BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

BMJ Open

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-083909
Article Type:	Original research
Date Submitted by the Author:	02-Jan-2024
Complete List of Authors:	Xing, Wenhui; The Sixth Medical Centre of PLA General Hospital; Hebei University of Chinese Medicine Piao, jing; Kobe University Graduate School of Health Sciences Ren, Tong; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Liang, Yujing; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Li, Qi; Hebei University of Chinese Medicine Gu, Yanmei; Hebei University of Chinese Medicine Wang, Rong; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery
Keywords:	Coronary heart disease < CARDIOLOGY, Cross-Sectional Studies, MENTAL HEALTH, Nursing Care

SCHOLARONE™
Manuscripts

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Authors

Wenhui Xing[1,2$], Jingjing Piao [3 $], Tong Ren[1], Yujing Liang[1], Qi Li [2], Yanmei Gu[2*], Rong Wang[1*]

Affiliations

[1]Department of Cardiovascular Surgery, The Sixth Medical Centre of PLA General Hospital, Beijing, CHN

[2] Faculty of Nursing, Hebei University of Chinese Medicine, Shijiazhuang, CHN

[3] Department of Rehabilitation Science, Kobe University Graduate School of Health Sciences, Kobe, JP

Corresponding author

*Rong Wang, The Sixth Medical Centre of PLA General Hospital, 3 Fucheng Road, Haidian District, Beijing, China

Email: wangrongd@126.com

Telephone: +86-010-66951518

Keywords Kinesiophobia; latent profile analysis; cardiac surgery; extracorporeal circulation; logistic regression

Number of words 3553

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

ABSTRACT

Objective: To investigate the potential classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation from a psychosocial perspective, and analyze the characteristic differences among different latent levels of patients.

Study design: This is a cross-sectional study of Chinese adults after cardiac surgery under extracorporeal circulation, aged over 18 years and older, recruited from a tertiary hospital in North China.

Methods: This study utilizes Latent Profile Analysis to identify potential classifications of kinesiophobia in questionnaires from 348 patients undergoing cardiac surgery under extracorporeal circulation. Multiple logistic analysis was used to evaluate the influencing factors at different latent classifications.

Results: The average performance of each indicator in Model 3 is best suited for analysis, Entroy=0.873 and BLRT(P) < 0.0001.The result of regression equation shows postoperative time (P<0.001), age, self-efficacy, pain, and social support level (P< 0.05) were the factors influencing the potential profile classification of patients after cardiac surgery under extracorporeal circulation.

Conclusion: The study identified three distinct classifications of patients: LMG, MK-HRPSG, and HK-HEAG. Addressing kinesiophobia, especially in older male patients during the early postoperative period, is

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

crucial. Enhancing self-efficacy seems effective in reducing kinesiophobia, while increasing social support may not be as beneficial for the HK-HEAG group. These findings provide a basis for implementing preventive interventions in cardiac rehabilitation.

Trial registration number: Chinese Clinical Trial Registry (ChiCTR2200057895).

Keywords: Kinesiophobia; latent profile analysis; cardiac surgery; extracorporeal circulation; logistic regression

STRENGTHS AND LIMITATIONS OF THIS STUDY

1、 It is a comprehensive investigation conducted in China, specifically examining the factors that potentially influence the level of kinesiophobia in patients who have undergone cardiac surgery with extracorporeal circulation.

2、 This study indicatively uses LPA to classify kinesiophobia of patients after cardiac surgery under extracorporeal circulation.

3、 The limitation of the current research is that the data are cross-sectional and self-reported.

4、 The adaptability of this model is limited to Chinese background.

INTRODUCTION

Kinesiophobia is defined as an irrational and excessive fear of carrying out a physical movement. [1] Previous studies have reported that psychological factors, such as kinesiophobia, are a significant barrier to

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

patient participation in cardiac rehabilitation (CR). [2-6] In the context of cardiac disease, it is mostly described as a fear of physical activity due to the apprehension of worsening cardiac disease or the possibility of inducing adverse outcomes. Kinesiophobia was detected in 65% of individuals with chronic heart failure and in 86.26% of patients with a first-time acute myocardial infarction. [7,8] According to a previous study, high levels of kinesiophobia can negatively impact not only the performance of daily activities but also CR engagement. [9]

Research has shown that kinesiophobia has an influence and intermediate role on attendance at CR. [1]As a mediator, kinesiophobia is influenced by predictive factors and has indirect effects. General health and muscle endurance increased the probability of attendance at CR, while self-rated anxiety had the opposite effect. There have been studies exploring whether there are positive changes in kinesiophobia based on CR, with higher levels of aerobic capacity and lower levels of physical activity compared to patients with low levels of kinesiophobia. Results showed a significant reduction in kinesiophobia after a exercise-based CR program. [10] CR is an important step in the recovery process after cardiac surgery. CR is a comprehensive strategy that is aimed at improving a person's physical, psychological, and social functioning. [11-13] Studies have shown that exercise-based CR can not only reduce mortality and hospital admissions for cardiovascular disease but also improve quality of life and

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

mental well-being. [12,14,15] CR's effectiveness and importance are recommended as level IA by most international cardiovascular societies. [16-18]

Kinesiophobia is a psychological disorder, we should pay more attention to those subjective factors that are self-influenced and in constant change. In a potential profile analysis of kinesiophobia in patients with coronary heart disease, [19]objective demographic information was included in the analysis, and the results showed that patients could be divided into three potential types: 'low fear type', 'intermediate fear type' and 'high fear type'. However, among the influencing factors of kinesiophobia, objective factors cannot be interfered with by medical staff. In addition, research supports that kinesiophobia is positively correlated with age , [19] but the explanation for these potential differences in age has not been studied. From the perspective of social psychology, the research results of Xiuting [20] showed that it was important to alleviate kinesiophobia for patients with low subjective social status, but the mechanism of how social support produced positive effects in different kinesiophobia classifications has not been clarified. Clinical professionals should collect objective influence factors as predictive factors, focusing on targeted interventions based on the patient's own subjective factors.

Few studies have investigated the effects of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. The number of

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

cardiac surgeries has increased tremendously in recent years. In China, cardiac surgery volume increased by 8% in 2020 compared to 2012. [21]In addition, the factors of kinesiophobia are complex and highly heterogeneous. From the social psychology perspective, the classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation has not been well characterized. Previous studies[22,23]mainly evaluated patients' kinesiophobia classification from the total score of the scale, which may have the same total score but the score of each item varies greatly. This study fills that gap. Latent profile analysis (LPA) is an "individual-centric" statistical analysis method that can homogenize sequential data, explore the characteristics of groups without categories and ethnic differences in groups, and then analyze their respective influence factors in different subgroups. [24] This study is based on the LPA method to study patients after surgery, examine their subgroup of kinesiophobia characteristics, and conduct an influence factor analysis to provide a basis for clinically formulating targeted post-heart surgery patient exercise interventions.

MATERIALS AND METHODS

Study design

In this cross-sectional study, subgroups of kinesiophobia characteristics and associated factors in patients after heart surgery were investigated. All participants were recruited from a tertiary hospital in

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

North China and completed the questionnaire from April 2022 to April 2023.

Ethical approval

The ethics committees granted ethical permission for this investigation（HZKY-PJ-2022-2）. Participants first read the form for informed consent and selected "I agree" if they chose to participate in the study. They were informed that the responses would remain anonymous and that no personal information would be disclosed. The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Participants

Participants who met the inclusion criteria were provided with information about the study prior to inclusion, consent and willingness to engage in this study after being fully informed of its objectives.

Meet the following inclusion and exclusion criteria:

Inclusion criteria

(a) Advised by the doctor to participate in CR.

(b) Patients who underwent cardiac surgery under extracorporeal circulation（e.g. Coronary artery bypass grafting and cardiac valve replacement）three months prior to the survey

(c) Adults aged 18-75 years

(d) Conscious, mentally and psychologically competent, and able to complete the questionnaire;

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Exclusion criteria

(a)With a contraindication to CR (e.g. uncontrollable or unstable angina, severe arrhythmias, etc.);

(b) Refusal to provide personal information to participate in the questionnaire.

(c) Recently, severe family events (e.g. malignancy); psychological instability; people who actively express depressive anxiety tendencies and are suspicious of mild cognitive impairment.

Study tools

Sociodemographic questionnaire

Sociodemographic data were collected, including gender, age, education level, marital status, vocational type, average monthly household income, current residence, smoking status, alcohol consumption, surgical operation approach, and postoperative time.

Tampa Scale for Kinesiophobia Heart (TSK-SV Heart)

The Chinese version of the TSK-SV Heart was used to assess the kinesiophobia levels of patients. [25]This scale consists of 17 items that assess danger, fear, avoidance, and dysfunction. The questions were evaluated using a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). A score of 37 or higher indicates a high level of kinesiophobia. [9,26]

Cardiac Exercise Self-efficacy Instrument (CESEI)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

The CESEI was developed by Hickey et al. to measure exercise self-efficacy in CR patients. [27] In 2021, a Chinese version of CESEI was developed through translation, back translation, and cultural adjustment. [28] The Chinese version of the CESEI includes 16 items corresponding to one dimension, which are scored on a scale of 1-5. The total score is determined by the sum of the item scores. The higher the score, the higher the patient's self-efficacy in CR. The Cronbach's alpha for the Chinese version of the CESEI is 0.941.

Social Support Rating Scale (SSRS)

The SSRS was used to examine the levels of social support among the participants. [29]The SSRS comprises 10 items divided into three categories: objective support, subjective support, and social support use. Low, medium, and high levels of social support are represented by total scores of 0–22, 23–44, and 45–66, respectively. The Cronbach's alpha of the scale is 0.81.

Multidimensional Fatigue Inventory (MFI-20)

The MFI-20 was used to determine participants' fatigue levels. [30] General weariness, physical fatigue, reduced activity, diminished motivation, and mental fatigue are the five categories of the MFI-20. Responses were given using a five-point Likert scale ranging from 1 (yes, this is true) to 5 (no, this is not true). This scale has a Cronbach's alpha of 0.882, and it is regularly used to assess patient weariness with good

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

reliability.

Hospital Anxiety and Depression Scale (HADS)

The HADS was used to determine the level of anxiety and depression in participants. [31] The HADS comprises 14 items with four possible answers ranging from 0 to 4, as well as two subscales, anxiety and depression. The HADS score indicates the severity of anxiety or depression. The higher the HADS score, the more severe the anxiety or sadness. This scale has been tested in a variety of countries.

Numerical Rating Scale (NRS)

The NRS is accurate, concise, and more feasible. It was once considered the gold standard for pain assessment by the American Pain Society. [32] Patients are asked to select a single number representing the intensity of their pain on a scale of 1-11 (0=no pain, 10=worst pain). A score of 7-8 is classified as severe pain, indicating that the pain is intense.

STATISTICAL ANALYSIS

The statistical analysis was conducted using SPSS 22.0 software. For normally distributed quantitative data, descriptive statistics were presented as mean ± standard deviation (x ± s), and group comparisons were performed using differential analysis. Qualitative data were described using frequencies and percentages, and group comparisons were performed using the $\chi 2$ test. To establish a latent profile analysis model, Mplus 8.3 software was utilized. The TSK-SV heart score of patients after heart

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

surgery was used as the model's observed variable. The initial model category was set to 1, and the number of model level was gradually increased. Model fit was assessed using various criteria, including the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Sample-Size-Adjusted BIC (aBIC), Entropy Index, Lo-Mendell Rubin Likelihood Ratio Test (LMR), and Bootstrap Likelihood Ratio Test (BLRT). Smaller values of AIC, BIC, and aBIC indicate better model fit. A higher entropy value closer to 1 suggests a higher probability of accurate individual classification. LMR and BLRT were used to compare the fit of k individual models to k-1 models. Based on the results of the latent profile analysis of kinesiophobia, a multinomial logistic regression analysis was performed to explore the factors influencing the latent profile classification of patients' kinesiophobia after heart surgery. The statistical tests were two-tailed, and a difference of $P < 0.05$ was considered statistically significant.

RESULTS

Convenience sampling was employed with 412 participants underwent cardiac surgery under extracorporeal circulation enrolled. Forty-two participants were excluded according to the inclusion and exclusion criteria with 370 eligible participants left. Eighteen questionnaires had more than five blanks or missed important information, while another four questionnaires had same answer choice for more than five consecutive questions. All the above 22 questionnaires had been excluded. Finally, 348

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

questionnaires left for analysis (Figure 1).

(insert figure 1. Flow diagram of participants)

Demographic characteristics of the participants

In the current study, 248 males (71.26%) and 100 females (28.74%) aged 18-45 years (18.97%), 46-65 years (40.80%), 66-75 years (40.23%) participants were included. 252 participants (72.41%) underwent conventional approach while 101 participants (27.58%) used sternum sparing approach. 95 participants (27.29%) were at 3-6 months postoperative, 132 participants (37.93%) at 7-12 months, 90 patients (25.86%) at 13-18 months, and 31 patients (8.90%) at 19-24 months.

Latent profile analysis of the participants' kinesiophobia scores

Latent profile analysis was conducted to identify the heterogeneity of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. Four models were initially constructed based on model fit indicators AIC, BIC, aBIC, entropy, LMR and BLRT. As the classification number increasing (**Table 1**), the AIC, BIC, and aBIC values gradually decreased and reached a minimum in Model 4 with LMR value 0.131(>0.05) while the matching indicators in Model 3 all fit well (<0.05). Furthermore, there was no cross in the three level as shown in **Figure 2**. Therefore, Model 3 of kinesiophobia after heart surgery was accepted in the current study.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Table 1 Model fitting indexes of all potential classification of kinesiophobia after cardiac surgery under extracorporeal circulation

Number of Class	AIC	BIC	aBIC	LMR(P)	BLRT(P)	Entroy	Sample proportion (%) per Class
1	17674.014	17810.812	17702.922	—	—	—	—
2	16629.692	16838.911	16673.903	**0.000**	0.000	**0.814**	0.576/0.423
3	16442.350	16723.991	16501.865	**0.031**	0.000	**0.873**	0.206/0.426/0.368
4	16294.501	16648.565	16369.321	**0.131**	0.000	**0.888**	0.177/0.373/0.419/0.031

(insert figure 2. Latent profile analysis classification)

In Model 3 the different groups were named as the low kinesiophobia group (LKG), the moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG) and high kinesiophobia - high exercise avoidance group (HK-HEAG). The LKG (72/348, 20.6%) had low scores in all items. TSK-SV Heart scored（34.08±4.12）.The MK-HRPSG (148/348, 42.6%) had moderate scores on all items. TSK-SV Heart scored（48.91±7.07）. The HK-HEAG (128/348, 36. 8%) had high scores in all items. TSK-SV Heart scored（51.81±6.07）.

One-way analysis of variance of different potential classification impact factors

There were differences in different potential classifications of kinesiophobia in participants, and there were statistically significant differences in the degree distribution of age, postoperative time, pain, social support and self-efficacy ($p< 0.05$) (showed in Table 2).

(insert Table 2. Single-factor analysis of potential classification impact factors)

Multiple logistic regression analysis of potential classification factors

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Taken LKG as a reference to conduct disordered multi-classification logistic regression analysis, the classifications of kinesiophobia were taken as dependent variable, with significant variables in the above analysis as independent variables and covariables. The results showed that age, postoperative time, self-efficacy, pain and social support were factors influencing the potential classification of kinesiophobia (p<0.05), as shown in Table 3.

Table 3 Multiple Logistic regression analysis of potential classification factors

Factor		MK-HRPSG				HK-HEAG			
		B	Standard error	Wald χ^2	p	B	Standard error	Wald χ^2	p
constant term		-17.143	2.849	36.204	＜0.001	-32.808	3.609	82.651	＜0.001
Age	18-45	0.080	0.638	0.016	0.900	-1.126	0.712	2.502	0.114
	46-65	-0.902	0.593	2.317	0.128	-1.796	0.661	7.185	**0.007**
	66-75	1.186	0.866	1.798	0.174	1.667	0.613	6.211	**0.013**
Postoperative time (Months)	3-6	-1.900	0.743	6.530	**0.011**	-3.105	0.899	11.928	**0.001**
	7-12	-0.761	0.726	1.099	0.295	-0.842	0.839	1.007	0.316
	13-18	-0.304	0.696	0.191	0.622	-1.699	0.830	4.186	0.401
	19-24	-0.783	0.519	2.235	0.127	-1.865	0.626	8.487	0.102
Self-efficacy		0.122	0.035	12.344	**＜0.001**	0.357	0.048	55.383	**＜0.001**
Pain		0.920	0.201	10.596	**＜0.001**	1.367	0.220	38.548	**＜0.001**
Social support		0.186	0.029	41.493	**＜0.001**	0.021	0.030	0.489	0.484

DISCUSSION

Characteristics of participants

The data for this study were collected from a tertiary hospital in the

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

country with ample volume of cardiac surgeries In this study, there was a higher proportion of male participants compared to female participants (male: female=2.48:1), which aligns with findings from previous studies. [33-36] It is noteworthy that female participants constitute no more than 30% of the study population in research trials. [35-37]

There are several factors contributing to this gender disparity. Firstly, mortality rates and risk for the most prevalent cardiovascular diseases consistently tend to be higher among men than women; [38] Moreover, women face disparities in wealth, income, and access to resources, which can hinder their timely access to medical care. A study revealed that women with low incomes, low levels of education, and residing in deprived areas are more likely to delay seeking medical attention. [39] Lastly, a lack of awareness among women about the importance of coronary heart disease (CHD) and emergency care contributes to delays in seeking medical attention. [40] A report from the European Heart Survey found that women aged 60 and above were less likely to undergo CABG compared to men, whereas they were more likely to receive PCI, adding to the gender differences in surgical treatment. [41]

Analysis of a 3- classification model of kinesiophobia score

Among the models tested, Model 3 exhibited significant characteristics. As our results indicate, Model 4 had the best-fitting AIC, BIC, and Entroy values. Model 4 allows variances and covariances to

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

be freely estimated and varied across profiles. However, this improvement in fit came at the expense of differences when compared to other models. Model 4 had a lower LMR value (0.131) in particular. Ultimately, we selected Model 3 due to its relatively low AIC and BIC values, along with a high entropy value of 0.873, suggesting accurate classification of participants into the appropriate profile. Furthermore, the LMR and BLRT values in Model 3 were low (0.05 and 0.01), indicating good model fit.

