	0.851
SRMR	Not available in supplied AMOS output

Note: The supplied AMOS output reported negative error variances for e14 (-2.561) and e13 (-0.335), indicating a possible Heywood case. Standardised estimates involving the self-efficacy paths were not available in the same output, and SRMR was not reported.

All non-fixed unstandardised paths in the supplied AMOS regression-weight table were statistically significant (Table 6). Health belief showed positive paths to ADL, self-efficacy and osteoporosis knowledge. ADL showed a positive path to self-efficacy and osteoporosis knowledge. Osteoporosis self-efficacy showed an unexpected negative unstandardised path to osteoporosis knowledge. Standardised estimates were incomplete and should be interpreted cautiously because the output also indicated negative error variances.

Table 6
Structural paths and measurement loadings from the supplied AMOS output

Dependent variable	Predictor	Estimate	SE	C.R.	P	Standardised estimate
ADL	Osteoporosis health belief	3.967	1.370	2.897	0.004	0.346
Osteoporosis self-efficacy	Osteoporosis health belief	1.117	0.348	3.210	0.001	Not available
Osteoporosis self-efficacy	ADL	0.021	0.008	2.470	0.013	Not available
Osteoporosis knowledge	Osteoporosis self-efficacy	-0.185	0.065	-2.845	0.004	Not available
Osteoporosis knowledge	Osteoporosis health belief	0.966	0.303	3.193	0.001	1.369
Osteoporosis knowledge	ADL	0.033	0.008	4.179	< 0.001	0.535
Risk-factor knowledge	Osteoporosis knowledge	1.000 fixed				0.392
Exercise knowledge	Osteoporosis knowledge	0.746	0.129	5.805	< 0.001	0.359
Calcium knowledge	Osteoporosis knowledge	0.759	0.131	5.801	< 0.001	0.359
Exercise self-efficacy	Osteoporosis self-efficacy	1.000 fixed				Not available
Calcium-intake self-efficacy	Osteoporosis self-efficacy	0.944	0.196	4.807	< 0.001	Not available
Calcium-intake barriers	Osteoporosis health belief	1.000 fixed				0.248
Exercise barriers	Osteoporosis health belief	1.546	0.362	4.270	< 0.001	0.383
Exercise benefits	Osteoporosis health belief	3.371	0.968	3.483	< 0.001	0.850
Health motivation	Osteoporosis health belief	3.263	0.939	3.474	< 0.001	0.826
Perceived seriousness	Osteoporosis health belief	1.730	0.518	3.340	< 0.001	0.598
Perceived susceptibility	Osteoporosis health belief	1.389	0.437	3.177	0.001	0.466

Dependent variable	Predictor	Estimate	SE	C.R.	P	Standardised estimate
Calcium-intake benefits	Osteoporosis health belief	2.892	0.836	3.459	< 0.001	0.786

Note: Estimates are unstandardised unless labelled standardised. Fixed rows were used for indicator scaling. AMOS reported ★ as $P < 0.001$.

The reported unstandardised total effect of health belief on osteoporosis knowledge was 0.874. The total effects of ADL and self-efficacy on osteoporosis knowledge were 0.029 and – 0.185, respectively (Table 7). Bootstrap confidence intervals for the indirect effects were not available in the supplied output.

Table 7
Direct, indirect and total effects from the supplied AMOS output

Effect type	Outcome	Predictor	Unstandardised	Standardised
Total	ADL	Osteoporosis health belief	3.967	0.346
Total	Osteoporosis self-efficacy	Osteoporosis health belief	1.200	Not available
Total	Osteoporosis self-efficacy	ADL	0.021	Not available
Total	Osteoporosis knowledge	Osteoporosis health belief	0.874	1.239
Total	Osteoporosis knowledge	ADL	0.029	0.471
Total	Osteoporosis knowledge	Osteoporosis self-efficacy	-0.185	Not available
Direct	ADL	Osteoporosis health belief	3.967	0.346
Direct	Osteoporosis self-efficacy	Osteoporosis health belief	1.117	Not available
Direct	Osteoporosis self-efficacy	ADL	0.021	Not available
Direct	Osteoporosis knowledge	Osteoporosis health belief	0.966	1.369
Direct	Osteoporosis knowledge	ADL	0.033	0.535
Direct	Osteoporosis knowledge	Osteoporosis self-efficacy	-0.185	Not available
Indirect	Osteoporosis self-efficacy	Osteoporosis health belief	0.083	Not available
Indirect	Osteoporosis knowledge	Osteoporosis health belief	-0.092	-0.130
Indirect	Osteoporosis knowledge	ADL	-0.004	-0.063

Note: Standardised effects were unavailable for several self-efficacy-related paths in the supplied AMOS output. Effect terms are SEM statistical terms and do not establish causality in this cross-sectional study.

