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SYSTEMATIC REVIEW

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Prevalence and influencing factors of kinesiophobia after total knee arthroplasty: a systematic review and meta-analysis

Xingbin Du[1,2*], Yuanwei Shao[3], Jian Xue[4] and Jianda Kong[2*]

Abstract

Background Knee osteoarthritis is a common degenerative disease in the elderly, and total knee arthroplasty is an effective treatment for end-stage knee joint diseases. However, kinesiophobia after surgery can impede patients' rehabilitation and affect the recovery of knee joint function. There are differences in the research on its related influencing factors.

Objectives This meta-analysis examined the prevalence and risk factors of kinesiophobia after TKA.

Methods Pubmed, The Cochrane Library, China National Knowledge Infrastructure (CNKI), Embase, Web of Science on the prevalence and risk factors of kinesiophobia after TKA was searched in science, MEDLINE and other databases. Duplicate literature, low quality literature, literature with inconsistent observation indicators, and literature without full text were excluded. Two independent researchers used Newcastle-Ottawa Scale (NOS) to evaluate the quality of the included literature. After data extraction, Meta-analysis was performed using Stata17.0.

Results A total of 11 articles involving 4039 cases were included in this meta-analysis to assess the prevalence of kinesiophobia after TKA. The overall prevalence was found to be 35% (95% CI: 27-44%). Subgroup analyses revealed varying prevalence rates based on age, education, income, and residence, with the highest prevalence observed in individuals under 65 years and those with lower levels of education and income. Key factors influencing the prevalence of kinesiophobia included pain (OR = 2.313, 95% CI: 1.556–3.07), low social support (OR = 1.681, 95% CI: 1.000-2.361), and negative coping strategies (OR = 1.344, 95% CI: 1.165–1.523).

Conclusion The prevalence of kinesiophobia after TKA is high. There are differences in the prevalence of kinesiophobia among people with different places of residence, different education levels, and different monthly incomes. At the same time, it is affected by many factors such as postoperative pain, low social support, low self-efficacy, negative coping, old age, and low education level.

Keywords Total knee arthroplasty, Kinesiophobia, Influencing factors, Meta-analysis

*Correspondence:
Xingbin Du
75462722@qq.com
Jianda Kong
jianda0426@163.com

[1]College of General Education, Shandong Huayu University of Technology, Zibo, China
[2]College of Sports Science, Qufu Normal University, Qufu, China
[3]The Second People's Hospital of Dezhou, Dezhou, China
[4]Qilu Hospital of Shandong University Dezhou Hospital, Dezhou, China

Introduction

Knee osteoarthritis is a common degenerative variation in the elderly, which is one of the causes of disability in the elderly [1]. Total knee arthroplasty is the best way to treat patients with end-stage knee osteoarthritis or rheumatoid arthritis that is ineffective through conservative treatment, which can relieve the pain of patients, improve the range of motion of knee joint, and improve the quality of life of patients [2]. Postoperative rehabilitation exercise runs through the whole process of knee joint recovery. Early functional exercise can reduce complications, increase knee range of motion, relieve pain, reduce muscle tension, enhance muscle strength, and relieve joint stiffness. TKA is the ultimate treatment for knee osteoarthritis. Kinesiophobia, also known as fear of exercise, is an irrational and excessive fear of activity caused by pain [3]. Lethem et al. put forward the "fear-avoidance" model in 1983 [4], that is, patients will adopt confrontation and avoidance in the face of pain, and patients with fear of pain will adopt avoidance behavior to exercise, which eventually leads to adverse reactions such as loss of musculoskeletal strength and negative emotions. In 1995, Vlaeyen et al. further extended the "fearing-avoidance" model to a cognitive behavioral model of fear of exercise or injury [5]. Fear of exercise may lead patients to avoid exercise, and patients often believe that exercise will further aggravate pain and dysfunction [6]. Patients with knee osteoarthritis often have joint pain after activities. Long-term pain memory will lead to pain catastrophizing and fear of postoperative rehabilitation exercise. Kinesiophobia can cause patients to avoid exercise, have low exercise compliance, miss the best rehabilitation time, and even increase the risk of complications such as lower limb thrombosis and muscle atrophy, which will eventually affect the recovery of knee joint function of patients [7]. Kinesiophobia has been confirmed to have a negative impact on the functional outcome of patients after surgery [8], but the research on its related influencing factors is quite different. There are many influencing factors of kinesiophobia in patients after TKA, such as gender, age, physiological factors, pain and psychological factors of population sociological characteristics. Therefore, it is very important to clarify the prevalence of kinesiophobia in TKA patients, the prevalence of kinesiophobia in different populations, and the influencing factors of kinesiophobia. Early identification of high-risk groups and corresponding intervention can reduce the incidence of kinesiophobia after TKA, thereby improving the postoperative efficacy of TKA and conducive to the prognosis of patients. Therefore, this study aims to explore the prevalence of kinesiophobia after TKA and its influencing factors through Meta-analysis, so as to provide evidence-based medical evidence for the identification and intervention of kinesiophobia.

Materials and methods

Research design

This study employed a systematic review and meta-analysis to evaluate the prevalence and influencing factors of kinesiophobia following TKA, providing evidence-based insights for clinical interventions. We systematically assessed relevant literature to synthesize findings on the impact of TKA on kinesiophobia and related factors.

Inclusion and exclusion criteria

We included studies that focused on adult patients undergoing TKA surgery for knee joint diseases diagnosed according to established criteria (e.g., ACR for osteoarthritis) with a follow-up period of at least 3 months post-surgery. Studies reporting on key interventions (TKA details such as approac, prosthesis, and perioperative management) and measuring kinesiophobia with validated tools (e.g., TSK) were included. We excluded non-original research types, such as reviews, case reports, expert consensus, and meta-analyses, as well as studies with incomplete data, or those using non-validated outcome measures.

Operational definition of influencing factors

To ensure high consistency in the definition and measurement of various influencing factors in different included studies, we conducted detailed operational definitions of key variables during the data extraction stage and strictly followed the measurement tools and truncation criteria reported in each study. Low self-efficacy "refers to a patient's lack of confidence in completing specific tasks, such as participating in rehabilitation exercises. Studies typically use validated self-efficacy scales, such as the General Self Efficacy Scale or scales specifically designed for TKA patients, for evaluation. In the included literature, we extracted self-efficacy scores reported by various research institutes and defined low self-efficacy as a level with scores below the predetermined criteria of each study based on the threshold values or grouping criteria set in the original research articles. If some studies do not clearly report specific cutoff values, data summary and comparison will be strictly based on the original description. Negative coping "mainly reflects an individual's tendency to adopt negative coping strategies such as avoidance, denial, and dependence when facing pressure or pain. Studies generally use coping strategies such as the Brief COPE scale or other validated coping behavior scales to evaluate patients' coping strategies. When extracting data, we recorded in detail the ratings and grouping criteria for negative coping strategies in each study, and defined 'negative coping' as being at a low level or meeting the negative coping criteria set in the article. We have compiled a detailed table in the supplementary

materials for readers to verify the specific measurement tools and cutoff values used in different studies.