The researchers established a score of 37 as the threshold for determining the presence of kinesiophobia. [42] A score of 37 or higher indicates a high level of kinesiophobia. [22] Notably, participants in the LKG group in Model 3 obtained a mean score of (34.08±4.12), indicating a lower degree of kinesiophobia. This finding aligns with previous studies. [22,43] The MK-HRPS in Model 3 scored lower on items 8 (2.00±0.73) and 16 (1.90±0.75), compared with an average item score of 2.33. These items belong to the risk perception dimension. The results suggest that participants in the MK-HRPS group exhibit a heightened perception of risk, which may result in decreased adherence to recommended treatments. [44] In contrast, participants in the HK-HEAG group in Model 3 obtained higher scores on item 2 (3.43±0.55) and lower scores on item 4 (2.86±0.84), compared to the average item score of 3.03. These particular items are indicative of exercise avoidance tendencies. Consequently, participants in the HK-HEAG group in Model 3 may

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

demonstrate greater resistance to and avoidance of physical activity when advised by their doctors regarding exercise prescriptions. [45]

Based on the presented results, Model 3 effectively minimize individual heterogeneity by considering latent traits, resulting in the identification of distinct subgroups. The results of this study showed potential classifications of kinesiophobia, which were mainly affected by age, postoperative time, self-efficacy, pain, and social support.

Factors affecting classification

We observed that age under 45 did not play a role in influencing the classification of kinesiophobia. In this study, age was analyzed categorically as a rank variable, which differed from previous studies that treated age as a continuous variable.[19] Remarkably, our findings emphasized the significance of age above 45, specifically indicating that patients aged over 45 were more likely to exhibit tendencies towards HK-HEAG. These results align with existing research showing higher levels of kinesiophobia among older adults, [46]which is consistent with our research. The increased kinesiophobia with aging can be attributed to factors such as physical frailty, which not only leads to a decrease in energy but also heightens the fear of injury and falling. In addition, it is difficult for the elderly to acquire scientific knowledge about kinesiophobia, [47]which further aggravates exercise avoidance. However, Gunn et al. [48] reported an adverse association between age and kinesiophobia among

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

adults, suggesting that older individuals may have more available time and exercise experience, which reduces their anxiety towards potentially harmful activities. It is important to note that generalizing findings based on age is not appropriate, as age under 45 did not prove to be a significant factor in our study. Future studies should focus on exploring the kinesiophobia classification in older adults.

There is a time effect of kinesiophobia in the postoperative period. Our study discovered that the period between 3 to 6 months after surgery is a critical time frame for kinesiophobia concerns. The level of kinesophobia decreased with the increase in postoperative time, [49,50] and postoperative time was not a factor affecting the classification of kinesophobia after 6 months. The longer the postoperative period, the less likely they were to be classified as HK-HEAG. This finding aligns with previous studies conducted on patients following an acute coronary artery disease event, which reported that kinesiophobia scores were highest (32.5) at baseline, decreasing to 30.9 after two weeks and 30.1 after four months, suggesting a decline in kinesiophobia over time. [51] This trend may be due to the gradual recovery of exercise capacity and cardiac function over time, as patients can gradually tolerate increased exercise and feel the benefits of participating in it. Early postoperative activity has been shown to improve functional recovery time , [52]especially through early postoperative activities on the floor. Clinical staff should help patients

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

overcome their kinesiophobia as early as possible to promote their engagement in cardiac rehabilitation as soon as possible, to improve their cardiopulmonary function, to reduce the incidence of postoperative venous thrombosis, [53] and to minimize the length of hospital stay. [54]

Self-efficacy plays an important role in kinesiophobia classifications. [55] In our study, we observed a negative association between self-efficacy and kinesiophobia, which aligns with previous research findings. [48,56] Patients with high self-efficacy scores were more likely to be classified as MK-HRPSG. According to Ralf Schwarzer's theory, individuals with low self-efficacy face difficulties accepting their health status and have lower confidence and expectations regarding exercise.[57] They exhibit extreme reluctance to seek help when faced with unexpected traumatic events during exercise and are more prone to kinesiophobia. [58] However, patients with high self-efficacy demonstrate favorable psychological adaptation and coping skills when faced with heart surgery, enabling them to approach challenges more proactively. [59]Consequently, enhancing self-efficacy is an effective measure for preventing and alleviating kinesiophobia, and various interventions focused on increasing self-efficacy are currently available in postoperative settings. [60-62] Further studies are needed to determine whether their use in patients undergoing cardiac surgery results in positive outcomes. Additionally, the inclusion of pain measurements in kinesophobia assessments is essential. [63] The fear-

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

avoidance model theory suggests that if patients perceive pain as a frightening stimulus and experience an exacerbation of pain, they adopt negative coping mechanisms to avoid activities that trigger pain, thus exhibiting kinesophobia. [64] Therefore, it is necessary to provide patients with education on pain perception, help them understand the benefits of exercise, relief their fear of pain, and enhance their confidence in engaging in physical activity. [65]

Social support emerges as the primary factor influencing kinesiophobia in MK-HRPSG patients. Social support was negatively correlated with the classification level of kinesophobia. [66] It is consistent with the results of a qualitative study on 16 female patients by Keessen. [67] In accordance with social support theory, [68,69] individuals with ample social support are more inclined to confide their negative emotions to family, friends, and social networks. This, in turn, boosts their confidence in facing discomfort and diminishes kinesiophobia. Notably, our observations revealed no significant correlation between social support and kinesiophobia in the HK-HEAG group. As a result, we postulate that alternative interventions should be explored to alleviate kinesiophobia in HK-HEAG patients, other than the domain of social support.

CONCLUSIONS

This study utilizes LPA to identify potential classifications of kinesiophobia in patients after cardiac surgery under extracorporeal

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

circulation. The findings indicate that patients fall into three distinct classifications: LMG, MK-HRPSG, and HK-HEAG. It is crucial for clinical staff to prioritize addressing kinesiophobia, particularly in older male patients during the early postoperative period. Furthermore, enhancing self-efficacy shows promise as an effective method for reducing kinesiophobia, while increasing social support may not yield desirable outcomes in the HK-HEAG. These findings offer a valuable evidence-based foundation for implementing preventative interventions to address kinesiophobia during cardiac rehabilitation for patients undergoing cardiac surgery. It is important to note that this study is cross-sectional, and future research should consider expanding the sample size and conducting longitudinal studies to validate the obtained results.

DECLARATION

Authorship contribution statement

WH Xing and JJ Piao are joint first authors. R Wang obtained funding. WH Xing designed the study. JJ Piao, T Ren and YJ Liang collected the data. WH Xing and QL were involved in data cleaning and analyzed the data. YM Gu contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content and approved the final version of the manuscript. All authors have read and approved the final manuscript. YM Gu and R Wang are the study guarantors.

Funding source

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

This work was supported by the National Key Research and Development Program of China [grant numbers 2022YFB4700805].

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

This study was approved by the ethical review committee of the Sixth Medical Centre of PLA General Hospital (Beijing, China). The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Data availability

No additional data are available.

Acknowledgements

The study was undertaken during the COVID-19 pandemic. Sincere thanks to the contribution from clinicians and nurses who supported the research for data collection. We would like to thank the study participants.

REFERENCES

1 Back M, Cider A, Herlitz J, et al. Kinesiophobia mediates the influences on attendance at exercise-based cardiac rehabilitation in patients with coronary artery disease. *Physiother Theory Pract*. 2016;32(8):571-80.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

2 Knapik A, Dąbek J, Brzęk A. Kinesiophobia as a Problem in Adherence to Physical Activity Recommendations in Elderly Polish Patients with Coronary Artery Disease . *Patient Preference and Adherence*. 2019;Volume 13:2129-35.

3 Rita Rubin M. Although Cardiac Rehab Saves Lives,Few Eligible Patients Take Part. *American Medical Association*. 2019;Aug 6;322(5):386-8.

4 Back M, Oberg B, Krevers B. Important aspects in relation to patients' attendance at exercise-based cardiac rehabilitation - facilitators, barriers and physiotherapist's role: a qualitative study. *BMC Cardiovasc Disord*. 2017;17(1):77.

5 Michelle C Rogerson BMM, Stephen Bird and Tony Morris. “I don’t have the heart”: a qualitative study of barriers to and facilitators of physical activity for people with coronary heart disease and depressive symptoms. *International Journal of Behavioral Nutrition and Physical Activity*. 2012 Nov 30;9:140.

6 Brunetti ND, Guerra A, Ieva R, et al. Scared for the scar: fearsome impact of acute cardiovascular disease on perceived kinesiophobia (fear of movement). *Clin Cardiol*. 2017;40(7):480-4.

7 WANG Yaxin SW, JIA Guanhua, QIN Nana, SUN Jingjing. The status quo and influencing factors of kinesiophobia among first-onset Acute Myocardial Infarction. *Chinese Nursing Management*. 2022;22(01):63-9.

8 QIN Jingwen , XIONG JuanjuanPAN Xin GK. The status and influencing factors of kinesiophobia in elderly patients with chronic heart failure. *Chinese Journal of Nursing*. 2022;57(04):408-14.

9 Back M, Cider A, Herlitz J, et al. The impact on kinesiophobia (fear of movement) by clinical

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

variables for patients with coronary artery disease. *Int J Cardiol*. 2013;167(2):391-7.

10 Baykal Sahin H, Kalaycioglu E, Sahin M. The effect of cardiac rehabilitation on kinesiophobia in patients with coronary artery disease. *Turk J Phys Med Rehabil*. 2021;67(2):203-10.

11 Winnige P, Vysoky R, Dosbaba F, et al. Cardiac rehabilitation and its essential role in the secondary prevention of cardiovascular diseases. *World J Clin Cases*. 2021;9(8):1761-84.

12 Taylor RS, Dalal HM, McDonagh STJ. The role of cardiac rehabilitation in improving cardiovascular outcomes. *Nat Rev Cardiol*. 2022;19(3):180-94.

13 Epstein E, Maisel S, Maysent K, et al. Cardiac rehabilitation for coronary artery disease: latest updates. *Curr Opin Cardiol*. 2021;36(5):556-64.

14 Abraham LN, Sibilitz KL, Berg SK, et al. Exercise-based cardiac rehabilitation for adults after heart valve surgery. *Cochrane Database Syst Rev*. 2021;5(5):CD010876.

15 Patel DK, Duncan MS, Shah AS, et al. Association of Cardiac Rehabilitation With Decreased Hospitalization and Mortality Risk After Cardiac Valve Surgery. *JAMA Cardiol*. 2019;4(12):1250-9.

16 Ambrosetti M, Abreu A, Corra U, et al. Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. *Eur J Prev Cardiol*. 2021;28(5):460-95.

17 Abreu A, Frederix I, Dendale P, et al. Standardization and quality improvement of secondary prevention through cardiovascular rehabilitation programmes in Europe: The avenue towards EAPC accreditation programme: A position statement of the Secondary

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Prevention and Rehabilitation Section of the European Association of Preventive Cardiology (EAPC). *Eur J Prev Cardiol*. 2021;28(5):496-509.

18 Budts W, Pieles GE, Roos-Hesselink JW, et al. Recommendations for participation in competitive sport in adolescent and adult athletes with Congenital Heart Disease (CHD): position statement of the Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC) Working Group on Adult Congenital Heart Disease and the Sports Cardiology, Physical Activity and Prevention Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J*. 2020;41(43):4191-9.

19 Wang Z, Zhang Y, Wang Y, et al. Kinesiophobia and its associated factors in patients with coronary heart disease: a cross-sectional study based on latent feature analysis. *BMJ Open*. 2023;13(7):e072170.

20 Zhang X, Zhao Q, Wang M, et al. Fear of movement and its associated psychosocial factors in heart failure patients: a cross-sectional study. *Eur J Cardiovasc Nurs*. 2023;22(3):273-81.

21 xiaotong HXHFH. White book of Chinese cardiovascular surgery and extracorporeal circulation in 2020. *Chinese Journal of Extracorporeal Circulation*. 2021;19(05):257-60.

22 Ding Y, Pan Y, Wang M, et al. Factors influencing kinesiophobia during the "blanking period" after radiofrequency catheter ablation in patients with atrial fibrillation by the fear-avoidance model. *Int J Cardiol*. 2022;363:49-55.

23 Wang H, Hu F, Lyu X, et al. Kinesiophobia could affect shoulder function after repair of rotator cuff tears. *BMC Musculoskelet Disord*. 2022;23(1):714.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

24 Zhou M, Thayer WM, Bridges JFP. Using Latent Class Analysis to Model Preference Heterogeneity in Health: A Systematic Review. *PharmacoEconomics*. 2017;36(2):175-87.

25 Damar HT, Bilik O, Baksi A, et al. Examining the relationship between elderly patients' fear of falling after spinal surgery and pain, kinesiophobia, anxiety, depression and the associated factors. *Geriatr Nurs*. 2021;42(5):1006-11.

26 LEI Mengjie LT, XIONG Siqi, SANG Ming, JIN Changde. Reliability and validity test of Chinese version of the Tampa Scale for Kinesiophobia Heart. *Chinese Nursing Management*. 2019;19(11):1637-42.

27 M L Hickey SVO, R D Froman. Instrument development: cardiac diet and exercise self-efficacy. *NURSING RESEARCH*. 1992;Nov-Dec;41(6):347-51.

28 Sun Yuxiao ZC, Zhu Yan,Yang Zhiyun,Tang Baoxin,Chen Jie, Zhang Yueyu. The Chinesization and reliability and validity test of the Cardiac Exercise Self-Efficacy Instrument. *Chinese Journal of Modern Nursing*. 2021;27(32):6.

29 Shuiyuan X. Theoretical basis and research application of social support rating Scale. *Journal of Clinical Psychiatry*. 1994;Apr;39(3):315-25.

30 E. M. A. SMETS BG, t B. BONKE and J. C. J. M. DE HAES. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *Journal of Psychosomatic Research*. 1995;39(3):315-25.

31 Herrmann C. International experiences with the Hospital Anxiety and Depression Scale--a review of validation data and clinical results. *Journal of Psychosomatic Research*. 1997;Jan;42(1):17-41.

32 Kasaeyan Naeini E, Subramanian A, Calderon M-D, et al. Pain Recognition With

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Electrocardiographic Features in Postoperative Patients: Method Validation Study. *Journal of Medical Internet Research*. 2021;23(5).

33 Alwekhyan SA, Alshraideh JA, Yousef KM, et al. Nurse-guided incentive spirometry use and postoperative pulmonary complications among cardiac surgery patients: A randomized controlled trial. *Int J Nurs Pract*. 2022;28(2):e13023.

34 Shruti Prabhakaran Nair RH, Vijayendra Rajguru. Evaluation of Fear Avoidance Belief and Kinesiophobia in Patients after Undergoing InPatient Cardiac Rehabilitation Post Cardiac Surgery. *International Journal of Health Sciences & Research*. 2018.

35 Turan A, Duncan A, Leung S, et al. Dexmedetomidine for reduction of atrial fibrillation and delirium after cardiac surgery (DECADE): a randomised placebo-controlled trial. *Lancet*. 2020;396(10245):177-85.

36 Shi J, Zhou C, Pan W, et al. Effect of High- vs Low-Dose Tranexamic Acid Infusion on Need for Red Blood Cell Transfusion and Adverse Events in Patients Undergoing Cardiac Surgery: The OPTIMAL Randomized Clinical Trial. *JAMA*. 2022;328(4):336-47.

37 Khamis RY, Ammari T, Mikhail GW. Gender differences in coronary heart disease. *Heart*. 2016;102(14):1142-9.

38 Townsend N, Kazakiewicz D, Lucy Wright F, et al. Epidemiology of cardiovascular disease in Europe. *Nat Rev Cardiol*. 2022;19(2):133-43.

39 Cifkova R. Gender differences in secondary prevention of coronary heart disease: Far from closing the gap. *Int J Cardiol*. 2022;355:52-3.

40 Grant SW, Ouzounian M. Closing the gender gap in cardiac surgery outcomes: more work to be done. *Eur J Cardiothorac Surg*. 2022;61(3):703-4.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

41 Ferrannini G, De Bacquer D, Vynckier P, et al. Gender differences in screening for glucose perturbations, cardiovascular risk factor management and prognosis in patients with dysglycaemia and coronary artery disease: results from the ESC-EORP EUROASPIRE surveys. *Cardiovasc Diabetol*. 2021;20(1):38.

42 Chen J, Guo W, Liu H, et al. Translation and psychometric evaluation of a scale to measure the fear of activity in Chinese patients with coronary artery disease. *Nurs Open*. 2023;10(6):4033-43.

43 Back M, Caldenius V, Svensson L, et al. Perceptions of Kinesiophobia in Relation to Physical Activity and Exercise After Myocardial Infarction: A Qualitative Study. *Phys Ther*. 2020;100(12):2110-9.