Discussion

Principal Findings

In this cross-sectional study of 214 patients with KOA, osteoporosis knowledge was positively correlated with health belief, self-efficacy and ADL. Osteoporosis-knowledge dimensions did not differ significantly across the assessed sociodemographic and clinical groups. In the specified SEM, osteoporosis-related health belief showed positive paths to ADL, self-efficacy and osteoporosis knowledge, whereas osteoporosis self-efficacy showed an unexpected negative unstandardised path to osteoporosis knowledge. These findings should be interpreted cautiously because the supplied AMOS output indicated suboptimal fit and negative error variances.

Comparison With Previous Studies

The positive association between osteoporosis-related health belief and knowledge is consistent with the HBM, which proposes that perceived susceptibility, seriousness, benefits, barriers and motivation shape health-related learning and behaviour [21, 23]. In patients with KOA, stronger osteoporosis-related health beliefs may increase attention to bone-health information because pain, mobility limitation and fall concerns make fracture prevention clinically salient.

The positive associations involving self-efficacy are also theoretically plausible in bivariate and univariable analyses. Patients who believe that osteoporosis prevention is important may feel more motivated to perform exercise, calcium-intake and other preventive behaviours. However, self-efficacy is behaviour-specific and may not reflect comprehensive understanding of OP risk factors, screening, pharmacological prevention, fall prevention or safe exercise progression. This distinction is important when designing education for patients with KOA.

ADL showed a positive association with osteoporosis knowledge. Better functional independence may reflect greater ability to attend rehabilitation sessions, communicate with clinicians and seek health information. Nevertheless, the model-based total effect of ADL on knowledge was small compared with the health-belief effect, suggesting that cognitive and motivational factors may be more central than functional capacity in explaining osteoporosis knowledge in this sample.

The negative path from osteoporosis self-efficacy to osteoporosis knowledge in the SEM requires particular caution. One possible explanation is a suppression effect within the specified model. Another possibility is that some patients with high confidence in exercise or calcium-intake behaviours may overestimate their preventive competence and therefore seek less information. Measurement overlap, reverse directionality, residual confounding, model misspecification, common-method bias and the Heywood case identified in the supplied AMOS output cannot be excluded. The finding should not be interpreted as showing that self-efficacy reduces knowledge.

Clinical and Nursing Implications

These results suggest that osteoporosis education for patients with KOA should assess knowledge, health beliefs and confidence together. Education should not aim only to increase confidence; it should also verify whether patients accurately understand exercise, calcium intake, vitamin D, fall prevention, bone-density testing and fracture-risk assessment. Educational content should be matched to patients' functional level so that recommended preventive behaviours are safe and feasible.

Strengths and Limitations

A strength of this study is its focus on the intersection between KOA care and osteoporosis health education, an area that is clinically relevant for older adults with pain, functional limitation and fall risk. The study also examined psychological and functional variables together in an SEM framework rather than relying only on bivariate associations.

Several limitations should be considered. First, the cross-sectional design cannot establish temporal order or causal pathways. Second, convenience sampling from a single clinical setting may limit generalisability. Third, the supplied AMOS output showed suboptimal model fit, RMSEA above commonly preferred thresholds and negative error variances for e14 and e13, suggesting a possible Heywood case. Fourth, standardised estimates, SRMR and bootstrap confidence intervals for indirect effects were incomplete or unavailable. Fifth, self-reported questionnaires may be affected by recall bias and social desirability bias. Sixth, potential confounders such as bone mineral density, KOA stage, pain severity, medication history, physical activity, nutrition, vitamin D status and health literacy were not fully reported. Longitudinal and multicentre studies with more complete SEM reporting are needed to verify the robustness of the observed paths.

Conclusions

In this cross-sectional study, osteoporosis-related health belief, self-efficacy and ADL were positively associated with osteoporosis knowledge among patients with KOA in descriptive analyses. Within the specified SEM, health belief showed a positive association with osteoporosis knowledge, whereas self-efficacy showed an unexpected negative model-based path. Because the supplied AMOS output showed suboptimal fit and negative variance estimates, these SEM findings should be treated as preliminary and require verification with a better-fitting model and complete reporting of standardised coefficients and indirect-effect confidence intervals.