Search strategy

We searched multiple databases, including PubMed, Embase, Web of Science, Cochrane Library, CNKI, Wanfan, and VIP, for studies published up to December 31, 2024. The search included terms related to TKA, kinesiophobia, and influencing factors like pain, psychological factors, and social support. The final search formula combined MeSH terms and free terms using Boolean operators to ensure comprehensive retrieval of relevant studies.

Data extraction

Two researchers independently extracted data from the included studies, focusing on study characteristics, sample sizes, surgical methods, outcome measures (e.g., kinesiophobia prevalence, pain scores, and self-efficacy), and follow-up details. Any discrepancies between researchers were resolved through discussion, and a third expert was consulted if necessary to ensure data accuracy.

Literature quality assessment

We assessed the quality of the included studies using the Newcastle-Ottawa Scale (NOS), considering factors such as study selection, comparability between groups, and measurement of exposure factors. Studies scoring less than 5 were excluded, those scoring between 5 and 7 were classified as medium quality, and studies with scores of 8 or higher were regarded as high-quality research. Disagreements were resolved by consulting a senior researcher. Final Search String: ("Total Knee Arthroplasty" OR "total knee replacement") AND ("Kinesiophobia" OR "fear of movement") AND ("pain" OR "psychological factors" OR "social support" OR "self-efficacy") AND ("rehabilitation" OR "post-surgery recovery" OR "functional outcomes").

Statistical analysis

We used Stata 17.0 for statistical analysis. Binary outcomes were described using odds ratios (OR) with 95% confidence intervals (CI), while continuous variables were analyzed using mean differences (MD) and 95% CI. Heterogeneity was assessed using the I^2 statistic, with a fixed-effect model applied for low heterogeneity ($I^2 \leq 50\%$) and a random-effect model for high heterogeneity ($I^2 \geq 50\%$). Subgroup and sensitivity analyses were conducted to explore heterogeneity and assess the stability of the findings. Funnel plots and Egger's test were used to evaluate publication bias.

Results

Literature retrieval and screening process

A total of 286 articles were retrieved. After reading the title and abstract, we excluded 159 articles that did not conform to the theme of the article, and 15 articles were determined to conform to the theme of the article. After reading the content and outcome indicators of the article, 4 articles were excluded. Finally, the data of 4039 patients in 11 articles were included in the study (Fig. 1).

Basic characteristics of the included studies

The sample size, mean age, and sex ratio of all patients were not statistically different (Table 1). All included literature met our prespecified inclusion criteria.

Quality evaluation results of included studies

A total of 11 articles were included in this study, including 9 cross-sectional studies and 2 cohort studies. The results of NOS score showed that there were 3 high quality studies, 8 medium quality studies, and no low quality studies (Table 1).

Results of Meta-analysis

Meta-analysis results of the prevalence of kinesiophobia after TKA

The results of meta-analysis of the prevalence of kinesiophobia after TKA showed that $I^2 = 97.05\%$, $P < 0.001$, that is, the prevalence of kinesiophobia after TKA was 35%[95%CI(19.6%,26.8%)], see Fig. 2. The results showed that there was no obvious source of heterogeneity, that is, the results of our study were reliable.

Meta-analysis results of postoperative prevalence of TKA in different subgroups

Age

We divided the age into two subgroups: those older than 65 years of age and those younger than 65 years of age (Table 2). There were 5 studies reported the relevant results in both subgroups [10, 11, 14, 15, 17]. Since the meta-analysis results all showed $I^2 > 50\%$, we used the random effects model. The results showed that the prevalence of the elderly over 65 years old was 17%[95%CI (15%,19%)], which was higher than that of the elderly under 65 years old [13% (95%CI(6%,21%)]. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Place of residence

We divided residence into urban and rural subgroups (Table 2). Four studies in each subgroup reported the relevant results [11, 13–15]. Since the meta-analysis results all showed $I^2 > 50\%$, we used the random effects model. The prevalence of urban residents was 16%[95%CI