44 Craske MG, Niles AN, Burklund LJ, et al. Randomized controlled trial of cognitive behavioral therapy and acceptance and commitment therapy for social phobia: outcomes and moderators. *J Consult Clin Psychol*. 2014;82(6):1034-48.

45 Bullock GS, Sell TC, Zarega R, et al. Kinesiophobia, Knee Self-Efficacy, and Fear Avoidance Beliefs in People with ACL Injury: A Systematic Review and Meta-Analysis. *Sports Med*. 2022;52(12):3001-19.

46 Larsson C, Ekvall Hansson E, Sundquist K, et al. Kinesiophobia and its relation to pain characteristics and cognitive affective variables in older adults with chronic pain. *BMC Geriatrics*. 2016;16(1).

47 Alpalhao V, Cordeiro N, Pezarat-Correia P. Kinesiophobia and Fear Avoidance in Older Adults: A Scoping Review on the State of Research Activity. *J Aging Phys Act*. 2022;30(6):1075-84.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

48 Gunn AH, Schwartz TA, Arbeeva LS, et al. Fear of Movement and Associated Factors Among Adults With Symptomatic Knee Osteoarthritis. *Arthritis Care Res (Hoboken)*. 2017;69(12):1826-33.

49 Archer KR, Devin CJ, Vanston SW, et al. Cognitive-Behavioral-Based Physical Therapy for Patients With Chronic Pain Undergoing Lumbar Spine Surgery: A Randomized Controlled Trial. *J Pain*. 2016;17(1):76-89.

50 Reinking S, Seehusen CN, Walker GA, et al. Transitory kinesiophobia after sport-related concussion and its correlation with reaction time. *J Sci Med Sport*. 2022;25(1):20-4.

51 Back M, Lundberg M, Cider A, et al. Relevance of Kinesiophobia in Relation to Changes Over Time Among Patients After an Acute Coronary Artery Disease Event. *J Cardiopulm Rehabil Prev*. 2018;38(4):224-30.

52 Mudumbai SC, Kim TE, Howard SK, et al. An ultrasound-guided fascia iliaca catheter technique does not impair ambulatory ability within a clinical pathway for total hip arthroplasty. *Korean J Anesthesiol*. 2016;69(4):368-75.

53 Feng S, Xie B, Li Z, et al. Retrospective Study on the Application of Enhanced Recovery After Surgery Measures to Promote Postoperative Rehabilitation in 50 Patients With Brain Tumor Undergoing Craniotomy. *Front Oncol*. 2021;11:755378.

54 Daskivich TJ, Houman J, Lopez M, et al. Association of Wearable Activity Monitors With Assessment of Daily Ambulation and Length of Stay Among Patients Undergoing Major Surgery. *JAMA Netw Open*. 2019;2(2):e187673.

55 Piao JJ, Gu Y, Ling Y, et al. Mediating effect of kinesiophobia between self-efficacy and physical activity levels in post-CABG patients: protocol for a prospective, multicentre, cross-

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

sectional study in China. *BMJ Open*. 2022;12(7):e062013.

56 Du S, Hu L, Bai Y, et al. The Influence of Self-Efficacy, Fear-Avoidance Belief, and Coping Styles on Quality of Life for Chinese Patients with Chronic Nonspecific Low Back Pain: A Multisite Cross-Sectional Study. *Pain Pract*. 2018;18(6):736-47.

57 Schwarzer R, Antoniuk A, Gholami M. A brief intervention changing oral self-care, self-efficacy, and self-monitoring. *Br J Health Psychol*. 2015;20(1):56-67.

58 Lin AW, Dollahite JS, Sobal J, et al. Health-related knowledge, beliefs and self-efficacy in women with polycystic ovary syndrome. *Hum Reprod*. 2018;33(1):91-100.

59 ZYT SY. Influence Path of Self-efficacy and Coping Methods on Self-care Behaviors of Patients with Chronic Cardiac Failure. *Nursing Journal Of Chinese Peoples Liberation Army*. 2017;2023-12-21.

60 Meng Y, Deng B, Liang X, et al. Effectiveness of self-efficacy-enhancing interventions on rehabilitation following total hip replacement: a randomized controlled trial with six-month follow-up. *Journal of Orthopaedic Surgery and Research*. 2022;17(1).

61 Kroemeke A, Sobczyk-Kruszelnicka M. Interaction effect of coping self-efficacy and received support in daily life of hematopoietic cell transplant patient-caregiver dyads. *PLoS One*. 2021;16(11):e0260128.

62 Egerton T, Bennell KL, McManus F, et al. Comparative effect of two educational videos on self-efficacy and kinesiophobia in people with knee osteoarthritis: an online randomised controlled trial. *Osteoarthritis Cartilage*. 2022;30(10):1398-410.

63 Asiri F, Reddy RS, Tedla JS, et al. Kinesiophobia and its correlations with pain, proprioception, and functional performance among individuals with chronic neck pain. *PLoS*

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

One. 2021;16(7):e0254262.

64 Johan W.S. Vlaeyen SJL. Fear-avoidance and its consequences in chronic musculoskeletal pain:

a state of the art. *Pain*. 2000;85 (2000) 317-332.

65 Giusti EM, Lacerenza M, Manzoni GM, et al. Psychological and psychosocial predictors of chronic postsurgical pain: a systematic review and meta-analysis. *Pain*. 2021;162(1):10-30.

66 Tan M, Liu Y, Zhao R, et al. The effect of pain social support on kinesiophobia in older patients with rheumatoid arthritis: The mediating role of self-perceived burden. *Geriatr Nurs*. 2023;50:52-7.

67 Keessen P, Latour CHM, van Duijvenbode ICD, et al. Factors related to fear of movement after acute cardiac hospitalization. *BMC Cardiovasc Disord*. 2020;20(1):495.

68 SY X. The theoretical basis and application of social support questionnaire. *clinical Psychol medical*. 1994;(1994) 4:98–100.

69 C P Langford JB, J P Maloney, P P Lillis. Social support:a conceptual analysis. *Journal of advanced nursing*. 1997;25,95-100.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

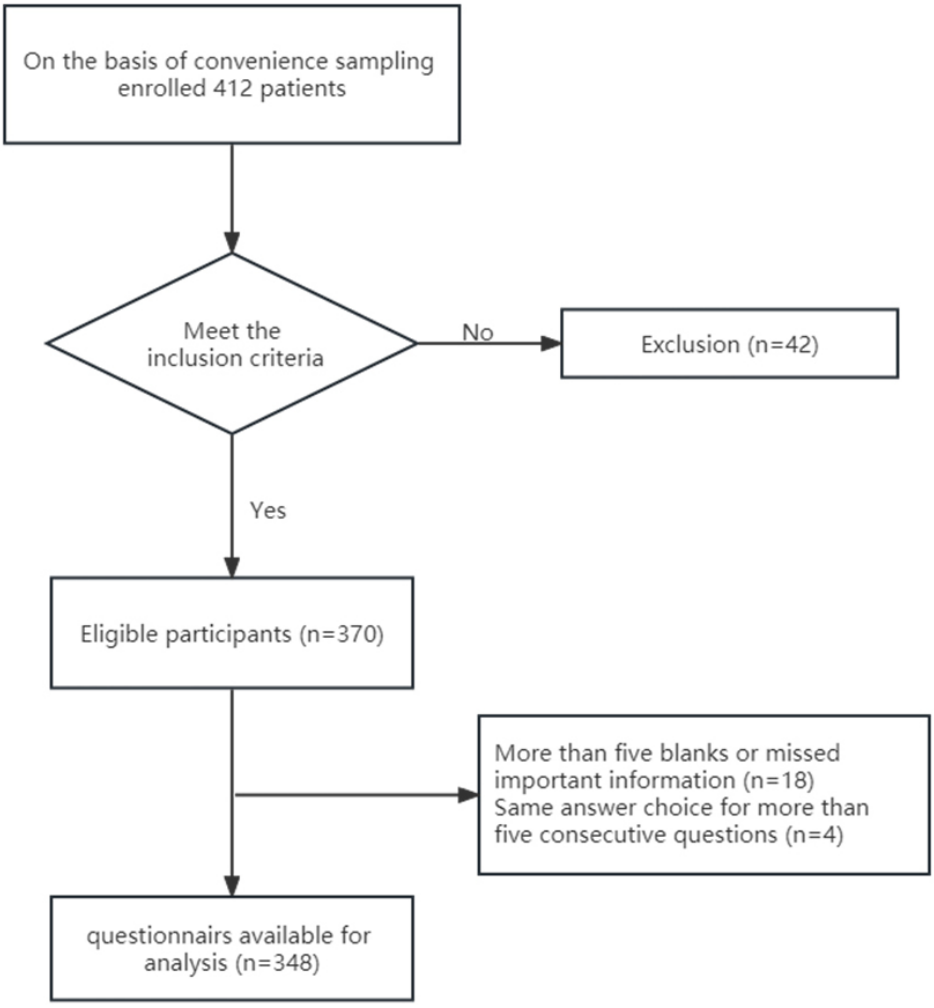

Figure1.Flow diagram of participants

228x244mm (96 x 96 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

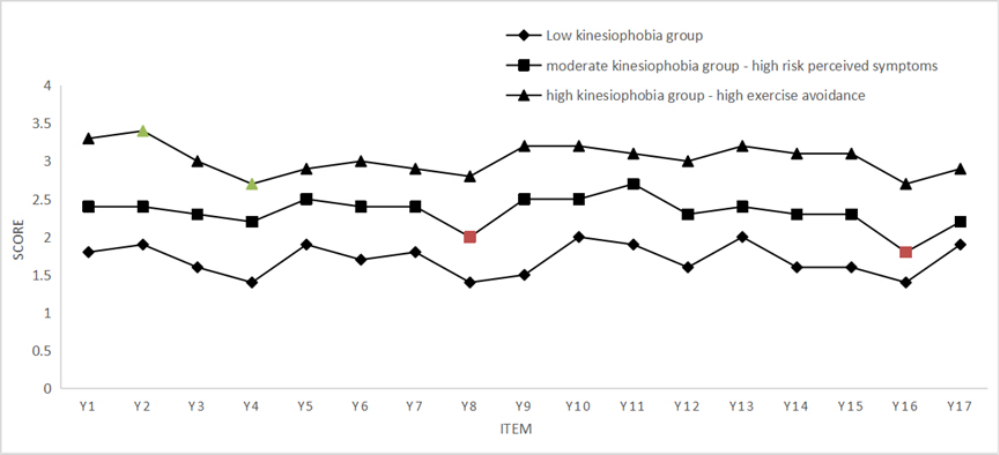

Figure2.Latent profile analysis classification

146x66mm (150 x 150 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 2. Single-factor analysis of potential classification impact factors (n = 348)

Variables		LKG (%)[1]	MK-HRPSG [2](%)	HK-HEAG[3] (%)	F/χ^2	P
Gender	Male	47(65.52)	110(74.42)	100(78.57)	3.694	0.055
	Female	25(34.48)	38(25.58)	28(21.43)		
Age	18-45	20（27.78）	71（47.97）	49(38.28)	7.582	**<0.05**
	46-65	42（58.33）	58（39.19））	42(32.81)		
	66-75	10（13.89）	19（12.84）	37(28.90)		
Educational level	Primary school or lower	39（54.16）	101（68.24）	85(66.40)	1.391	0.250
	High school	25（34.72）	28（18.92）	35(27.34)		
	University and above	8（11.12）	19（12.84）	8(6.26)		
Marital status	Married	64(89.66)	131(88.37)	119(92.86)	1.860	0.157
	Unmarried	8(10.34)	17(11.63)	9(7.14)		
Vocational type	Brainwork	29(40.27)	21(13.95)	36(28.57)	1.208	0.300
	Physical labor	22(30.56)	50(33.78)	36(28.57)		
	Retirement	21(29.17)	77(52.27)	56(42.86)		
Average monthly	≤1500	14(19.44)	42(28.38)	25(19.53)	0.133	0.940

[1] low kinesiophobia group(LKG）
[2] moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG)
[3] high kinesiophobia - high exercise avoidance group(HK-HEAG)

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

income (RMB)	1501-3500	10(13.88)	56(37.84)	24(18.75)		
	3501-5500	22(30.56)	27(18.24)	40(31.25)		
	≥5500	26(36.12)	23(15.54)	39(30.47)		
Current residence	Village	20(27.59)	43(29.05)	23(17.97)	3.319	0.069
	City	52(72.41)	105(70.95)	105(82.03)		
Smoking	Never	31(43.06)	24(16.21)	46(35.94)	0.513	0.599
	Past	35(48.61)	63(42.57)	68(53.12)		
	Current	6(8.33)	61(41.22)	14(10.94)		
Alcohol	Never	37(51.72)	62(41.86)	50(39.29)	1.376	0.254
	Past	30(41.38)	71(48.84)	64(50.00)		
	Current	5(6.90)	15(9.30)	14(10.71)		
Surgery	Coronary artery bypass graft	67(93.06)	118(79.73)	119(92.86)	0.448	0.504
	Valvular surgery	5(6.94)	30(20.27)	9(7.14)		
Surgical approach	Conventional surgery	48(68.97)	117(79.07)	87(67.86)	0.063	0.802
	Sternum sparing	24(31.03)	31(20.93)	41(32.14)		
Postoperative time (Months)	3-6	28(38.89)	40(27.03)	27(21.09)	6.257	**<0.05**
	7-12	17(23.61)	49(33.10)	66(51.56)		
	13-18	19（26.39）	48(32.43)	23(17.97)		
	19-24	8（11.12）	11(7.44)	12(9.38)		
Self-efficacy		46.62±7.51	50.08±6.55	55.68±4.26	4.704	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Fatigue	44.20±5. 41	43.71±5.45	43.15±4.96	0.905	0.581
Pain	5.26±1.28	6.55±1.51	7.31±1.54	12.572	**<0.05**
Anxiety & depression	11.59±4.35	12.16±6.23	12.82±6.31	1.090	0.347
Social support	36.95±8.27	47.35±8.41	49.14±8.25	5.156	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

BMJ Open

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-083909.R1
Article Type:	Original research
Date Submitted by the Author:	08-Nov-2024
Complete List of Authors:	Xing, Wenhui; The Sixth Medical Centre of PLA General Hospital; Hebei University of Chinese Medicine Piao, jing; Kobe University Graduate School of Health Sciences Ren, Tong; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Liang, Yujing; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Li, Qi; Hebei University of Chinese Medicine Gu, Yanmei; Hebei University of Chinese Medicine Wang, Rong; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery
Primary Subject Heading:	Nursing
Secondary Subject Heading:	Cardiovascular medicine
Keywords:	Coronary heart disease < CARDIOLOGY, Cross-Sectional Studies, MENTAL HEALTH, Nursing Care

SCHOLARONE™
Manuscripts

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Authors

Wenhui Xing[1,2$], Jingjing Piao[3 $], Tong Ren[1], Yujing Liang[1], Qi Li [2], Yanmei Gu[2*], Rong Wang[1*]

Affiliations

[1] Department of Cardiovascular Surgery, The Sixth Medical Centre of PLA General Hospital, Beijing, CHN

[2] Faculty of Nursing, Hebei University of Chinese Medicine, Shijiazhuang, CHN

[3] Department of Rehabilitation Science, Kobe University Graduate School of Health Sciences, Kobe, JP

Corresponding author

*Rong Wang, The Sixth Medical Centre of PLA General Hospital, 3 Fucheng Road, Haidian District, Beijing, China

Email: wangrongd@126.com

Telephone: +86-010-66951518

*Yanmei Gu, Faculty of Nursing, Hebei University of Chinese Medicine 3 Xingyuan Road, Shijiazhuang,China

E-mail: guyanmei@hebcm.edu.cn

Telephone: +86-0311-89926338

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

Keywords Kinesiophobia; research design; cardiac surgical procedures; extracorporeal circulation; logistic regression

Number of words 4532

ABSTRACT

Objective: To investigate the potential classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation from a psychosocial perspective, and analyze the characteristic differences among different latent levels of patients.

Study design: This is a cross-sectional study of Chinese adults after cardiac surgery under extracorporeal circulation, aged over 18 years and older, recruited from a tertiary hospital in North China.

Methods: This study utilizes Latent Profile Analysis to identify potential classifications of kinesiophobia in questionnaires from 348 patients undergoing cardiac surgery under extracorporeal circulation. Multiple logistic analysis was used to evaluate the influencing factors at different latent classifications.

Results: The average performance of each indicator in Model 3 is best suited for analysis, Entroy=0.873 and BLRT(P) < 0.0001.The result of regression equation shows postoperative time (P<0.001), age, self-efficacy, pain, and social support level (P< 0.05) were the factors influencing the potential profile classification of patients after cardiac surgery under

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

extracorporeal circulation.

Conclusion: The study identified three distinct classifications of patients: low kinesiophobia group, the moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG) and high kinesiophobia - high exercise avoidance group (HK-HEAG). Addressing kinesiophobia, especially in older male patients during the early postoperative period, is crucial. Enhancing self-efficacy seems effective in reducing kinesiophobia, while increasing social support may not be as beneficial for the HK-HEAG group. These findings provide a basis for implementing preventive interventions in cardiac rehabilitation.

Trial registration number: Chinese Clinical Trial Registry (ChiCTR2200057895).

Keywords: Kinesiophobia; research design; cardiac surgical procedures; extracorporeal circulation; logistic regression

STRENGTHS AND LIMITATIONS OF THIS STUDY

1、 It is a comprehensive investigation conducted in China, specifically examining the factors that potentially influence the level of kinesiophobia in patients who have undergone cardiac surgery with extracorporeal circulation.