Abbreviations

ADL
activities of daily living
AGFI
adjusted goodness-of-fit index
CFI

comparative fit index
CMIN/DF
chi-square divided by degrees of freedom
GFI
goodness-of-fit index
HBM
Health Belief Model
KOA
knee osteoarthritis
NFI
normed fit index
OHBS
Osteoporosis Health Belief Scale
OKT
Osteoporosis Knowledge Test
OP
osteoporosis
OSES
Osteoporosis Self-Efficacy Scale
RMSEA
root mean square error of approximation
SEM
structural equation modelling
SRMR
standardised root mean square residual
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
TLI
Tucker-Lewis index.

Declarations

Supplementary Information

Not applicable.

Ethics Approval and Consent to Participate

The study was approved by the Research Ethics Committee of Qilu Hospital of Shandong University (approval no. KYLL-2026-02-047; review date: 12 February 2026). All participants provided written

informed consent before enrolment. The study was conducted in accordance with the Declaration of Helsinki.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

Clinical trial registration

Not applicable. This study was a cross-sectional observational study and did not involve an interventional clinical trial requiring prospective registration.

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Author Contribution

XL: Conceptualization, Methodology, Investigation, Writing draft. LS: Methodology, Investigation. XZ: Investigation,. CS: Writing original draft. LF: Conceptualization, Supervision, Writing - review and editing. Xiangjun Li and Lili Sui contributed equally to this work. All authors read and approved the final manuscript. All authors reviewed the manuscript.

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Availability of Data and Materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

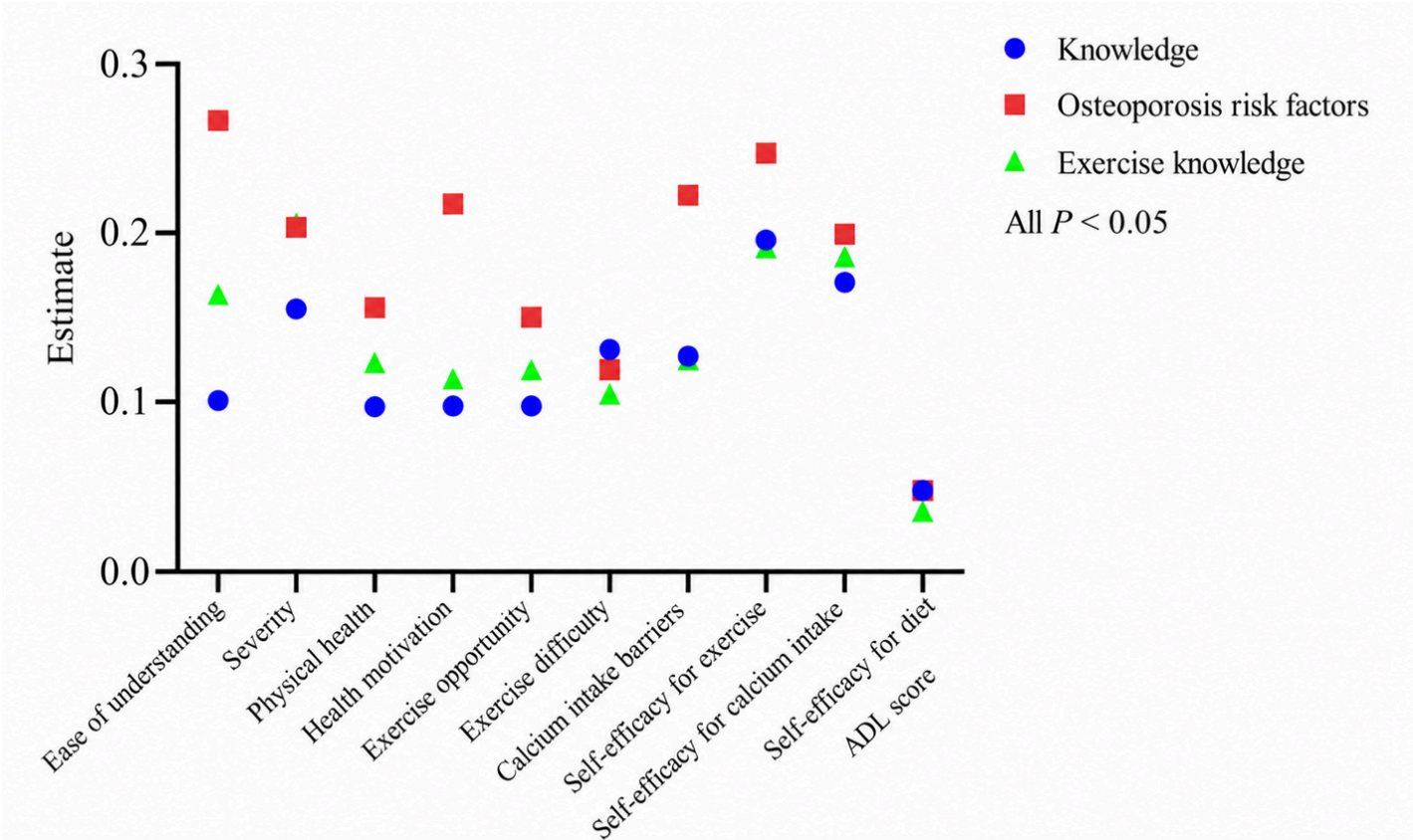


Figure 1

Coefficient plot for univariable linear regression analyses of osteoporosis-knowledge dimensions.