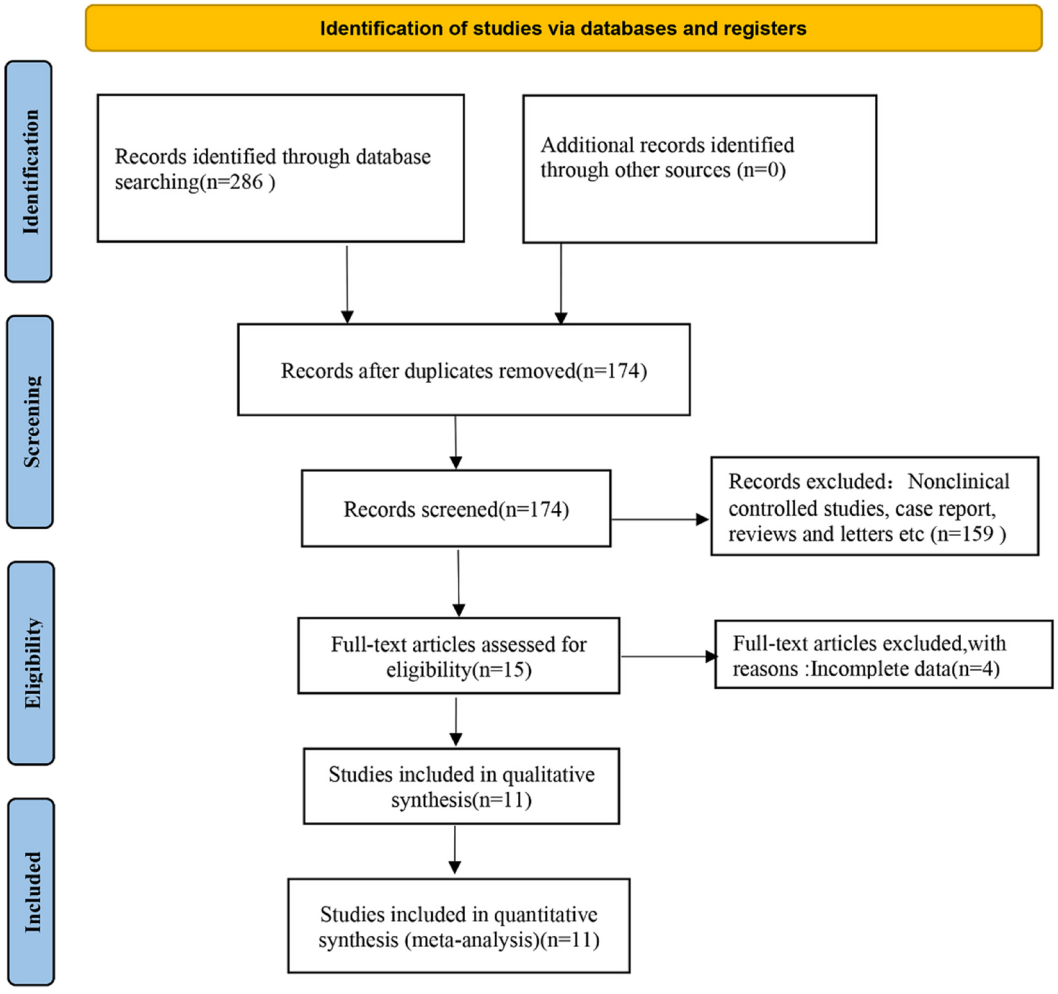

Fig. 1 Flow diagram of study identifcation and selection

Table 1 Characteristics of included literature studies

Author	Study design	Country	Year	Group	Patients	Gender(M/F)	Outcomes	NOS			
								Selection (0–4)	Comparability (0–2)	Outcome/ Exposure (0–3)	Total
Zhang [10]	Cross-sectional study	China	2021	TKA	450	122/328	(7)	3	1	3	7
Lei [11]	Cross-sectional study	China	2023	TKA	335	70/265	(1) (2) (3) (4) (5) (6) (7)	3	1	3	7
He [12]	Cross-sectional study	China	2023	TKA	121	25/96	(3) (5) (7)	3	2	3	8
Cai [13]	Cross-sectional study	China	2023	TKA	298	142/156	(1) (3) (6) (7)	3	1	3	7
Zhu [14]	Cross-sectional study	China	2012	TKA	862	383/479	(1) (2) (3) (4) (5) (6) (7)	3	1	3	7
Xin [15]	Cross-sectional study	China	2022	TKA	300	143/157	(1) (2) (6) (7)	3	1	3	7
Wen [16]	Cross-sectional study	China	2023	TKA	205	110/95	(7)	3	2	3	8
Zhang [17]	Cross-sectional study	China	2024	TKA	271	84/187	(1)(2)	3	1	3	7
Yan [18]	Cohort study	China	2023	TKA	257	87/170	(1)(5) (7)	3	1	3	7
Kocic [19]	Cohort study	Serbia	2015	TKA	78	19/59	(7)	4	2	3	9
Cai [20]	Cross-sectional study	China	2018	TKA	862	383/479	(1) (2) (3) (4) (6) (7)	3	1	3	7

Outcomes: (1)Pain intensity, (2) Social support, (3) Self-efficacy, (4) Negative coping, (5) Age, (6) educational level, (7) Agoraphobia

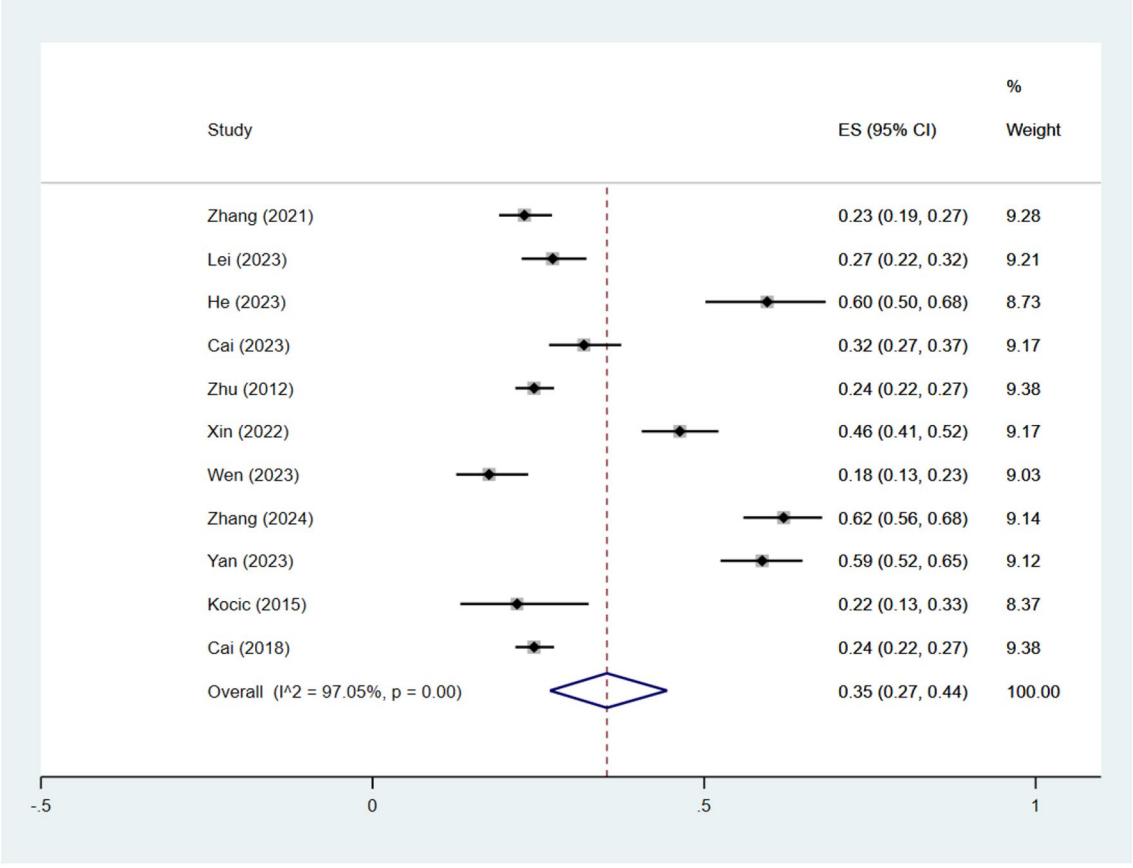

Fig. 2 A forest plot of the prevalence of agoraphobia

Table 2 Results of meta-analysis on the prevalence of kinesophobia in different subgroups after TKA

Sub-group	Number of Studies Included	Heterogeneity Test		Effect model	Egger's test	Meta-analysis of incidence rates.
		I^2	*P*			
Age						
Under 65 years old	5 [10, 11, 14, 15, 17]	96.22	<0.001	Random	0.308	0.13(0.06,0.21)
Over 65 years old	5 [10, 11, 14, 15, 17]	54.24	<0.001	Random	0.688	0.17(0.15,0.19)
Place of residence						
Town	4 [11, 13–15]	70.03	0.02	Random	0.457	0.16(0.13,0.20)
rural area	4 [11, 13–15]	92.75	<0.001	Random	0.377	0.14(0.09,0.21)
educational level						
Elementary school and below.	7 [10–16]	94.46	<0.001	Random	0.178	0.21(0.15,0.29)
Junior High School - Senior High School	7 [10–16]	88.56	<0.001	Random	0.713	0.02(0.01,0.05)
Bachelor's degree or higher	6 [10–14, 16]	70.07	0.01	Random	0.053	0.02(0.01,0.03)
Income						
Monthly income is less than 2000RMB	4 [10, 11, 13, 15]	97.68	<0.001	Random	0.624c	0.16(0.05,0.31)
2,000 to 3,000 RMB	4 [10, 11, 13, 15]	97.35	<0.001	Random	0.242	0.14(0.05,0.27)
Over 3000 RMB	4 [10–13]	97.55	<0.001	Random	0.098	0.11(0.02,0.25)