2、 This study indicatively uses LPA to classify kinesiophobia of patients after cardiac surgery under extracorporeal circulation.

3、 Self-report questionnaires in data collection may influence the

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

assessment of kinesiophobia in an objective approach.

4、 The adaptability of this model is limited to Chinese background.

INTRODUCTION

Kinesiophobia is defined as an irrational and excessive fear of carrying out a physical movement. [1] Previous studies have reported that psychological factors, such as kinesiophobia, are a significant barrier to patient participation in cardiac rehabilitation (CR). [2-6] In the context of cardiac disease, it is mostly described as a fear of physical activity due to the apprehension of worsening cardiac disease or the possibility of inducing adverse outcomes. Kinesiophobia was detected in 65% of individuals with chronic heart failure and in 86.26% of patients with a first-time acute myocardial infarction. [7,8] According to a previous study, high levels of kinesiophobia can negatively impact not only the performance of daily activities but also CR engagement. [9]

Research has shown that kinesiophobia has an influence and intermediate role on attendance at CR. [1]As a mediator, kinesiophobia is influenced by predictive factors and has indirect effects. General health and muscle endurance increased the probability of attendance at CR, while self-rated anxiety had the opposite effect. There have been studies exploring whether there are positive changes in kinesiophobia based on CR, with higher levels of aerobic capacity and lower levels of physical activity compared to patients with low levels of kinesiophobia. Results showed a

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

significant reduction in kinesiophobia after a exercise-based CR program. [10] CR is an important step in the recovery process after cardiac surgery. CR is a comprehensive strategy that is aimed at improving a person's physical, psychological, and social functioning. [11-13] Studies have shown that exercise-based CR can not only reduce mortality and hospital admissions for cardiovascular disease but also improve quality of life and mental well-being. [12,14,15] CR's effectiveness and importance are recommended as level IA by most international cardiovascular societies. [16-18]

Kinesiophobia is a psychological disorder, we should pay more attention to those subjective factors that are self-influenced and in constant change. In a potential profile analysis of kinesiophobia in patients with coronary heart disease, [19]objective demographic information was included in the analysis, and the results showed that patients could be divided into three potential types: 'low fear type', 'intermediate fear type' and 'high fear type'. However, among the influencing factors of kinesiophobia, objective factors cannot be interfered with by medical staff. In addition, research supports that kinesiophobia is positively correlated with age , [19] but the explanation for these potential differences in age has not been studied. From the perspective of social psychology, the research results of Xiuting [20] showed that it was important to alleviate kinesiophobia for patients with low subjective social status, but the

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

mechanism of how social support produced positive effects in different kinesiophobia classifications has not been clarified. Clinical professionals should collect objective influence factors as predictive factors, focusing on targeted interventions based on the patient's own subjective factors.

Few studies have investigated the effects of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. The number of cardiac surgeries has increased tremendously in recent years. In China, cardiac surgery volume increased by 8% in 2020 compared to 2012. [21]In addition, the factors of kinesiophobia are complex and highly heterogeneous. From the social psychology perspective, the classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation has not been well characterized. Previous studies[22,23]mainly evaluated patients' kinesiophobia classification from the total score of the scale, which may have the same total score but the score of each item varies greatly. This study fills that gap. Latent profile analysis (LPA) is an "individual-centric" statistical analysis method that can homogenize sequential data, explore the characteristics of groups without categories and ethnic differences in groups, and then analyze their respective influence factors in different subgroups. [24] We hypothesized that patients with kinesiophobia after cardiac surgery could be accurately divided into three subgroups using the LPA method, and the features between the groups were well distinguished. According to the classification results of

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

this study, it provides a reliable reference for clinical medical staff to intervene in kinesiophobia.

MATERIALS AND METHODS

Study design

In this cross-sectional study, subgroups of kinesiophobia characteristics and associated factors in patients after heart surgery were investigated. All participants were recruited from a tertiary hospital in North China and completed the questionnaire from April 2022 to April 2023.

Ethical approval

The Medical Ethics Committee of The Sixth Medical Centre of PLA General Hospital granted ethical permission for this investigation （HZKY-PJ-2022-2）. Participants first read the form for informed consent and selected "I agree" if they chose to participate in the study. They were informed that the responses would remain anonymous and that no personal information would be disclosed. The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Participants

Participants who met the inclusion criteria were provided with information about the study prior to inclusion, consent and willingness to engage in this study after being fully informed of its objectives.

Meet the following inclusion and exclusion criteria:

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Inclusion criteria

(a) Advised by the doctor to participate in CR.

(b) Patients who underwent cardiac surgery under extracorporeal circulation （e.g. Coronary artery bypass grafting and cardiac valve replacement）three months prior to the survey

(c) Adults aged 18-75 years

(d) Conscious, mentally and psychologically competent, and able to complete the questionnaire;

Exclusion criteria

(a)With a contraindication to CR (e.g. uncontrollable or unstable angina, severe arrhythmias, etc.);

(b) Refusal to provide personal information to participate in the questionnaire.

(c) Recently, severe family events (e.g. malignancy); psychological instability; people who actively express depressive anxiety tendencies and are suspicious of mild cognitive impairment.

Study tools

Sociodemographic questionnaire

Sociodemographic data were collected, including gender, age, education level, marital status, vocational type, average monthly household income, current residence, smoking status, alcohol consumption, surgical operation approach, and postoperative time.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Tampa Scale for Kinesiophobia Heart (TSK-SV Heart)

The Chinese version of the TSK-SV Heart was used to assess the kinesiophobia levels of patients. [25]This scale consists of 17 items that assess danger, fear, avoidance, and dysfunction. The questions were evaluated using a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). A score of 37 or higher indicates a high level of kinesiophobia. [9,26]

Cardiac Exercise Self-efficacy Instrument (CESEI)

The CESEI was developed by Hickey et al. to measure exercise self-efficacy in CR patients. [27] In 2021, a Chinese version of CESEI was developed through translation, back translation, and cultural adjustment. [28] The Chinese version of the CESEI includes 16 items corresponding to one dimension, which are scored on a scale of 1-5. The total score is determined by the sum of the item scores. The higher the score, the higher the patient's self-efficacy in CR. The Cronbach's alpha for the Chinese version of the CESEI is 0.941.

Social Support Rating Scale (SSRS)

The SSRS was used to examine the levels of social support among the participants. [29]The SSRS comprises 10 items divided into three categories: objective support, subjective support, and social support use. Low, medium, and high levels of social support are represented by total scores of 0–22, 23–44, and 45–66, respectively. The Cronbach's alpha of

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

the scale is 0.81.

Multidimensional Fatigue Inventory (MFI-20)

The MFI-20 was used to determine participants' fatigue levels. [30] General weariness, physical fatigue, reduced activity, diminished motivation, and mental fatigue are the five categories of the MFI-20. Responses were given using a five-point Likert scale ranging from 1 (yes, this is true) to 5 (no, this is not true). This scale has a Cronbach's alpha of 0.882, and it is regularly used to assess patient weariness with good reliability.

Hospital Anxiety and Depression Scale (HADS)

The HADS was used to determine the level of anxiety and depression in participants. [31] The HADS comprises 14 items with four possible answers ranging from 0 to 4, as well as two subscales, anxiety and depression. The HADS score indicates the severity of anxiety or depression. The higher the HADS score, the more severe the anxiety or sadness. This scale has been tested in a variety of countries.

Numerical Rating Scale (NRS)

The NRS is accurate, concise, and more feasible. It was once considered the gold standard for pain assessment by the American Pain Society. [32] Patients are asked to select a single number representing the intensity of their pain on a scale of 1-11 (0=no pain, 10=worst pain). A score of 7-8 is classified as severe pain, indicating that the pain is intense.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

STATISTICAL ANALYSIS

The statistical analysis was conducted using SPSS 22.0 software. For normally distributed quantitative data, descriptive statistics were presented as mean ± standard deviation (x ± s), and group comparisons were performed using differential analysis. Qualitative data were described using frequencies and percentages, and group comparisons were performed using the $\chi 2$ test. To establish a latent profile analysis model, Mplus 8.3 software was utilized. The TSK-SV heart score of patients after heart surgery was used as the model's observed variable. The initial model category was set to 1, and the number of model level was gradually increased. Model fit was assessed using various criteria, including the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Sample-Size-Adjusted BIC (aBIC), Entropy Index, Lo-Mendell Rubin Likelihood Ratio Test (LMRT), and Bootstrap Likelihood Ratio Test (BLRT). Smaller values of AIC, BIC, and aBIC indicate better model fit. A higher entropy value closer to 1 suggests a higher probability of accurate individual classification. LMRT and BLRT were used to compare the fit of k individual models to k-1 models. Based on the results of the latent profile analysis of kinesiophobia, a multiple logistic analysis was performed to explore the factors influencing the latent profile classification of patients' kinesiophobia after heart surgery. The statistical tests were two-tailed, and a difference of $P < 0.05$ was considered statistically significant.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

RESULTS

Convenience sampling was employed with 412 participants underwent cardiac surgery under extracorporeal circulation enrolled. Forty-two participants were excluded according to the inclusion and exclusion criteria with 370 eligible participants left. Eighteen questionnaires had more than five blanks or missed important information, while another four questionnaires had same answer choice for more than five consecutive questions. All the above 22 questionnaires had been excluded. Finally, 348 questionnaires left for analysis (Figure 1).

insert figure 1. Flow diagram of participants

Demographic characteristics of the participants

In the current study, 248 males (71.26%) and 100 females (28.74%) aged 18-45 years (18.97%), 46-65 years (40.80%), 66-75 years (40.23%) participants were included. 252 participants (72.41%) underwent conventional approach while 101 participants (27.58%) used sternum sparing approach. 95 participants (27.29%) were at 3-6 months postoperative, 132 participants (37.93%) at 7-12 months, 90 patients (25.86%) at 13-18 months, and 31 patients (8.90%) at 19-24 months. Detail characteristics of the participants are displayed in Supplementary Table 1.

Latent profile analysis was conducted to identify the heterogeneity of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. Four models were initially constructed based on model fit

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

indicators AIC, BIC, aBIC, entropy, LMRT and BLRT. As the classification number increasing (**Table 1**), the AIC, BIC, and aBIC values gradually decreased and reached a minimum in Model 4 with LMRT value 0.131(>0.05) while the matching indicators in Model 3 all fit well (<0.05). Furthermore, there was no cross in the three level as shown in **Figure 2**. Therefore, Model 3 of kinesiophobia after heart surgery was accepted in the current study.

Number of Class	1	2	3	4
AIC	17674.014	16629.692	16442.350	16294.501
BIC	17810.812	16838.911	16723.991	16648.565
aBIC	17702.922	16673.903	16501.865	16369.321
LMRT(P)	—	**0.000**	**0.031**	**0.131**
BLRT(P)	—	0.000	0.000	0.000
Entroy	—	**0.814**	**0.873**	**0.888**
Sample proportion (%) per Class	—	0.576/0.423	0.206/0.426/0.368	0.177/0.373/0.419/0.031

Table 1 Model fitting indexes of all potential classification of kinesiophobia after cardiac surgery under extracorporeal circulation

insert figure 2. Latent profile analysis classification

In Model 3 the different groups were named as the low kinesiophobia group (LKG), the moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG) and high kinesiophobia - high exercise avoidance group (HK-HEAG). The LKG **(**72/348, 20.6%) had low scores in all items. TSK-SV Heart scored（34.08±4.12）.The MK-HRPSG (148/348, 42.6%) had moderate scores on all items. TSK-SV Heart scored（48.91±7.07）. The HK-HEAG (128/348, 36. 8%) had high scores in all items. TSK-SV Heart scored（51.81±6.07）.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

One-way analysis of variance of different potential classification impact factors

There were differences in different potential classifications of kinesiophobia in participants, and there were statistically significant differences in the degree distribution of age, postoperative time, pain, social support and self-efficacy ($p< 0.05$)， as showed in Supplementary Table 2.

Multiple logistic regression analysis of potential classification factors

Taken LKG as a reference to conduct disordered multi-classification logistic regression analysis, the classifications of kinesiophobia were taken as dependent variable, with significant variables in the above analysis as independent variables and covariables. The results showed that age, postoperative time, self-efficacy, pain and social support were factors influencing the potential classification of kinesiophobia ($p<0.05$), as shown in Supplementary Table 3.

DISCUSSION

Characteristics of participants

The data for this study were collected from a tertiary hospital in the country with ample volume of cardiac surgeries In this study, there was a higher proportion of male participants compared to female participants (male: female=2.48:1), which aligns with findings from previous studies. [33-36] It is noteworthy that female participants constitute no more than

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

30% of the study population in research trials. [35-37]

There are several factors contributing to this gender disparity. Firstly, mortality rates and risk for the most prevalent cardiovascular diseases consistently tend to be higher among men than women; [38] Moreover, women face disparities in wealth, income, and access to resources, which can hinder their timely access to medical care. A study revealed that women with low incomes, low levels of education, and residing in deprived areas are more likely to delay seeking medical attention. [39] Lastly, a lack of awareness among women about the importance of coronary heart disease (CHD) and emergency care contributes to delays in seeking medical attention. [40] A report from the European Heart Survey found that women aged 60 and above were less likely to undergo CABG compared to men, whereas they were more likely to receive PCI, adding to the gender differences in surgical treatment. [41]

Analysis of a 3- classification model of kinesiophobia score

Among the models tested, Model 3 exhibited significant characteristics. As our results indicate, Model 4 had the best-fitting AIC, BIC, and Entroy values. Model 4 allows variances and covariances to be freely estimated and varied across profiles. However, this improvement in fit came at the expense of differences when compared to other models. Model 4 had a lower LMRT value (0.131) in particular. Ultimately, we selected Model 3 due to its relatively low AIC and BIC values, along with

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

a high entropy value of 0.873, suggesting accurate classification of participants into the appropriate profile. Furthermore, the LMRT and BLRT values in Model 3 were low (0.05 and 0.01), indicating good model fit.

The researchers established a score of 37 as the threshold for determining the presence of kinesiophobia. [42] A score of 37 or higher indicates a high level of kinesiophobia. [22] Notably, participants in the LKG group in Model 3 obtained a mean score of （34.08±4.12）, indicating a lower degree of kinesiophobia. This finding aligns with previous studies. [22,43] The MK-HRPS in Model 3 scored lower on items 8 (2.00±0.73) and 16 (1.90±0.75), compared with an average item score of 2.33. These items belong to the risk perception dimension. The results suggest that participants in the MK-HRPS group exhibit a heightened perception of risk, which may result in decreased adherence to recommended treatments. [44] In contrast, participants in the HK-HEAG group in Model 3 obtained higher scores on item 2 (3.43±0.55) and lower scores on item 4 (2.86±0.84), compared to the average item score of 3.03. These particular items are indicative of exercise avoidance tendencies. Consequently, participants in the HK-HEAG group in Model 3 may demonstrate greater resistance to and avoidance of physical activity when advised by their doctors regarding exercise prescriptions. [45]

Based on the presented results, Model 3 effectively minimize

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

individual heterogeneity by considering latent traits, resulting in the identification of distinct subgroups. The results of this study showed potential classifications of kinesiophobia, which were mainly affected by age, postoperative time, self-efficacy, pain, and social support.

Factors affecting classification

We observed that age under 45 did not play a role in influencing the classification of kinesiophobia. In this study, age was analyzed categorically as a rank variable, which differed from previous studies that treated age as a continuous variable.[19] Remarkably, our findings emphasized the significance of age above 45, specifically indicating that patients aged over 45 were more likely to exhibit tendencies towards HK-HEAG. These results align with existing research showing higher levels of kinesiophobia among older adults, [46]which is consistent with our research. The increased kinesiophobia with aging can be attributed to factors such as physical frailty, which not only leads to a decrease in energy but also heightens the fear of injury and falling. In addition, it is difficult for the elderly to acquire scientific knowledge about kinesiophobia, [47]which further aggravates exercise avoidance. However, Gunn et al. [48] reported an adverse association between age and kinesiophobia among adults, suggesting that older individuals may have more available time and exercise experience, which reduces their anxiety towards potentially harmful activities. It is important to note that generalizing findings based

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

on age is not appropriate, as age under 45 did not prove to be a significant factor in our study. Future studies should focus on exploring the kinesiophobia classification in older adults.