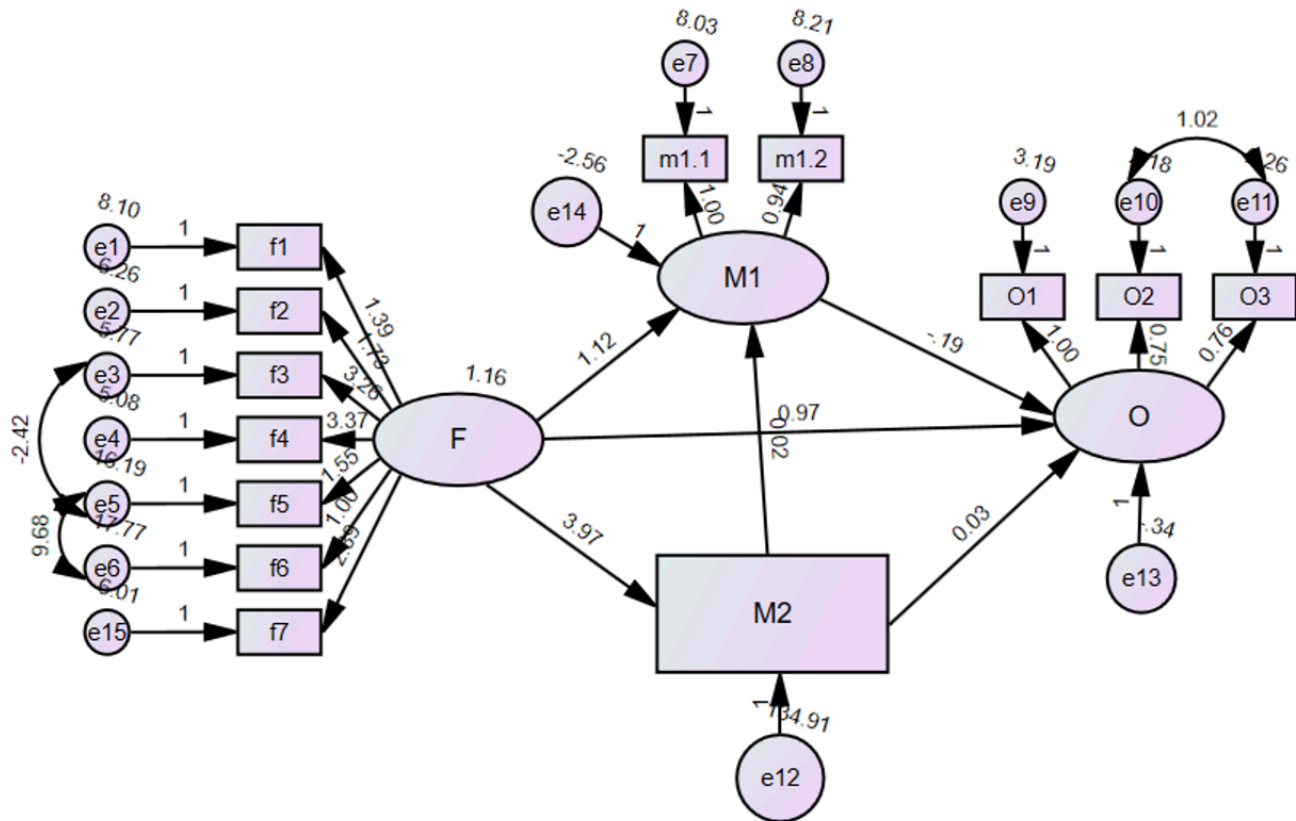


Figure 2

Structural equation model. Abbreviations: O, osteoporosis knowledge; O1, osteoporosis risk-factor knowledge; O2, exercise knowledge; O3, calcium knowledge; F, osteoporosis health belief; f1, susceptibility; f2, seriousness; f3, health motivation; f4, exercise benefits; f5, exercise barriers; f6, calcium-intake barriers; f7, calcium benefits; M1, osteoporosis self-efficacy; m1.1, exercise self-efficacy; m1.2, calcium-intake self-efficacy; M2, activities of daily living.