(13%,20%)], which was higher than that of rural residents 14% [(95%CI (9%,21%)]. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Education level

We divided the education level into three subgroups: primary school and below, middle school and high school, and college and above (Table 2). Results were reported in 7, 7, and 6 studies, respectively. Since the meta-analysis

results all showed $I^2 > 50\%$, we used the random effects model. The prevalence was 21%[95%CI (15%,29%)] in people with primary school education or below, which was higher than 2%[95%CI (1%,5%)] in people with junior high school education. 2%[95%CI (1%,3%)]. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Monthly income

We divided the monthly income into three subgroups: less than 2k RMB, 2–3 K RMB, and more than 3k RMB (Table 2). Four studies reported the relevant results. Since the meta-analysis results all showed $I^2 > 50\%$, we used the random effects model. The prevalence was 21%[95%CI (15%,29%)] in people with primary school education or below, which was higher than 2%[95%CI (1%,5%)] in people with junior high school education. 2%[95%CI (1%,3%)]. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Meta-analysis results of influencing factors of kinesiophobia after TKA

Pain

A total of seven studies reported the effect of pain on the prevalence of kinesiophobia after TKA (Table 3). Since the meta-analysis results showed that I^2 was 0, we chose the fixed effects model. Our results showed that postoperative pain was a risk factor for the prevalence of kinesiophobia [OR = 2.313,95%CI (1.556,3.07)], $P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Social support

A total of five studies reported the effect of social support on the prevalence of kinesiophobia after TKA (Table 3). Since meta-analysis results showed $I^2 > 50\%$, we chose a random effects model. Our results showed that low social support was a risk factor for the prevalence of kinesiophobia [OR = 1.681,95%CI (1.000,2.361)], $P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Self-efficacy

A total of five studies reported the effect of self-efficacy on the prevalence of kinesiophobia after TKA (Table 3). Since meta-analysis results showed $I^2 > 50\%$, we chose a random effects model. Our results showed that low self-efficacy was a risk factor for the prevalence of kinesiophobia [OR = 0.835,95%CI (0.663,1.008)], $P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Personal coping style

A total of three studies reported the influence of personal coping styles on the prevalence of kinesiophobia after TKA (Table 3). Since the meta-analysis results showed that I^2 was 0, we chose the fixed effects model. Our results showed that negative coping style was a risk factor for the prevalence of kinesiophobia [OR = 1.344,95%CI (1.165,1.523)], $P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Age

A total of four studies reported the effect of age on the prevalence of kinesiophobia after TKA (Table 3). Since meta-analysis results showed $I^2 > 50\%$, we chose a random effects model. Our results showed that advanced age was a risk factor for the prevalence of kinesiophobia [OR = 1.359,95%CI (0.814,1.904)], $P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Educational level

A total of three studies reported the effect of educational level on the prevalence of kinesiophobia after TKA (Table 3). Since meta-analysis results showed $I^2 > 50\%$, we chose a random effects model. Our results showed that low education level was a risk factor for the prevalence of kinesiophobia [OR = 0.514,95%CI (0.109,0.918)],

Table 3 Results of meta-analysis of influencing factors on the prevalence of kinesophobia after TKA

Factors affecting	Number of Studies Included	Heterogeneity Test		Effect model	The results of the meta-analysis	
		I^2	*P*			
Pain intensity	7 [11, 13–15, 17, 18, 20]	0	0.725	Fixed	2.313(1.556,3.07)	<0.0001
social support	5 [11, 14, 15, 17, 20]	96.9	<0.0001	Random	1.681(1.000,2.361)	<0.0001
Self-efficacy	5 [11–14, 20]	85.3	<0.0001	Random	0.835(0.663,1.008)	<0.0001
Personal coping strategies	3 [11, 14, 20]	0	0.394	Fixed	1.344(1.165,1.523)	<0.0001
Age	4 [11, 12, 14, 18]	67.4	0.027	Random	1.359(0.814,1.904)	<0.0001
educational level	3 [13–15, 20]	93.4	<0.0001	Random	0.514(0.109,0.918)	<0.0001

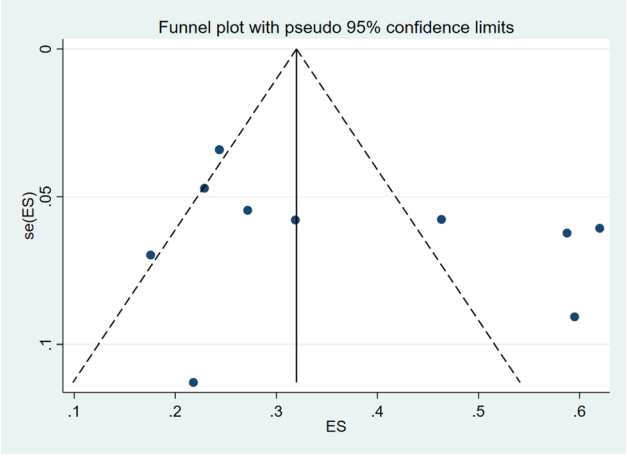

Fig. 3 A funnel chart of the prevalence of agoraphobia

$P < 0.0001$. At the same time, we conducted Egger's test, and the results showed that P was greater than 0.05, which indicated that there was no publication bias in our study results.

Publication bias analysis

We used Stata17.0 to analyze the publication bias of outcome indicators with more than 10 included literatures, and the funnel plot showed basic symmetry (Fig. 3). Egger's test ($P = 0.142$, > 0.05) indicated that there was no significant publication bias (Fig. 4). Sensitivity analysis was performed on all outcome indicators, and the results showed that the meta-analysis results of this study were stable.

Sensitivity analysis

Age

The sensitivity analysis for Age (Fig. 5) shows that the robustness of the original combined effect size (0.98) is highly dependent on the studies by Lei and Yan. The exclusion of Lei's study led to a reversal of the effect direction, which may be related to its sample characteristics, methodological differences, or potential biases. The exclusion of Yan's study significantly reduced the effect strength, suggesting that it had a strong supporting role for the positive results. Although other studies (such as He and Zhu) showed lower sensitivity to the results, the overall analysis indicates that the current conclusion should be interpreted with caution. Future research should further verify the quality of Lei and Yan's studies and explore potential sources of heterogeneity (such as population differences, interventions, etc.).