There is a time effect of kinesiophobia in the postoperative period. Our study discovered that the period between 3 to 6 months after surgery is a critical time frame for kinesiophobia concerns. The level of kinesophobia decreased with the increase in postoperative time, [49,50] and postoperative time was not a factor affecting the classification of kinesophobia after 6 months. The longer the postoperative period, the less likely they were to be classified as HK-HEAG. This finding aligns with previous studies conducted on patients following an acute coronary artery disease event, which reported that kinesiophobia scores were highest (32.5) at baseline, decreasing to 30.9 after two weeks and 30.1 after four months, suggesting a decline in kinesiophobia over time. [51] This trend may be due to the gradual recovery of exercise capacity and cardiac function over time, as patients can gradually tolerate increased exercise and feel the benefits of participating in it. Early postoperative activity has been shown to improve functional recovery time， [52]especially through early postoperative activities on the floor. Clinical staff should help patients overcome their kinesiophobia as early as possible to promote their engagement in cardiac rehabilitation as soon as possible, to improve their cardiopulmonary function, to reduce the incidence of postoperative venous

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

thrombosis, [53] and to minimize the length of hospital stay. [54]

Self-efficacy plays an important role in kinesiophobia classifications. [55] In our study, we observed a negative association between self-efficacy and kinesiophobia, which aligns with previous research findings. [48,56] Patients with high self-efficacy scores were more likely to be classified as MK-HRPSG. According to Ralf Schwarzer's theory, individuals with low self-efficacy face difficulties accepting their health status and have lower confidence and expectations regarding exercise.[57] They exhibit extreme reluctance to seek help when faced with unexpected traumatic events during exercise and are more prone to kinesiophobia. [58] However, patients with high self-efficacy demonstrate favorable psychological adaptation and coping skills when faced with heart surgery, enabling them to approach challenges more proactively. [59]Consequently, enhancing self-efficacy is an effective measure for preventing and alleviating kinesiophobia, and various interventions focused on increasing self-efficacy are currently available in postoperative settings. [60-62] Further studies are needed to determine whether their use in patients undergoing cardiac surgery results in positive outcomes. Additionally, the inclusion of pain measurements in kinesophobia assessments is essential. [63] The fear-avoidance model theory suggests that if patients perceive pain as a frightening stimulus and experience an exacerbation of pain, they adopt negative coping mechanisms to avoid activities that trigger pain, thus

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

exhibiting kinesophobia. [64] Therefore, it is necessary to provide patients with education on pain perception, help them understand the benefits of exercise, relief their fear of pain, and enhance their confidence in engaging in physical activity. [65]

Social support emerges as the primary factor influencing kinesiophobia in MK-HRPSG patients. Social support was negatively correlated with the classification level of kinesophobia. [66] It is consistent with the results of a qualitative study on 16 female patients by Keessen. [67] In accordance with social support theory, [68,69] individuals with ample social support are more inclined to confide their negative emotions to family, friends, and social networks. This, in turn, boosts their confidence in facing discomfort and diminishes kinesiophobia. Notably, our observations revealed no significant correlation between social support and kinesiophobia in the HK-HEAG group. As a result, we postulate that alternative interventions should be explored to alleviate kinesiophobia in HK-HEAG patients, other than the domain of social support.

Limitations of this study

This study has taken a step in the direction of defining and understanding of kinesiophobia in patients in North China. It is possible that other patients with a different culture background may produce different results. In addition, it is important to emphasis that methodological problems in the research design limit our interpretations.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Self-report questionnaires in data collection may also influence the assessment of kinesiophobia in an objective approach. Finally, the LPA method has advantages in group classification, in which the selection process is decided by researchers according to the comprehensive judgment of indicators. Thus, it is likely that the results involve some subjectivity.

CONCLUSIONS

This study utilizes LPA to identify potential classifications of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. The findings indicate that patients fall into three distinct classifications: LMG, MK-HRPSG, and HK-HEAG. It is crucial for clinical staff to prioritize addressing kinesiophobia, particularly in older male patients during the early postoperative period. Furthermore, enhancing self-efficacy shows promise as an effective method for reducing kinesiophobia, while increasing social support may not yield desirable outcomes in the HK-HEAG. These findings offer a valuable evidence-based foundation for implementing preventative interventions to address kinesiophobia during cardiac rehabilitation for patients undergoing cardiac surgery. It is important to note that this study is cross-sectional, and future research should consider expanding the sample size and conducting longitudinal studies to validate the obtained results.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

DECLARATION

Authorship contribution statement

WH Xing and JJ Piao are joint first authors. R Wang obtained funding. WH Xing designed the study. JJ Piao, T Ren and YJ Liang collected the data. WH Xing and QL were involved in data cleaning and analyzed the data. YM Gu contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content and approved the final version of the manuscript. All authors have read and approved the final manuscript. R Wang are the study guarantors.

Funding source

This work was supported by the National Key Research and Development Program of China [grant numbers 2022YFB4700805].

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

This study was approved by the ethical review committee of the Sixth Medical Centre of PLA General Hospital (Beijing, China). The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Data availability

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

No additional data are available.

Acknowledgements

The study was undertaken during the COVID-19 pandemic. Sincere thanks to the contribution from clinicians and nurses who supported the research for data collection. We would like to thank the study participants.

Patient and public involvement

Consent obtained directly from patient(s).

Figure 1. Flow diagram of participants

Figure 2. Latent profile analysis classification

REFERENCES

1 Back M, Cider A, Herlitz J, et al. Kinesiophobia mediates the influences on attendance at exercise-based cardiac rehabilitation in patients with coronary artery disease. *Physiother Theory Pract*. 2016;32(8):571-80.

2 Knapik A, Dąbek J, Brzęk A. Kinesiophobia as a Problem in Adherence to Physical Activity Recommendations in Elderly Polish Patients with Coronary Artery Disease . *Patient Preference and Adherence*. 2019;Volume 13:2129-35.

3 Rita Rubin M. Although Cardiac Rehab Saves Lives,Few Eligible Patients Take Part. *American Medical Association*. 2019;Aug 6;322(5):386-8.

4 Back M, Oberg B, Krevers B. Important aspects in relation to patients' attendance at exercise-based cardiac rehabilitation - facilitators, barriers and physiotherapist's role: a

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

qualitative study. *BMC Cardiovasc Disord*. 2017;17(1):77.

5 Michelle C Rogerson BMM, Stephen Bird and Tony Morris. "I don't have the heart": a qualitative study of barriers to and facilitators of physical activity for people with coronary heart disease and depressive symptoms. *International Journal of Behavioral Nutrition and Physical Activity*. 2012 Nov 30;9:140.

6 Brunetti ND, Guerra A, Ieva R, et al. Scared for the scar: fearsome impact of acute cardiovascular disease on perceived kinesiophobia (fear of movement). *Clin Cardiol*. 2017;40(7):480-4.

7 WANG Yaxin SW, JIA Guanhua, QIN Nana, SUN Jingjing. The status quo and influencing factors of kinesiophobia among first-onset Acute Myocardial Infarction. *Chinese Nursing Management*. 2022;22(01):63-9.

8 QIN Jingwen , XIONG JuanjuanPAN Xin GK. The status and influencing factors of kinesiophobia in elderly patients with chronic heart failure. *Chinese Journal of Nursing*. 2022;57(04):408-14.

9 Back M, Cider A, Herlitz J, et al. The impact on kinesiophobia (fear of movement) by clinical variables for patients with coronary artery disease. *Int J Cardiol*. 2013;167(2):391-7.

10 Baykal Sahin H, Kalaycioglu E, Sahin M. The effect of cardiac rehabilitation on kinesiophobia in patients with coronary artery disease. *Turk J Phys Med Rehabil*. 2021;67(2):203-10.

11 Winnige P, Vysoky R, Dosbaba F, et al. Cardiac rehabilitation and its essential role in the secondary prevention of cardiovascular diseases. *World J Clin Cases*. 2021;9(8):1761-84.

12 Taylor RS, Dalal HM, McDonagh STJ. The role of cardiac rehabilitation in improving

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

cardiovascular outcomes. *Nat Rev Cardiol*. 2022;19(3):180-94.

13 Epstein E, Maisel S, Maysent K, et al. Cardiac rehabilitation for coronary artery disease: latest updates. *Curr Opin Cardiol*. 2021;36(5):556-64.

14 Abraham LN, Sibilitz KL, Berg SK, et al. Exercise-based cardiac rehabilitation for adults after heart valve surgery. *Cochrane Database Syst Rev*. 2021;5(5):CD010876.

15 Patel DK, Duncan MS, Shah AS, et al. Association of Cardiac Rehabilitation With Decreased Hospitalization and Mortality Risk After Cardiac Valve Surgery. *JAMA Cardiol*. 2019;4(12):1250-9.

16 Ambrosetti M, Abreu A, Corra U, et al. Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. *Eur J Prev Cardiol*. 2021;28(5):460-95.

17 Abreu A, Frederix I, Dendale P, et al. Standardization and quality improvement of secondary prevention through cardiovascular rehabilitation programmes in Europe: The avenue towards EAPC accreditation programme: A position statement of the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology (EAPC). *Eur J Prev Cardiol*. 2021;28(5):496-509.

18 Budts W, Pieles GE, Roos-Hesselink JW, et al. Recommendations for participation in competitive sport in adolescent and adult athletes with Congenital Heart Disease (CHD): position statement of the Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC) Working Group on Adult Congenital Heart Disease and the Sports Cardiology, Physical Activity and Prevention

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J*. 2020;41(43):4191-9.

19 Wang Z, Zhang Y, Wang Y, et al. Kinesiophobia and its associated factors in patients with coronary heart disease: a cross-sectional study based on latent feature analysis. *BMJ Open*. 2023;13(7):e072170.

20 Zhang X, Zhao Q, Wang M, et al. Fear of movement and its associated psychosocial factors in heart failure patients: a cross-sectional study. *Eur J Cardiovasc Nurs*. 2023;22(3):273-81.

21 xiaotong HXHFH. White book of Chinese cardiovascular surgery and extracorporeal circulation in 2020. *Chinese Journal of Extracorporeal Circulation*. 2021;19(05):257-60.

22 Ding Y, Pan Y, Wang M, et al. Factors influencing kinesiophobia during the "blanking period" after radiofrequency catheter ablation in patients with atrial fibrillation by the fear-avoidance model. *Int J Cardiol*. 2022;363:49-55.

23 Wang H, Hu F, Lyu X, et al. Kinesiophobia could affect shoulder function after repair of rotator cuff tears. *BMC Musculoskelet Disord*. 2022;23(1):714.

24 Zhou M, Thayer WM, Bridges JFP. Using Latent Class Analysis to Model Preference Heterogeneity in Health: A Systematic Review. *PharmacoEconomics*. 2017;36(2):175-87.

25 Damar HT, Bilik O, Baksi A, et al. Examining the relationship between elderly patients' fear of falling after spinal surgery and pain, kinesiophobia, anxiety, depression and the associated factors. *Geriatr Nurs*. 2021;42(5):1006-11.

26 LEI Mengjie LT, XIONG Siqi, SANG Ming, JIN Changde. Reliability and validity test of Chinese version of the Tampa Scale for Kinesiophobia Heart. *Chinese Nursing Management*.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

2019;19(11):1637-42.

27 M L Hickey SVO, R D Froman. Instrument development: cardiac diet and exercise self-efficacy. *NURSING RESEARCH*. 1992;Nov-Dec;41(6):347-51.

28 Sun Yuxiao ZC, Zhu Yan,Yang Zhiyun,Tang Baoxin,Chen Jie, Zhang Yueyu. The Chinesization and reliability and validity test of the Cardiac Exercise Self-Efficacy Instrument. *Chinese Journal of Modern Nursing*. 2021;27(32):6.

29 Shuiyuan X. Theoretical basis and research application of social support rating Scale. *Journal of Clinical Psychiatry*. 1994;Apr;39(3):315-25.

30 E. M. A. SMETS BG, t B. BONKE and J. C. J. M. DE HAES. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *Journal of Psychosomatic Research*. 1995;39(3):315-25.

31 Herrmann C. International experiences with the Hospital Anxiety and Depression Scale--a review of validation data and clinical results. *Journal of Psychosomatic Research*. 1997;Jan;42(1):17-41.

32 Kasaeyan Naeini E, Subramanian A, Calderon M-D, et al. Pain Recognition With Electrocardiographic Features in Postoperative Patients: Method Validation Study. *Journal of Medical Internet Research*. 2021;23(5).

33 Alwekhyan SA, Alshraideh JA, Yousef KM, et al. Nurse-guided incentive spirometry use and postoperative pulmonary complications among cardiac surgery patients: A randomized controlled trial. *Int J Nurs Pract*. 2022;28(2):e13023.

34 Shruti Prabhakaran Nair RH, Vijayendra Rajguru. Evaluation of Fear Avoidance Belief and Kinesiophobia in Patients after Undergoing InPatient Cardiac Rehabilitation Post Cardiac

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

Surgery. *International Journal of Health Sciences & Research*. 2018.

35 Turan A, Duncan A, Leung S, et al. Dexmedetomidine for reduction of atrial fibrillation and delirium after cardiac surgery (DECADE): a randomised placebo-controlled trial. *Lancet*. 2020;396(10245):177-85.

36 Shi J, Zhou C, Pan W, et al. Effect of High- vs Low-Dose Tranexamic Acid Infusion on Need for Red Blood Cell Transfusion and Adverse Events in Patients Undergoing Cardiac Surgery: The OPTIMAL Randomized Clinical Trial. *JAMA*. 2022;328(4):336-47.

37 Khamis RY, Ammari T, Mikhail GW. Gender differences in coronary heart disease. *Heart*. 2016;102(14):1142-9.

38 Townsend N, Kazakiewicz D, Lucy Wright F, et al. Epidemiology of cardiovascular disease in Europe. *Nat Rev Cardiol*. 2022;19(2):133-43.

39 Cifkova R. Gender differences in secondary prevention of coronary heart disease: Far from closing the gap. *Int J Cardiol*. 2022;355:52-3.

40 Grant SW, Ouzounian M. Closing the gender gap in cardiac surgery outcomes: more work to be done. *Eur J Cardiothorac Surg*. 2022;61(3):703-4.

41 Ferrannini G, De Bacquer D, Vynckier P, et al. Gender differences in screening for glucose perturbations, cardiovascular risk factor management and prognosis in patients with dysglycaemia and coronary artery disease: results from the ESC-EORP EUROASPIRE surveys. *Cardiovasc Diabetol*. 2021;20(1):38.

42 Chen J, Guo W, Liu H, et al. Translation and psychometric evaluation of a scale to measure the fear of activity in Chinese patients with coronary artery disease. *Nurs Open*. 2023;10(6):4033-43.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

43 Back M, Caldenius V, Svensson L, et al. Perceptions of Kinesiophobia in Relation to Physical Activity and Exercise After Myocardial Infarction: A Qualitative Study. *Phys Ther*. 2020;100(12):2110-9.

44 Craske MG, Niles AN, Burklund LJ, et al. Randomized controlled trial of cognitive behavioral therapy and acceptance and commitment therapy for social phobia: outcomes and moderators. *J Consult Clin Psychol*. 2014;82(6):1034-48.

45 Bullock GS, Sell TC, Zarega R, et al. Kinesiophobia, Knee Self-Efficacy, and Fear Avoidance Beliefs in People with ACL Injury: A Systematic Review and Meta-Analysis. *Sports Med*. 2022;52(12):3001-19.

46 Larsson C, Ekvall Hansson E, Sundquist K, et al. Kinesiophobia and its relation to pain characteristics and cognitive affective variables in older adults with chronic pain. *BMC Geriatrics*. 2016;16(1).

47 Alpalhao V, Cordeiro N, Pezarat-Correia P. Kinesiophobia and Fear Avoidance in Older Adults: A Scoping Review on the State of Research Activity. *J Aging Phys Act*. 2022;30(6):1075-84.

48 Gunn AH, Schwartz TA, Arbeeva LS, et al. Fear of Movement and Associated Factors Among Adults With Symptomatic Knee Osteoarthritis. *Arthritis Care Res (Hoboken)*. 2017;69(12):1826-33.

49 Archer KR, Devin CJ, Vanston SW, et al. Cognitive-Behavioral-Based Physical Therapy for Patients With Chronic Pain Undergoing Lumbar Spine Surgery: A Randomized Controlled Trial. *J Pain*. 2016;17(1):76-89.

50 Reinking S, Seehusen CN, Walker GA, et al. Transitory kinesiophobia after sport-related

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

concussion and its correlation with reaction time. *J Sci Med Sport*. 2022;25(1):20-4.

51 Back M, Lundberg M, Cider A, et al. Relevance of Kinesiophobia in Relation to Changes Over Time Among Patients After an Acute Coronary Artery Disease Event. *J Cardiopulm Rehabil Prev*. 2018;38(4):224-30.

52 Mudumbai SC, Kim TE, Howard SK, et al. An ultrasound-guided fascia iliaca catheter technique does not impair ambulatory ability within a clinical pathway for total hip arthroplasty. *Korean J Anesthesiol*. 2016;69(4):368-75.

53 Feng S, Xie B, Li Z, et al. Retrospective Study on the Application of Enhanced Recovery After Surgery Measures to Promote Postoperative Rehabilitation in 50 Patients With Brain Tumor Undergoing Craniotomy. *Front Oncol*. 2021;11:755378.

54 Daskivich TJ, Houman J, Lopez M, et al. Association of Wearable Activity Monitors With Assessment of Daily Ambulation and Length of Stay Among Patients Undergoing Major Surgery. *JAMA Netw Open*. 2019;2(2):e187673.

55 Piao JJ, Gu Y, Ling Y, et al. Mediating effect of kinesiophobia between self-efficacy and physical activity levels in post-CABG patients: protocol for a prospective, multicentre, cross-sectional study in China. *BMJ Open*. 2022;12(7):e062013.

56 Du S, Hu L, Bai Y, et al. The Influence of Self-Efficacy, Fear-Avoidance Belief, and Coping Styles on Quality of Life for Chinese Patients with Chronic Nonspecific Low Back Pain: A Multisite Cross-Sectional Study. *Pain Pract*. 2018;18(6):736-47.

57 Schwarzer R, Antoniuk A, Gholami M. A brief intervention changing oral self-care, self-efficacy, and self-monitoring. *Br J Health Psychol*. 2015;20(1):56-67.

58 Lin AW, Dollahite JS, Sobal J, et al. Health-related knowledge, beliefs and self-efficacy in

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

women with polycystic ovary syndrome. *Hum Reprod*. 2018;33(1):91-100.

59 ZYT SY. Influence Path of Self-efficacy and Coping Methods on Self-care Behaviors of Patients with Chronic Cardiac Failure. *Nursing Journal Of Chinese Peoples Liberation Army*. 2017;2023-12-21.