Total social support score

The sensitivity analysis (Fig. 6) indicates that the combined effect size of social support (1.31) is highly dependent on the studies by Lei and Xin. The exclusion of Lei's study led to a reversal of the effect direction, which may be related to its unique research design (such as differences in the social support measurement tool) or sample characteristics (such as high-risk groups). The exclusion of Xin's study significantly reduced the effect strength,

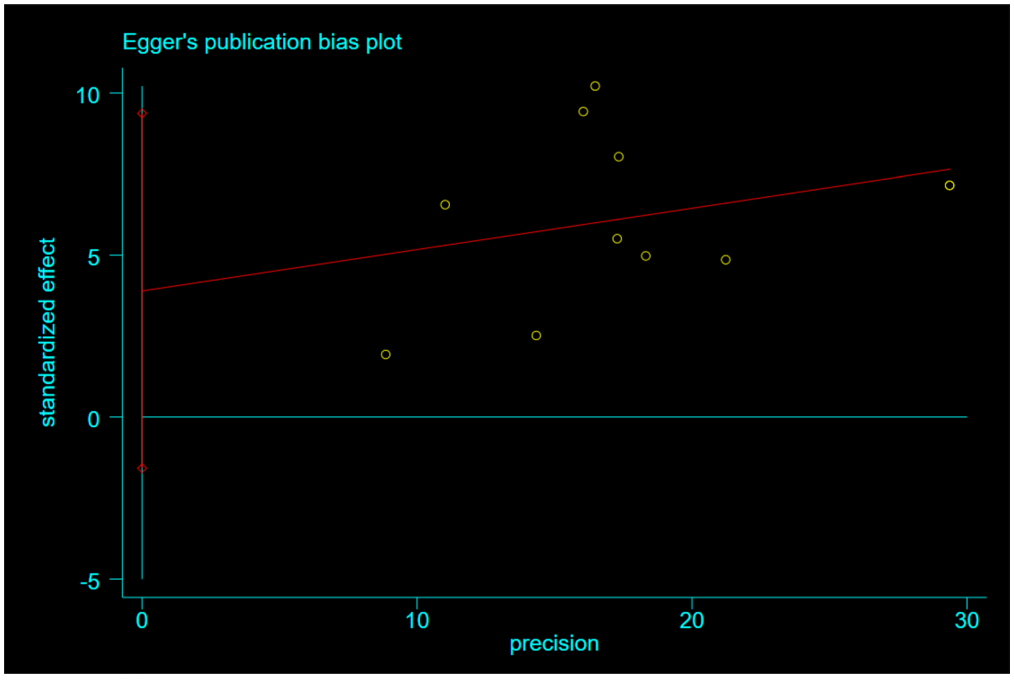

Fig. 4 Eggers' test

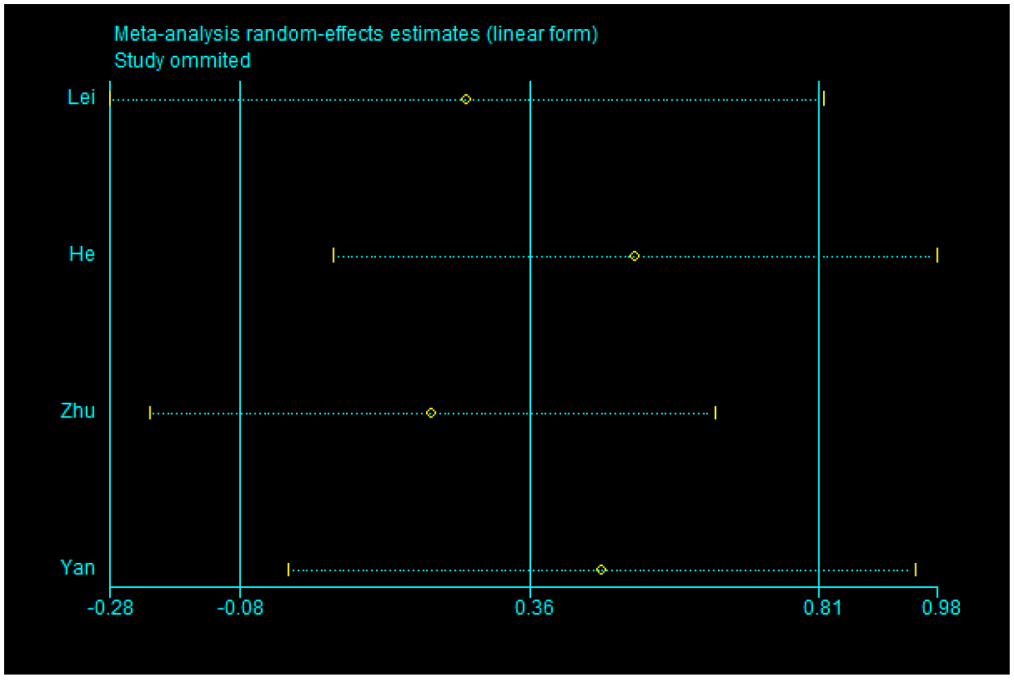

Fig. 5 Sensitivity Analysis of Age

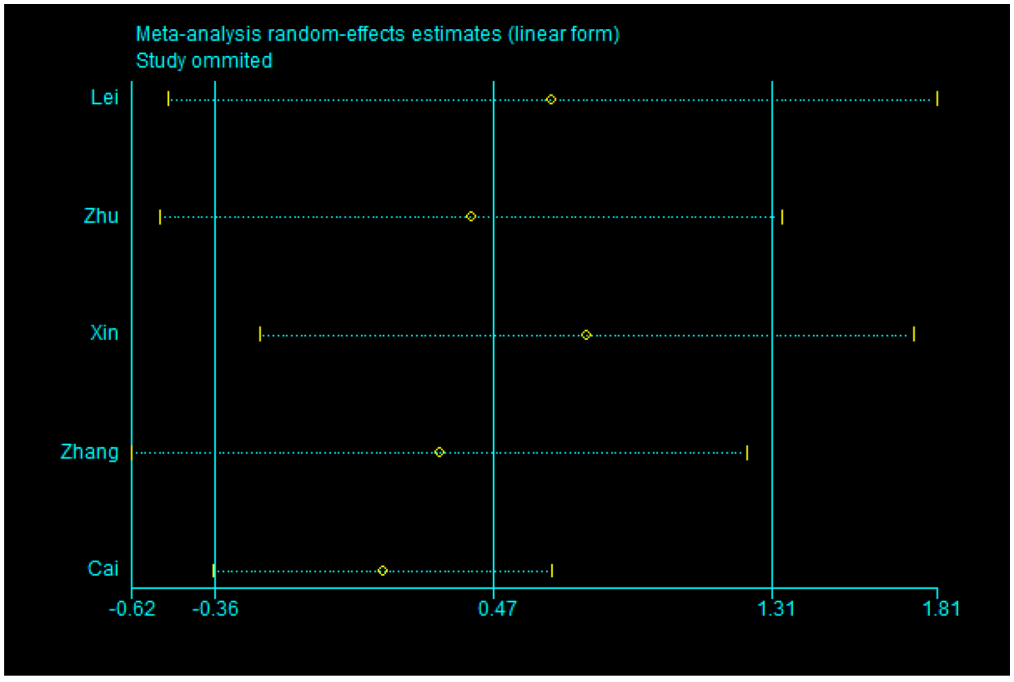

Fig. 6 Sensitivity Analysis of Total Social Support Score

suggesting its supportive role in the positive results. It is worth noting that the exclusion of the studies by Zhang and Cai did not cause any changes, and their data independence or methodological consistency should be verified. The results of this study suggest that although the overall effect of social support is significant, its robustness is greatly influenced by a small number of studies. Future research should focus on verifying the potential biases in the studies by Lei and Xin (such as selection bias) and explore sources of heterogeneity through subgroup analyses (such as cultural background and differences in types of support). Additionally, it is recommended to use regression models to control for

confounding variables in order to enhance the reliability of the conclusions.