60 Meng Y, Deng B, Liang X, et al. Effectiveness of self-efficacy-enhancing interventions on rehabilitation following total hip replacement: a randomized controlled trial with six-month follow-up. *Journal of Orthopaedic Surgery and Research*. 2022;17(1).

61 Kroemeke A, Sobczyk-Kruszelnicka M. Interaction effect of coping self-efficacy and received support in daily life of hematopoietic cell transplant patient-caregiver dyads. *PLoS One*. 2021;16(11):e0260128.

62 Egerton T, Bennell KL, McManus F, et al. Comparative effect of two educational videos on self-efficacy and kinesiophobia in people with knee osteoarthritis: an online randomised controlled trial. *Osteoarthritis Cartilage*. 2022;30(10):1398-410.

63 Asiri F, Reddy RS, Tedla JS, et al. Kinesiophobia and its correlations with pain, proprioception, and functional performance among individuals with chronic neck pain. *PLoS One*. 2021;16(7):e0254262.

64 Johan W.S. Vlaeyen SJL. Fear-avoidance and its consequences in chronic musculoskeletal pain:

a state of the art. *Pain*. 2000;85 (2000) 317-332.

65 Giusti EM, Lacerenza M, Manzoni GM, et al. Psychological and psychosocial predictors of chronic postsurgical pain: a systematic review and meta-analysis. *Pain*. 2021;162(1):10-30.

66 Tan M, Liu Y, Zhao R, et al. The effect of pain social support on kinesiophobia in older

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

patients with rheumatoid arthritis: The mediating role of self-perceived burden. *Geriatr Nurs*. 2023;50:52-7.

67 Keessen P, Latour CHM, van Duijvenbode ICD, et al. Factors related to fear of movement after acute cardiac hospitalization. *BMC Cardiovasc Disord*. 2020;20(1):495.

68 SY X. The theoretical basis and application of social support questionnaire. *clinical Psychol medical*. 1994;(1994) 4:98–100.

69 C P Langford JB, J P Maloney, P P Lillis. Social support:a conceptual analysis. *Journal of advanced nursing*. 1997;25,95-100.

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

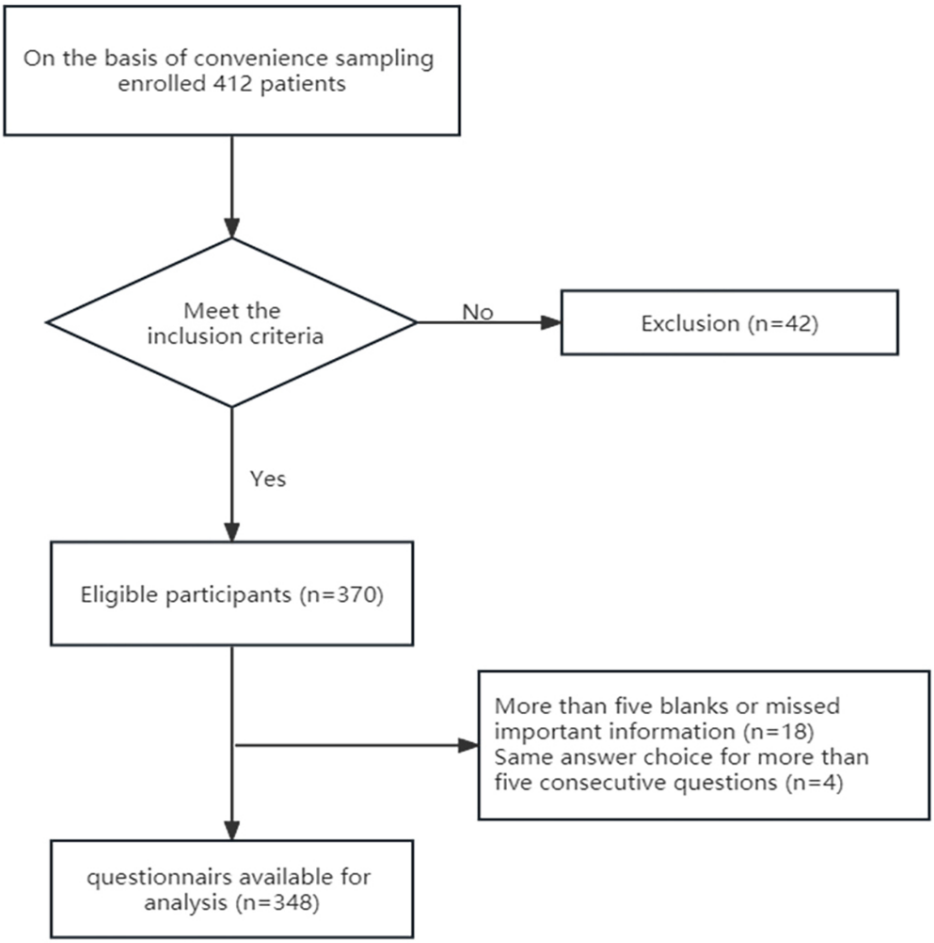

Figure 1. Flow diagram of participants

90x90mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

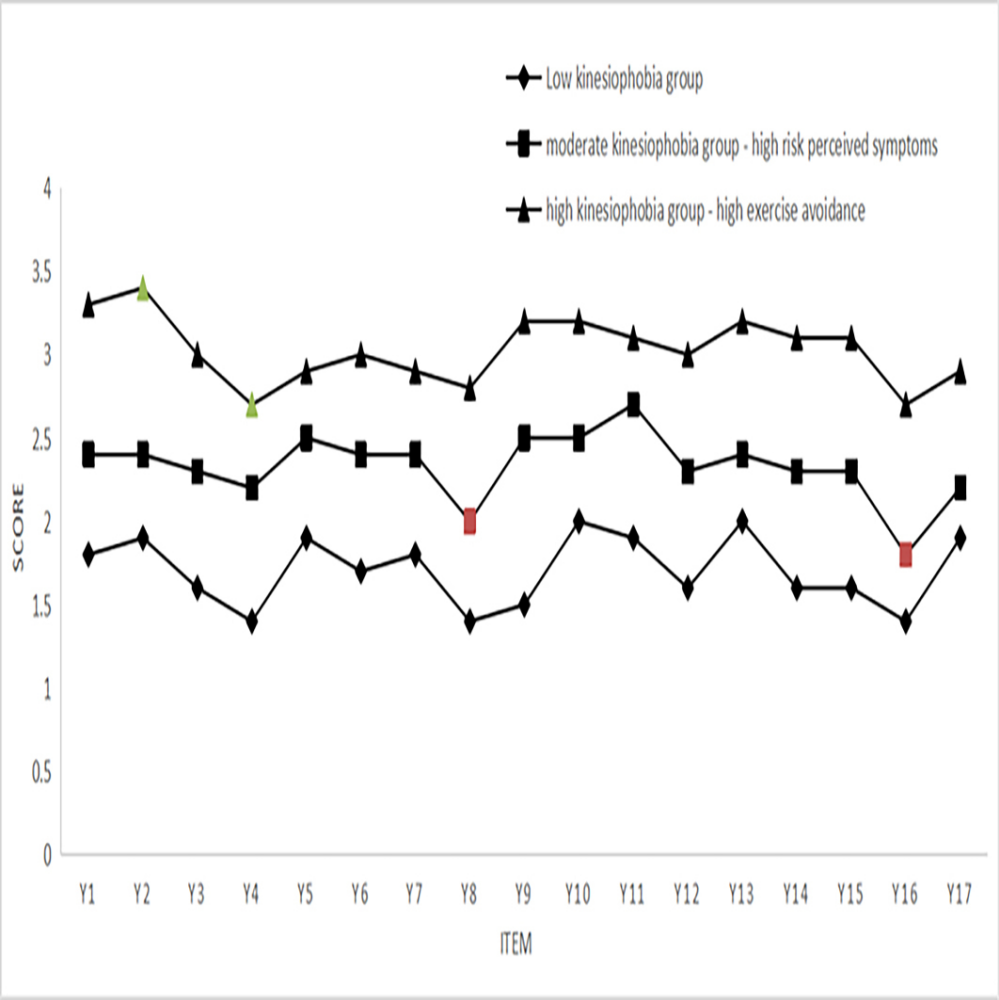

Figure 2. Latent profile analysis classification

90x90mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Supplementary Table 1 Characteristics of study population (n = 348)

Characteristics	
Age	
18-45	32（9.20%）
46-65	151（43.39%）
66-75	165（47.41%）
Sex	
Male	248（71.26%）
Female	100（28.74%）
Educational level	
Primary school or lower	176 (50.57%)
High school	127 (36.49)
University and above	45 (12.93)
Marital status	
Married	312(89.66%)
Unmarried	36 (10.34%)
Average monthly income (RMB)	
≤1500	49 (14.08%)
1501-3500	122 (35.06%)
3501-5500	96 (27.59%)
≥5500	81 (23.28%)
Current residence	
Village	111 (31.90%)
City	237 (68.10%)
Smoking	
Never	139 (39.94%)
Past	183 (52.59%)
Current	26 (7.47%)
Alcohol	
Never	142 (40.80%)
Past	173 (49.71%)
Current	33 (9.48*)
Surgical approach	
Conventional surgery	247 (70.98%)
Sternum sparing	101 (29.02%)
Postoperative time (Months)	
3-6	165 (45.19%)
7-12	119 (34.44%)
13-18	53 (16.30%)
19-24	11 (3.33%)

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

Supplementary Table 2. Single-factor analysis of potential classification impact factors (n = 348)

Variables		LKG (%)[1]	MK-HRPSG[2](%)	HK-HEAG[3] (%)	F/χ^2	P
Gender	Male	47(65.52)	110(74.42)	100(78.57)	3.694	0.055
	Female	25(34.48)	38(25.58)	28(21.43)		
Age	18-45	20（27.78）	71（47.97）	49(38.28)	7.582	**<0.05**
	46-65	42（58.33）	58（39.19））	42(32.81)		
	66-75	10（13.89）	19（12.84）	37(28.90)		
Educational level	Primary school or lower	39（54.16）	101（68.24）	85(66.40)	1.391	0.250
	High school	25（34.72）	28（18.92）	35(27.34)		
	University and above	8（11.12）	19（12.84）	8(6.26)		
Marital status	Married	64(89.66)	131(88.37)	119(92.86)	1.860	0.157
	Unmarried	8(10.34)	17(11.63)	9(7.14)		
Vocational type	Brainwork	29(40.27)	21(13.95)	36(28.57)	1.208	0.300
	Physical labor	22(30.56)	50(33.78)	36(28.57)		
	Retirement	21(29.17)	77(52.27)	56(42.86)		
Average monthly income (RMB)	≤1500	14(19.44)	42(28.38)	25(19.53)	0.133	0.940
	1501-3500	10(13.88)	56(37.84)	24(18.75)		
	3501-5500	22(30.56)	27(18.24)	40(31.25)		

[1] low kinesiophobia group(LKG）
[2] moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG)
[3] high kinesiophobia - high exercise avoidance group(HK-HEAG)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

	≥5500	26(36.12)	23(15.54)	39(30.47)		
Current residence	Village	20(27.59)	43(29.05)	23(17.97)	3.319	0.069
	City	52(72.41)	105(70.95)	105(82.03)		
Smoking	Never	31(43.06)	24(16.21)	46(35.94)	0.513	0.599
	Past	35(48.61)	63(42.57)	68(53.12)		
	Current	6(8.33)	61(41.22)	14(10.94)		
Alcohol	Never	37(51.72)	62(41.86)	50(39.29)	1.376	0.254
	Past	30(41.38)	71(48.84)	64(50.00)		
	Current	5(6.90)	15(9.30)	14(10.71)		
Surgery	Coronary artery bypass graft	67(93.06)	118(79.73)	119(92.86)	0.448	0.504
	Valvular surgery	5(6.94)	30(20.27)	9(7.14)		
Surgical approach	Conventional surgery	48(68.97)	117(79.07)	87(67.86)	0.063	0.802
	Sternum sparing	24(31.03)	31(20.93)	41(32.14)		
Postoperative time (Months)	3-6	28(38.89)	40(27.03)	27(21.09)	6.257	**<0.05**
	7-12	17(23.61)	49(33.10)	66(51.56)		
	13-18	19（26.39）	48(32.43)	23(17.97)		
	19-24	8（11.12）	11(7.44)	12(9.38)		
Self-efficacy		46.62±7.51	50.08±6.55	55.68±4.26	4.704	**<0.05**
Fatigue		44.20±5. 41	43.71±5.45	43.15±4.96	0.905	0.581
Pain		5.26±1.28	6.55±1.51	7.31±1.54	12.572	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Anxiety & depression	11.59±4.35	12.16±6.23	12.82±6.31	1.090	0.347
Social support	36.95±8.27	47.35±8.41	49.14±8.25	5.156	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Supplementary Table 3: Multiple Logistic regression analysis of potential classification factors

		Moderate kinesiophobia -high risk perceived symptoms				High kinesiophobia -high exercise avoidance			
		B	Standard error	Wald χ^2	*p*	B	Standard error	Wald χ^2	*p*
Age	18-45	0.565	0.486	1.274	0.261	1.554	1.301	1.876	0.189
	46-65	2.245	0.855	6.545	0.014	2.016	0.876	5.223	0.021
	66-75	1.186	0.866	1.798	0.174	1.667	0.613	6.211	0.013
Postoperative time (Months)	3-6	-2.267	0.465	16.956	＜0.001	-3.246	0.655	20.366	＜0.001
	7-12	-1.506	0.438	12.122	＜0.001	-2.922	0.721	17.627	＜0.001
	13-18	-1.236	0.403	8.262	0.018	-1.965	0.668	8.874	0.016
	19-24	-0.783	0.519	2.235	0.127	-1.865	0.626	8.487	0.012
Self-efficacy		-3.134	0.671	8.332	0.017	-2.554	1.626	1.688	0.032
Pain		1.887	0.609	10.596	0.016	1.732	0.633	11.227	0.011
Social support		-1.102	0.421	7.306	0.026	-1.174	0.846	1.936	0.176

For peer review only

Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

classification	factor	B	Standard error	*p*	OR（95%CI）

For peer review only

Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

BMJ Open

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-083909.R2
Article Type:	Original research
Date Submitted by the Author:	09-Dec-2024
Complete List of Authors:	Xing, Wenhui; The Sixth Medical Centre of PLA General Hospital; Hebei University of Chinese Medicine Piao, jing; Kobe University Graduate School of Health Sciences Ren, Tong; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Liang, Yujing; The Sixth Medical Centre of PLA General Hospital, Department of Cardiovascular Surgery Li, Qi; Hebei University of Chinese Medicine Gu, Yanmei; Hebei Key Laboratory of Health Care with Traditional Chinese Medicine; Hebei University of Chinese Medicine Wang, Rong; Sixth Medical Center of PLA General Hospital, Department of Cardiovascular Surgery
Primary Subject Heading:	Nursing
Secondary Subject Heading:	Cardiovascular medicine
Keywords:	Coronary heart disease < CARDIOLOGY, Cross-Sectional Studies, MENTAL HEALTH, Nursing Care

SCHOLARONE™
Manuscripts

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation in China: latent profile and influencing factors analysis from a cross-sectional study

Authors

Wenhui Xing[1,2$], Jingjing Piao[3 $], Tong Ren[1], Yujing Liang[1], Qi Li [2], Yanmei Gu[2*], Rong Wang[1*]

Affiliations

[1] Department of Cardiovascular Surgery, The Sixth Medical Centre of PLA General Hospital, Beijing, CHN

[2] Faculty of Nursing, Hebei University of Chinese Medicine, Shijiazhuang, CHN

[3] Department of Rehabilitation Science, Kobe University Graduate School of Health Sciences, Kobe, JP

Corresponding author

*Rong Wang, The Sixth Medical Centre of PLA General Hospital, 3 Fucheng Road, Haidian District, Beijing, China

Email: wangrongd@126.com

Telephone: +86-010-66951518

*Yanmei Gu, Faculty of Nursing, Hebei University of Chinese Medicine 3 Xingyuan Road, Shijiazhuang,China

E-mail: guyanmei@hebcm.edu.cn

Telephone: +86-0311-89926338

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

Keywords Kinesiophobia; research design; cardiac surgical procedures; extracorporeal circulation; logistic regression

Number of words 4532

ABSTRACT

Objective: To investigate the potential classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation from a psychosocial perspective, and analyze the characteristic differences among different latent levels of patients.

Study design: This is a cross-sectional study of Chinese adults after cardiac surgery under extracorporeal circulation, aged over 18 years and older, recruited from a tertiary hospital in North China.

Methods: This study utilizes Latent Profile Analysis to identify potential classifications of kinesiophobia in questionnaires from 348 patients undergoing cardiac surgery under extracorporeal circulation. Multiple logistic analysis was used to evaluate the influencing factors at different latent classifications.

Results: The average performance of each indicator in Model 3 is best suited for analysis, Entroy=0.873 and BLRT(P) < 0.0001.The result of regression equation shows postoperative time (P<0.001), age, self-efficacy, pain, and social support level (P< 0.05) were the factors influencing the potential profile classification of patients after cardiac surgery under

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

extracorporeal circulation.

Conclusion: The study identified three distinct classifications of patients: low kinesiophobia group, the moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG) and high kinesiophobia - high exercise avoidance group (HK-HEAG). Addressing kinesiophobia, especially in older male patients during the early postoperative period, is crucial. Enhancing self-efficacy seems effective in reducing kinesiophobia, while increasing social support may not be as beneficial for the HK-HEAG group. These findings provide a basis for implementing preventive interventions in cardiac rehabilitation.

Trial registration number: Chinese Clinical Trial Registry (ChiCTR2200057895).

Keywords: Kinesiophobia; research design; cardiac surgical procedures; extracorporeal circulation; logistic regression

STRENGTHS AND LIMITATIONS OF THIS STUDY

1、 It is a comprehensive investigation conducted in China, specifically examining the factors that potentially influence the level of kinesiophobia in patients who have undergone cardiac surgery with extracorporeal circulation.

2、 This study indicatively uses LPA to classify kinesiophobia of patients after cardiac surgery under extracorporeal circulation.

3、 Self-report questionnaires in data collection may influence the

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

assessment of kinesiophobia in an objective approach.

4、 The adaptability of this model is limited to Chinese background.

INTRODUCTION

Kinesiophobia is defined as an irrational and excessive fear of carrying out a physical movement. [1] Previous studies have reported that psychological factors, such as kinesiophobia, are a significant barrier to patient participation in cardiac rehabilitation (CR). [2-6] In the context of cardiac disease, it is mostly described as a fear of physical activity due to the apprehension of worsening cardiac disease or the possibility of inducing adverse outcomes. Kinesiophobia was detected in 65% of individuals with chronic heart failure and in 86.26% of patients with a first-time acute myocardial infarction. [7,8] According to a previous study, high levels of kinesiophobia can negatively impact not only the performance of daily activities but also CR engagement. [9]

Research has shown that kinesiophobia has an influence and intermediate role on attendance at CR. [1]As a mediator, kinesiophobia is influenced by predictive factors and has indirect effects. General health and muscle endurance increased the probability of attendance at CR, while self-rated anxiety had the opposite effect. There have been studies exploring whether there are positive changes in kinesiophobia based on CR, with higher levels of aerobic capacity and lower levels of physical activity compared to patients with low levels of kinesiophobia. Results showed a

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

significant reduction in kinesiophobia after a exercise-based CR program. [10] CR is an important step in the recovery process after cardiac surgery. CR is a comprehensive strategy that is aimed at improving a person's physical, psychological, and social functioning. [11-13] Studies have shown that exercise-based CR can not only reduce mortality and hospital admissions for cardiovascular disease but also improve quality of life and mental well-being. [12,14,15] CR's effectiveness and importance are recommended as level IA by most international cardiovascular societies. [16-18]

Kinesiophobia is a psychological disorder, we should pay more attention to those subjective factors that are self-influenced and in constant change. In a potential profile analysis of kinesiophobia in patients with coronary heart disease, [19]objective demographic information was included in the analysis, and the results showed that patients could be divided into three potential types: 'low fear type', 'intermediate fear type' and 'high fear type'. However, among the influencing factors of kinesiophobia, objective factors cannot be interfered with by medical staff. In addition, research supports that kinesiophobia is positively correlated with age , [19] but the explanation for these potential differences in age has not been studied. From the perspective of social psychology, the research results of Xiuting [20] showed that it was important to alleviate kinesiophobia for patients with low subjective social status, but the

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

mechanism of how social support produced positive effects in different kinesiophobia classifications has not been clarified. Clinical professionals should collect objective influence factors as predictive factors, focusing on targeted interventions based on the patient's own subjective factors.

Few studies have investigated the effects of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. The number of cardiac surgeries has increased tremendously in recent years. In China, cardiac surgery volume increased by 8% in 2020 compared to 2012. [21] Extracorporeal circulation replaces cardiopulmonary function in a non-physiological way during cardiac surgery, and the lung function of patients is significantly decreased after the operation,[22,23] while the blood is in a hypercoagulable state after the operation and there is a risk of thrombosis.[24] Exercise is the main form of cardiac rehabilitation, and early postoperative activity is beneficial to patients to reduce postoperative pulmonary complications and thrombotic events. [25,26] However, due to various reasons, patients with kinesiophobia caused the decline of exercise compliance.[1]The factors of kinesiophobia are complex and highly heterogeneous. From the social psychology perspective, the classification of kinesiophobia in patients after cardiac surgery under extracorporeal circulation has not been well characterized. Previous studies[27,28]mainly evaluated patients' kinesiophobia classification from the total score of the scale, which may have the same total score but the score of each item varies

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

greatly. This study fills that gap. Latent profile analysis (LPA) is an "individual-centric" statistical analysis method that can homogenize sequential data, explore the characteristics of groups without categories and ethnic differences in groups, and then analyze their respective influence factors in different subgroups. [29] We hypothesized that patients with kinesiophobia after cardiac surgery could be accurately divided into three subgroups using the LPA method, and the features between the groups were well distinguished. According to the classification results of this study, it provides a reliable reference for clinical medical staff to intervene in kinesiophobia.

MATERIALS AND METHODS

Study design

In this cross-sectional study, subgroups of kinesiophobia characteristics and associated factors in patients after heart surgery were investigated. All participants were recruited from a tertiary hospital in North China and completed the questionnaire from April 2022 to April 2023.

Ethical approval

The Medical Ethics Committee of The Sixth Medical Centre of PLA General Hospital granted ethical permission for this investigation （HZKY-PJ-2022-2）. Participants first read the form for informed consent and selected "I agree" if they chose to participate in the study. They

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

were informed that the responses would remain anonymous and that no personal information would be disclosed. The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Participants

Participants who met the inclusion criteria were provided with information about the study prior to inclusion, consent and willingness to engage in this study after being fully informed of its objectives.

Meet the following inclusion and exclusion criteria:

Inclusion criteria

(a) Advised by the doctor to participate in CR.

(b) Patients who underwent cardiac surgery under extracorporeal circulation （e.g. Coronary artery bypass grafting and cardiac valve replacement）three months prior to the survey

(c) Adults aged 18-75 years

(d) Conscious, mentally and psychologically competent, and able to complete the questionnaire;

Exclusion criteria

(a)With a contraindication to CR (e.g. uncontrollable or unstable angina, severe arrhythmias, etc.);

(b) Refusal to provide personal information to participate in the questionnaire.

(c) Recently, severe family events (e.g. malignancy); psychological

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

instability; people who actively express depressive anxiety tendencies and are suspicious of mild cognitive impairment.

Study tools

Sociodemographic questionnaire

Sociodemographic data were collected, including gender, age, education level, marital status, vocational type, average monthly household income, current residence, smoking status, alcohol consumption, surgical operation approach, and postoperative time.

Tampa Scale for Kinesiophobia Heart (TSK-SV Heart)

The Chinese version of the TSK-SV Heart was used to assess the kinesiophobia levels of patients. [30]This scale consists of 17 items that assess danger, fear, avoidance, and dysfunction. The questions were evaluated using a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). A score of 37 or higher indicates a high level of kinesiophobia. [9,31]

Cardiac Exercise Self-efficacy Instrument (CESEI)

The CESEI was developed by Hickey et al. to measure exercise self-efficacy in CR patients. [32] In 2021, a Chinese version of CESEI was developed through translation, back translation, and cultural adjustment. [33] The Chinese version of the CESEI includes 16 items corresponding to one dimension, which are scored on a scale of 1-5. The total score is determined by the sum of the item scores. The higher the score, the higher

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

the patient's self-efficacy in CR. The Cronbach's alpha for the Chinese version of the CESEI is 0.941.

Social Support Rating Scale (SSRS)

The SSRS was used to examine the levels of social support among the participants. [34]The SSRS comprises 10 items divided into three categories: objective support, subjective support, and social support use. Low, medium, and high levels of social support are represented by total scores of 0–22, 23–44, and 45–66, respectively. The Cronbach's alpha of the scale is 0.81.

Multidimensional Fatigue Inventory (MFI-20)

The MFI-20 was used to determine participants' fatigue levels. [35] General weariness, physical fatigue, reduced activity, diminished motivation, and mental fatigue are the five categories of the MFI-20. Responses were given using a five-point Likert scale ranging from 1 (yes, this is true) to 5 (no, this is not true). This scale has a Cronbach's alpha of 0.882, and it is regularly used to assess patient weariness with good reliability.

Hospital Anxiety and Depression Scale (HADS)

The HADS was used to determine the level of anxiety and depression in participants. [36] The HADS comprises 14 items with four possible answers ranging from 0 to 4, as well as two subscales, anxiety and depression. The HADS score indicates the severity of anxiety or depression.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

The higher the HADS score, the more severe the anxiety or sadness. This scale has been tested in a variety of countries.

Numerical Rating Scale (NRS)

The NRS is accurate, concise, and more feasible. It was once considered the gold standard for pain assessment by the American Pain Society. [37] Patients are asked to select a single number representing the intensity of their pain on a scale of 1-11 (0=no pain, 10=worst pain). A score of 7-8 is classified as severe pain, indicating that the pain is intense.

STATISTICAL ANALYSIS

The statistical analysis was conducted using SPSS 22.0 software. For normally distributed quantitative data, descriptive statistics were presented as mean ± standard deviation (x ± s), and group comparisons were performed using differential analysis. Qualitative data were described using frequencies and percentages, and group comparisons were performed using the $\chi 2$ test. To establish a latent profile analysis model, Mplus 8.3 software was utilized. The TSK-SV heart score of patients after heart surgery was used as the model's observed variable. The initial model category was set to 1, and the number of model level was gradually increased. Model fit was assessed using various criteria, including the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Sample-Size-Adjusted BIC (aBIC), Entropy Index, Lo-Mendell Rubin Likelihood Ratio Test (LMRT), and Bootstrap Likelihood Ratio Test

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

(BLRT). Smaller values of AIC, BIC, and aBIC indicate better model fit. A higher entropy value closer to 1 suggests a higher probability of accurate individual classification. LMRT and BLRT were used to compare the fit of k individual models to k-1 models. Based on the results of the latent profile analysis of kinesiophobia, a multiple logistic analysis was performed to explore the factors influencing the latent profile classification of patients' kinesiophobia after heart surgery. The statistical tests were two-tailed, and a difference of $P < 0.05$ was considered statistically significant.

RESULTS

Convenience sampling was employed with 412 participants underwent cardiac surgery under extracorporeal circulation enrolled. Forty-two participants were excluded according to the inclusion and exclusion criteria with 370 eligible participants left. Eighteen questionnaires had more than five blanks or missed important information, while another four questionnaires had same answer choice for more than five consecutive questions. All the above 22 questionnaires had been excluded. Finally, 348 questionnaires left for analysis (Figure 1).

insert figure 1. Flow diagram of participants

Demographic characteristics of the participants

In the current study, 248 males (71.26%) and 100 females (28.74%) aged 18-45 years (18.97%), 46-65 years (40.80%), 66-75 years (40.23%) participants were included. 252 participants (72.41%) underwent

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

conventional approach while 101 participants (27.58%) used sternum sparing approach. 95 participants (27.29%) were at 3-6 months postoperative, 132 participants (37.93%) at 7-12 months, 90 patients (25.86%) at 13-18 months, and 31 patients (8.90%) at 19-24 months. Detail characteristics of the participants are displayed in Supplemental Table 1.

insert Supplemental Table 1 .Characteristics of study population

Latent profile analysis of the participants' kinesiophobia scores

Latent profile analysis was conducted to identify the heterogeneity of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. Four models were initially constructed based on model fit indicators AIC, BIC, aBIC, entropy, LMRT and BLRT. As the classification number increasing (**Supplemental Table 2**), the AIC, BIC, and aBIC values gradually decreased and reached a minimum in Model 4 with LMRT value 0.131(>0.05) while the matching indicators in Model 3 all fit well (<0.05). Furthermore, there was no cross in the three level as shown in **Figure 2**. Therefore, Model 3 of kinesiophobia after heart surgery was accepted in the current study.

insert Supplemental Table 2. Model fitting indexes of all potential classification of kinesiophobia after cardiac surgery under extracorporeal circulation

insert figure 2. Latent profile analysis classification

In Model 3 the different groups were named as the low kinesiophobia

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

group (LKG), the moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG) and high kinesiophobia - high exercise avoidance group (HK-HEAG). The LKG (72/348, 20.6%) had low scores in all items. TSK-SV Heart scored (34.08±4.12) .The MK-HRPSG (148/348, 42.6%) had moderate scores on all items. TSK-SV Heart scored (48.91±7.07) . The HK-HEAG (128/348, 36. 8%) had high scores in all items. TSK-SV Heart scored (51.81±6.07) .

One-way analysis of variance of different potential classification impact factors

There were differences in different potential classifications of kinesiophobia in participants, and there were statistically significant differences in the degree distribution of age, postoperative time, pain, social support and self-efficacy ($p< 0.05$) , as showed in Supplemental Table 3.

insert Supplemental Table 3. Single-factor analysis of potential classification impact factors

Multiple logistic regression analysis of potential classification factors

Taken LKG as a reference to conduct disordered multi-classification logistic regression analysis, the classifications of kinesiophobia were taken as dependent variable, with significant variables in the above analysis as independent variables and covariables. The results showed that age, postoperative time, self-efficacy, pain and social support were factors

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

influencing the potential classification of kinesiophobia (p<0.05), as shown in Supplemental Table 4.

insert Supplemental Table 4. Multiple Logistic regression analysis of potential classification factors

DISCUSSION

Characteristics of participants

The data for this study were collected from a tertiary hospital in the country with ample volume of cardiac surgeries In this study, there was a higher proportion of male participants compared to female participants (male: female=2.48:1), which aligns with findings from previous studies. [38-41] It is noteworthy that female participants constitute no more than 30% of the study population in research trials. [40-42]

There are several factors contributing to this gender disparity. Firstly, mortality rates and risk for the most prevalent cardiovascular diseases consistently tend to be higher among men than women; [43] Moreover, women face disparities in wealth, income, and access to resources, which can hinder their timely access to medical care. A study revealed that women with low incomes, low levels of education, and residing in deprived areas are more likely to delay seeking medical attention. [44] Lastly, a lack of awareness among women about the importance of coronary heart disease (CHD) and emergency care contributes to delays in seeking medical attention. [45] A report from the European Heart Survey found

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

that women aged 60 and above were less likely to undergo CABG compared to men, whereas they were more likely to receive PCI, adding to the gender differences in surgical treatment. [46]

Analysis of a 3- classification model of kinesiophobia score

Among the models tested, Model 3 exhibited significant characteristics. As our results indicate, Model 4 had the best-fitting AIC, BIC, and Entroy values. Model 4 allows variances and covariances to be freely estimated and varied across profiles. However, this improvement in fit came at the expense of differences when compared to other models. Model 4 had a lower LMRT value (0.131) in particular. Ultimately, we selected Model 3 due to its relatively low AIC and BIC values, along with a high entropy value of 0.873, suggesting accurate classification of participants into the appropriate profile. Furthermore, the LMRT and BLRT values in Model 3 were low (0.05 and 0.01), indicating good model fit.

The researchers established a score of 37 as the threshold for determining the presence of kinesiophobia. [47] A score of 37 or higher indicates a high level of kinesiophobia. [27] Notably, participants in the LKG group in Model 3 obtained a mean score of (34.08±4.12) , indicating a lower degree of kinesiophobia. This finding aligns with previous studies. [27,48] The MK-HRPS in Model 3 scored lower on items 8 (2.00±0.73) and 16 (1.90±0.75), compared with an average item score of

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

2.33. These items belong to the risk perception dimension. The results suggest that participants in the MK-HRPS group exhibit a heightened perception of risk, which may result in decreased adherence to recommended treatments. [49] In contrast, participants in the HK-HEAG group in Model 3 obtained higher scores on item 2 (3.43±0.55) and lower scores on item 4 (2.86±0.84), compared to the average item score of 3.03. These particular items are indicative of exercise avoidance tendencies. Consequently, participants in the HK-HEAG group in Model 3 may demonstrate greater resistance to and avoidance of physical activity when advised by their doctors regarding exercise prescriptions. [50]

Based on the presented results, Model 3 effectively minimize individual heterogeneity by considering latent traits, resulting in the identification of distinct subgroups. The results of this study showed potential classifications of kinesiophobia, which were mainly affected by age, postoperative time, self-efficacy, pain, and social support.

Factors affecting classification

We observed that age under 45 did not play a role in influencing the classification of kinesiophobia. In this study, age was analyzed categorically as a rank variable, which differed from previous studies that treated age as a continuous variable.[19] Remarkably, our findings emphasized the significance of age above 45, specifically indicating that patients aged over 45 were more likely to exhibit tendencies towards HK-

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

HEAG. These results align with existing research showing higher levels of kinesiophobia among older adults, [51]which is consistent with our research. The increased kinesiophobia with aging can be attributed to factors such as physical frailty, which not only leads to a decrease in energy but also heightens the fear of injury and falling. In addition, it is difficult for the elderly to acquire scientific knowledge about kinesiophobia, [52]which further aggravates exercise avoidance. However, Gunn et al. [53] reported an adverse association between age and kinesiophobia among adults, suggesting that older individuals may have more available time and exercise experience, which reduces their anxiety towards potentially harmful activities. It is important to note that generalizing findings based on age is not appropriate, as age under 45 did not prove to be a significant factor in our study. Future studies should focus on exploring the kinesiophobia classification in older adults.