Pain factors

The sensitivity analysis (Fig. 7) shows that the combined effect size of pain factors (1.31) is mainly influenced by the studies by Lei and Cai. The exclusion of Lei's study led to a significant decrease in the effect size, which may be related to its sample characteristics (such as differences in pain assessment methods) or the specificity of the intervention. The exclusion of Cai's study also significantly reduced the effect strength, requiring verification of its data quality or potential biases. It is worth noting that the exclusion of Zhang's study did not cause any changes, and its data independence or overlap with other studies should be verified.

Education level

The sensitivity analysis (Fig. 8) shows that the combined effect size of education level (1.74) is highly dependent on the studies by Cal and Xin. The exclusion of Cal's study led to a complete reversal of the effect direction, which may be related to its unique research design (such as differences in the measurement tool for education level) or sample characteristics (such as the low education level group). The exclusion of Xin's study significantly reduced the effect strength, suggesting its support for the positive results. It is worth noting that the research names and effect size numbers in the data do not fully match (for example, only three studies are listed but four groups of values are included), requiring verification to check if any studies are unmarked or if there are input errors (such as whether "90" in "-3.02 90" is redundant information).

Negative coping

The sensitivity analysis (Fig. 9) shows that the combined effect size of negative coping (0.75) is primarily influenced by the studies by Lei and Zhu: the exclusion of Lei's study led to a sharp decrease in the effect size, which may be related to its sample characteristics (such as a high baseline level of negative coping) or differences in the measurement tool. The exclusion of Zhu's study further weakened the effect strength, requiring a review of its data quality or potential methodological biases. The sensitivity of Cai's study is low, but its exclusion still results in a significantly lower effect size than the original value, suggesting that further analysis based on the specific research design is needed.

Self-Efficacy

The sensitivity analysis (Fig. 10) indicates that the combined effect size of self-efficacy (0.20) is highly dependent on the studies by Lei and He: the exclusion of Lei's study reversed the effect direction, which may be related to sample characteristics (such as low baseline self-efficacy) or the specificity of the intervention. The exclusion of He's study significantly weakened the negative effect, requiring verification of its methodological consistency

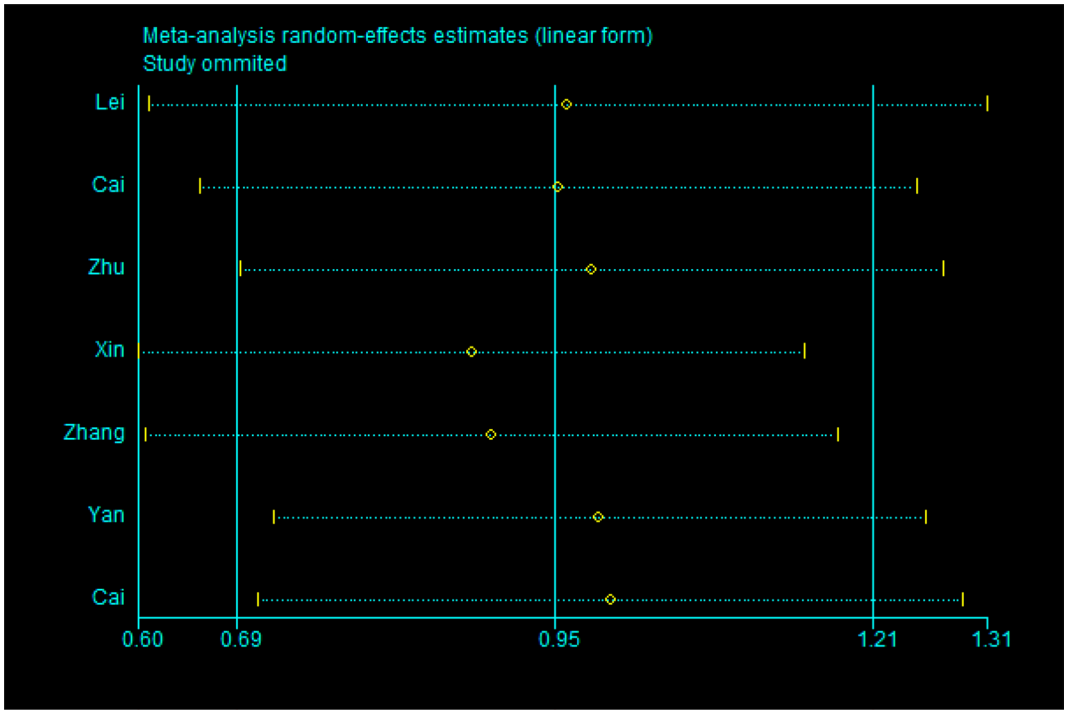

Fig. 7 Sensitivity Analysis of Pain Factors

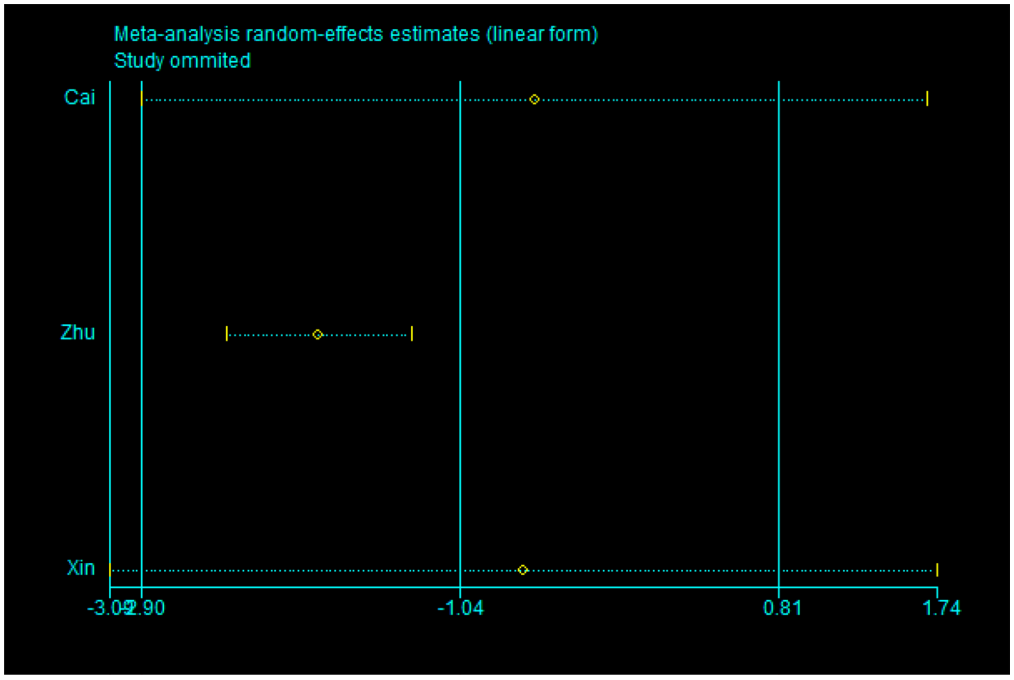

Fig. 8 Sensitivity Analysis of Education Level

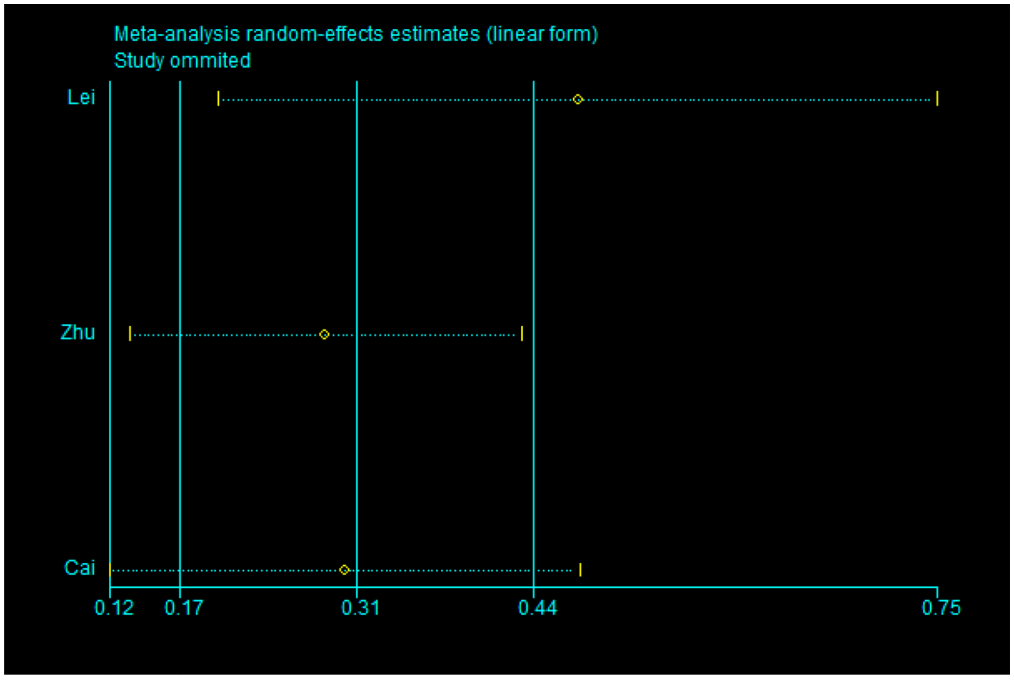

Fig. 9 Sensitivity Analysis of Negative Coping

(such as the self-efficacy measurement tool). The exclusion of Cai's study (first labeled) partially alleviated the negative effect, but the exclusion of its repeated labeled study did not cause any changes, suggesting that the data may contain redundancy or labeling errors.

Discussion

This is the first study to conduct a meta-analysis of kinesiophobia after TKA and its influencing factors. Our study shows that there are differences in prevalence among different populations, while being affected by different influencing factors. The main influencing factors are as follows: (1) Age: with the increase of age, the

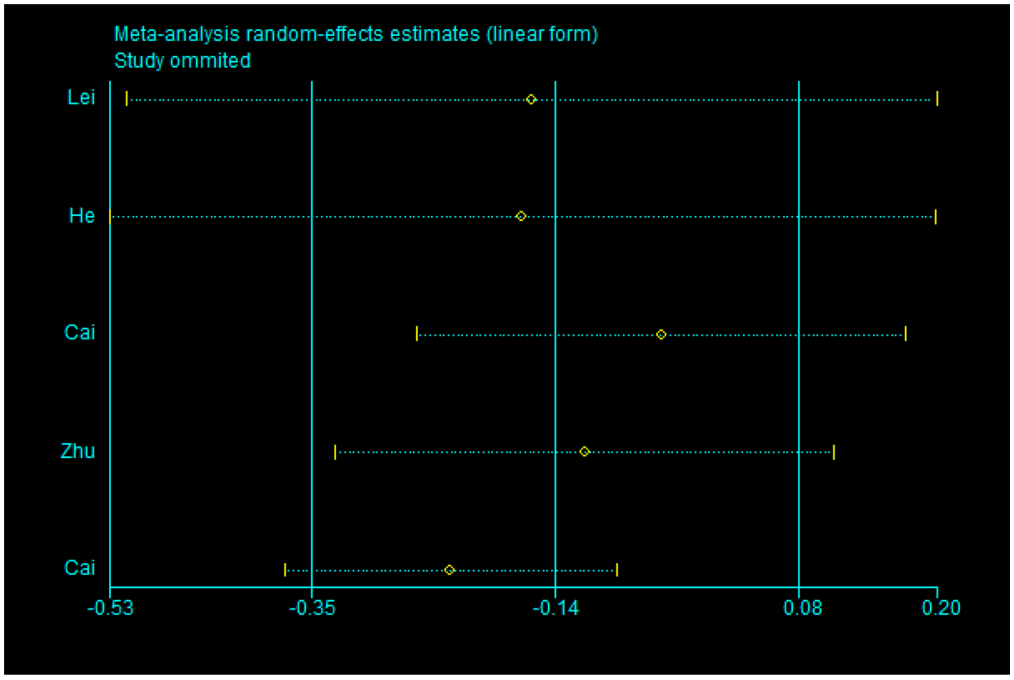

Fig. 10 Sensitivity Analysis of Self-Efficacy

physical physiological function of patients will gradually decline, and elderly patients have limitations in cognitive function and mental state, which may lead to insecurity or fear of injury, which may be the reason for the higher prevalence of kinesiophobia in elderly patients over 65 years old after TKA [21]. (2) Pain: surgical trauma can cause moderate to severe pain for several days or even weeks. Postoperative pain-related fear will stimulate the escape mechanism of patients. Strengthen the pain management of TKA patients, evaluate the pain intensity of different patients, select and adjust the analgesic management plan of different pain levels, and promote patients to carry out active functional exercise [22, 23]. (3) Place of residence: there may be some differences in the cognitive level of disease among people in different places of residence, which may be the reason for the slightly higher prevalence of kinesiophobia after TKA in urban residents. (4) Education level: TKA patients with low education level have poor pain acceptance and knowledge understanding ability, difficulty in acquiring medical rehabilitation knowledge, and will not treat postoperative pain rationally. In addition, patients with low education level will have wrong cognition of rehabilitation. Patients generally believe that bed rest will recover better, and exercise will increase postoperative injury, so they will not take the initiative and dare not exercise [24]. (5) Income level: patients spend a lot of money during hospitalization, and patients worry about the medical expenses required for rehabilitation after surgery, which aggravates the family burden [25]. Patients have less discretionary rehabilitation exercise time and knowledge of the disease, so they lack necessary rehabilitation support. (6) Social support: when family members encounter problems, families with high social support will have a harmonious family atmosphere and good family function [26], which will promote family members to share responsibilities, provide patients with comfort such as care, respect and support from the family, and enhance patients' confidence in disease treatment and rehabilitation exercise [27]. (7) Self-efficacy: TKA patients have more difficulty admitting the fact of postoperative limb pain, lack confidence in coping, and use more negative coping strategies to cope with postoperative rehabilitation. In addition, patients have low confidence in participating in postoperative rehabilitation programs and coping with possible pain, which leads to the occurrence of kinesiophobia. During rehabilitation guidance, family members should give patients spiritual and emotional support, help patients to seek adequate support resources, and mobilize positive coping behaviors to improve exercise enthusiasm [28]. (8) Negative Coping: There is a close correlation between negative coping style and the occurrence of kinesiophobia [29]. The analysis is that patients do not reduce pressure and adopt negative coping strategies. When negative coping is adopted, patients will show negative thoughts about pain, distraction and social withdrawal, which will affect physical and psychological functions in the long term and further promote the occurrence of kinesiophobia [30]. Therefore, in clinical work, we should accurately identify high-risk groups

and establish personalized and accurate early intervention programs to reduce the probability of kinesiophobia in patients after TKA, so as to improve the prognosis of patients.

This study also has some limitations, such as: (1) There are few articles in Chinese and English, and the outcomes may have certain bias; (2) The literatures included in this study were mainly cross-sectional studies, and there was a lack of a certain number of case-control studies. (3) The literature included in this study is relatively new, indicating that the research on the prevalence and influencing factors of kinesiophobia after TKA is still in the development stage, so the interpretation of the results should be cautious; Therefore, the meta-integration of sexual research and qualitative research is needed in the future to obtain more comprehensive and scientific research results.

Based on the results of the sensitivity analysis, this study reveals the key factors affecting the occurrence of postoperative kinesiophobia and delves into the stability of its data. The sensitivity analysis primarily examined the impact of different variables, such as age, social support, pain, self-efficacy, and others, on the outcomes. Below is the discussion of the sensitivity analysis results.

In the sensitivity analysis for age, we found significant heterogeneity across different studies, especially those from Lei and Yan. The exclusion of Lei's study resulted in a reversal of the effect direction, which may be related to differences in sample characteristics or methodology. Further validation of the quality of these studies and the potential biases is crucial to understand their impact on the results. Yan's study had a strong supporting effect on the results, and its exclusion significantly weakened the effect size, indicating its potential contribution in the research design. Therefore, although our results suggest that older age is a risk factor for kinesiophobia, this conclusion should be interpreted with caution. Future studies should explore these potential sources of heterogeneity in greater depth, such as intervention methods, patient cultural background, and demographic differences.Social support, as a key psychosocial factor influencing kinesiophobia, showed that Lei and Xin's studies had a considerable impact on the stability of the overall effect in the sensitivity analysis. After excluding Lei's study, the effect direction significantly changed, indicating that its unique research design (such as the different measurement tools for social support) or sample characteristics might be the primary factors influencing the results. Furthermore, the exclusion of Xin's study notably weakened the effect strength, suggesting that its research design and intervention strategy might have had a potential contribution in this field. However, other studies, such as those by Zhang and Cai, did not significantly affect the results, suggesting their stronger independence. Therefore, future studies should further focus on the measurement tools for social support, sample selection, and cultural background to explore their impact on the results, particularly through more detailed analyses of low-income and high-risk populations.

Pain is one of the important physiological factors in kinesiophobia. Sensitivity analysis showed that Lei and Cai's studies had a considerable influence on the relationship between pain and kinesiophobia, with the exclusion of Lei's study leading to a significant decrease in effect size. This may be due to differences in pain assessment methods or the specific characteristics of the sample. The exclusion of Cai's study also significantly weakened the effect strength, suggesting that data quality or potential bias in its study might have affected the overall effect estimate. However, the exclusion of Zhang's study did not result in significant changes, indicating that its research design may be more robust. The role of pain in kinesiophobia should be further verified through standardized pain assessment tools and more refined subgroup analyses, especially regarding early postoperative pain interventions. The sensitivity analysis of education level revealed a significant impact from Cal and Xin's studies. In particular, the exclusion of Cal's study resulted in a complete reversal of the effect direction, which might be due to differences in the measurement tools for education level or the influence of specific groups in the sample. After excluding Xin's study, the effect size significantly weakened, suggesting its supporting role in the data. Therefore, as an important socio-demographic factor, the relationship between education level and kinesiophobia may be influenced by different cultural backgrounds, intervention methods, and measurement tools. To further understand the impact of education level on kinesiophobia, future studies should consider using more consistent classifications of education level and validate the findings in multi-center, multi-cultural studies. The relationship between negative coping styles and kinesiophobia showed high sensitivity in this study, especially with Lei and Zhu's studies contributing significantly to the overall effect. After excluding Lei's study, the effect size significantly weakened, which may be related to its sample characteristics (such as a group with higher levels of negative coping) or differences in measurement tools. Zhu's study also had a significant impact on the results, suggesting that the unique research design and methodology may have played a key role in interpreting the impact of negative coping on kinesiophobia. Therefore, negative coping, as an important psychological factor in kinesiophobia, is closely related to the patient's emotions, cognition, and psychosocial support, and future research should further explore the moderating effect of different psychological interventions on negative coping styles.

The results of the sensitivity analysis suggest that, although our main conclusion points to the influence of multiple factors such as age, education level, pain, self-efficacy, social support, and negative coping on postoperative kinesiophobia, the data heterogeneity indicates that these conclusions should be interpreted with caution. Future studies should pay more attention to potential differences in interventions, cultural backgrounds, measurement tool choices, and other factors in order to provide solid evidence for the development of more personalized intervention plans.

Conclusion

Meta-analysis showed that old age, low education level, low income, postoperative pain, low self-efficacy, low social support, and negative coping style were all risk factors for kinesiophobia after TKA. Therefore, in clinical practice, medical staff should focus on the early screening of these factors and carry out personalized intervention as soon as possible to improve the prognosis of patients.

Abbreviations

TKA	Total knee arthroplasty
OR	Odds ratio
MD	Mean difference
CI	Confidence interval
FE	Fixed effect model
RE	Randomized effect model

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Author contributions
X.D. and J.K. were responsible for the study design and development of the search strategy. X.D., Y.S., and J.X. conducted the literature search, screening, and data extraction. J.K. and Y.S. independently evaluated the quality of the included studies. X.D. performed the statistical analysis. X.D. and Y.S. wrote the main manuscript text. J.X. prepared the figures and tables. All authors participated in the interpretation of the results, reviewed and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

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Not applicable.

Consent for publication
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