There is a time effect of kinesiophobia in the postoperative period. Our study discovered that the period between 3 to 6 months after surgery is a critical time frame for kinesiophobia concerns. The level of kinesophobia decreased with the increase in postoperative time, [54,55] and postoperative time was not a factor affecting the classification of kinesophobia after 6 months. The longer the postoperative period, the less likely they were to be classified as HK-HEAG. This finding aligns with previous studies conducted on patients following an acute coronary artery

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

disease event, which reported that kinesiophobia scores were highest (32.5) at baseline, decreasing to 30.9 after two weeks and 30.1 after four months, suggesting a decline in kinesiophobia over time. [56] This trend may be due to the gradual recovery of exercise capacity and cardiac function over time, as patients can gradually tolerate increased exercise and feel the benefits of participating in it. Early postoperative activity has been shown to improve functional recovery time , [57]especially through early postoperative activities on the floor. Clinical staff should help patients overcome their kinesiophobia as early as possible to promote their engagement in cardiac rehabilitation as soon as possible, to improve their cardiopulmonary function, to reduce the incidence of postoperative venous thrombosis, [58] and to minimize the length of hospital stay. [59]

Self-efficacy plays an important role in kinesiophobia classifications. [60] In our study, we observed a negative association between self-efficacy and kinesiophobia, which aligns with previous research findings. [53,61] Patients with high self-efficacy scores were more likely to be classified as MK-HRPSG. According to Ralf Schwarzer's theory, individuals with low self-efficacy face difficulties accepting their health status and have lower confidence and expectations regarding exercise.[62] They exhibit extreme reluctance to seek help when faced with unexpected traumatic events during exercise and are more prone to kinesiophobia. [63] However, patients with high self-efficacy demonstrate favorable psychological

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

adaptation and coping skills when faced with heart surgery, enabling them to approach challenges more proactively. [64]Consequently, enhancing self-efficacy is an effective measure for preventing and alleviating kinesiophobia, and various interventions focused on increasing self-efficacy are currently available in postoperative settings. [65-67] Further studies are needed to determine whether their use in patients undergoing cardiac surgery results in positive outcomes. Additionally, the inclusion of pain measurements in kinesophobia assessments is essential. [68] The fear-avoidance model theory suggests that if patients perceive pain as a frightening stimulus and experience an exacerbation of pain, they adopt negative coping mechanisms to avoid activities that trigger pain, thus exhibiting kinesophobia. [69] Therefore, it is necessary to provide patients with education on pain perception, help them understand the benefits of exercise, relief their fear of pain, and enhance their confidence in engaging in physical activity. [70]

Social support emerges as the primary factor influencing kinesiophobia in MK-HRPSG patients. Social support was negatively correlated with the classification level of kinesophobia. [71] It is consistent with the results of a qualitative study on 16 female patients by Keessen. [72] In accordance with social support theory, [73,74] individuals with ample social support are more inclined to confide their negative emotions to family, friends, and social networks. This, in turn, boosts their

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

confidence in facing discomfort and diminishes kinesiophobia. Notably, our observations revealed no significant correlation between social support and kinesiophobia in the HK-HEAG group. As a result, we postulate that alternative interventions should be explored to alleviate kinesiophobia in HK-HEAG patients, other than the domain of social support.

Limitations of this study

This study has taken a step in the direction of defining and understanding of kinesiophobia in patients in North China. It is possible that other patients with a different culture background may produce different results. In addition, it is important to emphasis that methodological problems in the research design limit our interpretations. Self-report questionnaires in data collection may also influence the assessment of kinesiophobia in an objective approach. Finally, the LPA method has advantages in group classification, in which the selection process is decided by researchers according to the comprehensive judgment of indicators. Thus, it is likely that the results involve some subjectivity.

CONCLUSIONS

This study utilizes LPA to identify potential classifications of kinesiophobia in patients after cardiac surgery under extracorporeal circulation. The findings indicate that patients fall into three distinct

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

classifications: LMG, MK-HRPSG, and HK-HEAG. It is crucial for clinical staff to prioritize addressing kinesiophobia, particularly in older male patients during the early postoperative period. Furthermore, enhancing self-efficacy shows promise as an effective method for reducing kinesiophobia, while increasing social support may not yield desirable outcomes in the HK-HEAG. These findings offer a valuable evidence-based foundation for implementing preventative interventions to address kinesiophobia during cardiac rehabilitation for patients undergoing cardiac surgery. It is important to note that this study is cross-sectional, and future research should consider expanding the sample size and conducting longitudinal studies to validate the obtained results.

DECLARATION

Authorship contribution statement

WH Xing and JJ Piao are joint first authors. R Wang obtained funding. WH Xing designed the study. JJ Piao, T Ren and YJ Liang collected the data. WH Xing and QL were involved in data cleaning and analyzed the data. YM Gu contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content and approved the final version of the manuscript. All authors have read and approved the final manuscript. R Wang are the study guarantors.

Funding source

This work was supported by the National Key Research and

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Development Program of China [grant numbers 2022YFB4700805].

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

This study was approved by the ethical review committee of the Sixth Medical Centre of PLA General Hospital (Beijing, China). The research was registered with the Chinese Clinical Trial Registry (ChiCTR2200057895).

Data availability

No additional data are available.

Acknowledgements

The study was undertaken during the COVID-19 pandemic. Sincere thanks to the contribution from clinicians and nurses who supported the research for data collection. We would like to thank the study participants.

Patient and public involvement

Consent obtained directly from patient(s).

Figure 1. Flow diagram of participants

Figure 2. Latent profile analysis classification

REFERENCES

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

1 Back M, Cider A, Herlitz J, et al. Kinesiophobia mediates the influences on attendance at exercise-based cardiac rehabilitation in patients with coronary artery disease. *Physiother Theory Pract*. 2016;32(8):571-80.

2 Knapik A, Dąbek J, Brzęk A. Kinesiophobia as a Problem in Adherence to Physical Activity Recommendations in Elderly Polish Patients with Coronary Artery Disease . *Patient Preference and Adherence*. 2019;Volume 13:2129-35.

3 Rita Rubin M. Although Cardiac Rehab Saves Lives,Few Eligible Patients Take Part. *American Medical Association*. 2019;Aug 6;322(5):386-8.

4 Back M, Oberg B, Krevers B. Important aspects in relation to patients' attendance at exercise-based cardiac rehabilitation - facilitators, barriers and physiotherapist's role: a qualitative study. *BMC Cardiovasc Disord*. 2017;17(1):77.

5 Michelle C Rogerson BMM, Stephen Bird and Tony Morris. "I don't have the heart": a qualitative study of barriers to and facilitators of physical activity for people with coronary heart disease and depressive symptoms. *International Journal of Behavioral Nutrition and Physical Activity*. 2012 Nov 30;9:140.

6 Brunetti ND, Guerra A, Ieva R, et al. Scared for the scar: fearsome impact of acute cardiovascular disease on perceived kinesiophobia (fear of movement). *Clin Cardiol*. 2017;40(7):480-4.

7 WANG Yaxin SW, JIA Guanhua, QIN Nana, SUN Jingjing. The status quo and influencing factors of kinesiophobia among first-onset Acute Myocardial Infarction. *Chinese Nursing Management*. 2022;22(01):63-9.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

8 QIN Jingwen , XIONG JuanjuanPAN Xin GK. The status and influencing factors of kinesiophobia in elderly patients with chronic heart failure. *Chinese Journal of Nursing*. 2022;57(04):408-14.

9 Back M, Cider A, Herlitz J, et al. The impact on kinesiophobia (fear of movement) by clinical variables for patients with coronary artery disease. *Int J Cardiol*. 2013;167(2):391-7.

10 Baykal Sahin H, Kalaycioglu E, Sahin M. The effect of cardiac rehabilitation on kinesiophobia in patients with coronary artery disease. *Turk J Phys Med Rehabil*. 2021;67(2):203-10.

11 Winnige P, Vysoky R, Dosbaba F, et al. Cardiac rehabilitation and its essential role in the secondary prevention of cardiovascular diseases. *World J Clin Cases*. 2021;9(8):1761-84.

12 Taylor RS, Dalal HM, McDonagh STJ. The role of cardiac rehabilitation in improving cardiovascular outcomes. *Nat Rev Cardiol*. 2022;19(3):180-94.

13 Epstein E, Maisel S, Maysent K, et al. Cardiac rehabilitation for coronary artery disease: latest updates. *Curr Opin Cardiol*. 2021;36(5):556-64.

14 Abraham LN, Sibilitz KL, Berg SK, et al. Exercise-based cardiac rehabilitation for adults after heart valve surgery. *Cochrane Database Syst Rev*. 2021;5(5):CD010876.

15 Patel DK, Duncan MS, Shah AS, et al. Association of Cardiac Rehabilitation With Decreased Hospitalization and Mortality Risk After Cardiac Valve Surgery. *JAMA Cardiol*. 2019;4(12):1250-9.

16 Ambrosetti M, Abreu A, Corra U, et al. Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

of Preventive Cardiology. *Eur J Prev Cardiol*. 2021;28(5):460-95.

17 Abreu A, Frederix I, Dendale P, et al. Standardization and quality improvement of secondary prevention through cardiovascular rehabilitation programmes in Europe: The avenue towards EAPC accreditation programme: A position statement of the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology (EAPC). *Eur J Prev Cardiol*. 2021;28(5):496-509.

18 Budts W, Pieles GE, Roos-Hesselink JW, et al. Recommendations for participation in competitive sport in adolescent and adult athletes with Congenital Heart Disease (CHD): position statement of the Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC) Working Group on Adult Congenital Heart Disease and the Sports Cardiology, Physical Activity and Prevention Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J*. 2020;41(43):4191-9.

19 Wang Z, Zhang Y, Wang Y, et al. Kinesiophobia and its associated factors in patients with coronary heart disease: a cross-sectional study based on latent feature analysis. *BMJ Open*. 2023;13(7):e072170.

20 Zhang X, Zhao Q, Wang M, et al. Fear of movement and its associated psychosocial factors in heart failure patients: a cross-sectional study. *Eur J Cardiovasc Nurs*. 2023;22(3):273-81.

21 xiaotong HXHFH. White book of Chinese cardiovascular surgery and extracorporeal circulation in 2020. *Chinese Journal of Extracorporeal Circulation*. 2021;19(05):257-60.

22 Li XF, Jiang RJ, Mao WJ, et al. The effect of driving pressure-guided versus conventional

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

mechanical ventilation strategy on pulmonary complications following on-pump cardiac surgery: A randomized clinical trial. *J Clin Anesth*. 2023;89:111150.

23 Martinsson A, Houltz E, Wallinder A, et al. Lung recruitment in the prone position after cardiac surgery: a randomised controlled study. *Br J Anaesth*. 2021;126(5):1067-74.

24 Chu MWA, Ruel M, Graeve A, et al. Low-Dose vs Standard Warfarin After Mechanical Mitral Valve Replacement: A Randomized Trial. *Ann Thorac Surg*. 2023;115(4):929-38.

25 Ramos Dos Santos PM, Aquaroni Ricci N, Aparecida Bordignon Suster E, et al. Effects of early mobilisation in patients after cardiac surgery: a systematic review. *Physiotherapy*. 2017;103(1):1-12.

26 Dibben GO, Faulkner J, Oldridge N, et al. Exercise-based cardiac rehabilitation for coronary heart disease: a meta-analysis. *Eur Heart J*. 2023;44(6):452-69.

27 Ding Y, Pan Y, Wang M, et al. Factors influencing kinesiophobia during the "blanking period" after radiofrequency catheter ablation in patients with atrial fibrillation by the fear-avoidance model. *Int J Cardiol*. 2022;363:49-55.

28 Wang H, Hu F, Lyu X, et al. Kinesiophobia could affect shoulder function after repair of rotator cuff tears. *BMC Musculoskelet Disord*. 2022;23(1):714.

29 Zhou M, Thayer WM, Bridges JFP. Using Latent Class Analysis to Model Preference Heterogeneity in Health: A Systematic Review. *PharmacoEconomics*. 2017;36(2):175-87.

30 Damar HT, Bilik O, Baksi A, et al. Examining the relationship between elderly patients' fear of falling after spinal surgery and pain, kinesiophobia, anxiety, depression and the associated factors. *Geriatr Nurs*. 2021;42(5):1006-11.

31 LEI Mengjie LT, XIONG Siqi, SANG Ming, JIN Changde. Reliability and validity test of

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

Chinese version of the Tampa Scale for Kinesiophobia Heart. *Chinese Nursing Management*. 2019;19(11):1637-42.

32 M L Hickey SVO, R D Froman. Instrument development: cardiac diet and exercise self-efficacy. *NURSING RESEARCH*. 1992;Nov-Dec;41(6):347-51.

33 Sun Yuxiao ZC, Zhu Yan,Yang Zhiyun,Tang Baoxin,Chen Jie, Zhang Yueyu. The Chinesization and reliability and validity test of the Cardiac Exercise Self-Efficacy Instrument. *Chinese Journal of Modern Nursing*. 2021;27(32):6.

34 Shuiyuan X. Theoretical basis and research application of social support rating Scale. *Journal of Clinical Psychiatry*. 1994;Apr;39(3):315-25.

35 E. M. A. SMETS BG, t B. BONKE and J. C. J. M. DE HAES. The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *Journal of Psychosomatic Research*. 1995;39(3):315-25.

36 Herrmann C. International experiences with the Hospital Anxiety and Depression Scale--a review of validation data and clinical results. *Journal of Psychosomatic Research*. 1997;Jan;42(1):17-41.

37 Kasaeyan Naeini E, Subramanian A, Calderon M-D, et al. Pain Recognition With Electrocardiographic Features in Postoperative Patients: Method Validation Study. *Journal of Medical Internet Research*. 2021;23(5).

38 Alwekhyan SA, Alshraideh JA, Yousef KM, et al. Nurse-guided incentive spirometry use and postoperative pulmonary complications among cardiac surgery patients: A randomized controlled trial. *Int J Nurs Pract*. 2022;28(2):e13023.

39 Shruti Prabhakaran Nair RH, Vijayendra Rajguru. Evaluation of Fear Avoidance Belief and

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Kinesiophobia in Patients after Undergoing InPatient Cardiac Rehabilitation Post Cardiac Surgery. *International Journal of Health Sciences & Research*. 2018.

40 Turan A, Duncan A, Leung S, et al. Dexmedetomidine for reduction of atrial fibrillation and delirium after cardiac surgery (DECADE): a randomised placebo-controlled trial. *Lancet*. 2020;396(10245):177-85.

41 Shi J, Zhou C, Pan W, et al. Effect of High- vs Low-Dose Tranexamic Acid Infusion on Need for Red Blood Cell Transfusion and Adverse Events in Patients Undergoing Cardiac Surgery: The OPTIMAL Randomized Clinical Trial. *JAMA*. 2022;328(4):336-47.

42 Khamis RY, Ammari T, Mikhail GW. Gender differences in coronary heart disease. *Heart*. 2016;102(14):1142-9.

43 Townsend N, Kazakiewicz D, Lucy Wright F, et al. Epidemiology of cardiovascular disease in Europe. *Nat Rev Cardiol*. 2022;19(2):133-43.

44 Cifkova R. Gender differences in secondary prevention of coronary heart disease: Far from closing the gap. *Int J Cardiol*. 2022;355:52-3.

45 Grant SW, Ouzounian M. Closing the gender gap in cardiac surgery outcomes: more work to be done. *Eur J Cardiothorac Surg*. 2022;61(3):703-4.

46 Ferrannini G, De Bacquer D, Vynckier P, et al. Gender differences in screening for glucose perturbations, cardiovascular risk factor management and prognosis in patients with dysglycaemia and coronary artery disease: results from the ESC-EORP EUROASPIRE surveys. *Cardiovasc Diabetol*. 2021;20(1):38.

47 Chen J, Guo W, Liu H, et al. Translation and psychometric evaluation of a scale to measure the fear of activity in Chinese patients with coronary artery disease. *Nurs Open*.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

2023;10(6):4033-43.

48 Back M, Caldenius V, Svensson L, et al. Perceptions of Kinesiophobia in Relation to Physical Activity and Exercise After Myocardial Infarction: A Qualitative Study. *Phys Ther*. 2020;100(12):2110-9.

49 Craske MG, Niles AN, Burklund LJ, et al. Randomized controlled trial of cognitive behavioral therapy and acceptance and commitment therapy for social phobia: outcomes and moderators. *J Consult Clin Psychol*. 2014;82(6):1034-48.

50 Bullock GS, Sell TC, Zarega R, et al. Kinesiophobia, Knee Self-Efficacy, and Fear Avoidance Beliefs in People with ACL Injury: A Systematic Review and Meta-Analysis. *Sports Med*. 2022;52(12):3001-19.

51 Larsson C, Ekvall Hansson E, Sundquist K, et al. Kinesiophobia and its relation to pain characteristics and cognitive affective variables in older adults with chronic pain. *BMC Geriatrics*. 2016;16(1).

52 Alpalhao V, Cordeiro N, Pezarat-Correia P. Kinesiophobia and Fear Avoidance in Older Adults: A Scoping Review on the State of Research Activity. *J Aging Phys Act*. 2022;30(6):1075-84.

53 Gunn AH, Schwartz TA, Arbeeva LS, et al. Fear of Movement and Associated Factors Among Adults With Symptomatic Knee Osteoarthritis. *Arthritis Care Res (Hoboken)*. 2017;69(12):1826-33.

54 Archer KR, Devin CJ, Vanston SW, et al. Cognitive-Behavioral-Based Physical Therapy for Patients With Chronic Pain Undergoing Lumbar Spine Surgery: A Randomized Controlled Trial. *J Pain*. 2016;17(1):76-89.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

55 Reinking S, Seehusen CN, Walker GA, et al. Transitory kinesiophobia after sport-related concussion and its correlation with reaction time. *J Sci Med Sport*. 2022;25(1):20-4.

56 Back M, Lundberg M, Cider A, et al. Relevance of Kinesiophobia in Relation to Changes Over Time Among Patients After an Acute Coronary Artery Disease Event. *J Cardiopulm Rehabil Prev*. 2018;38(4):224-30.

57 Mudumbai SC, Kim TE, Howard SK, et al. An ultrasound-guided fascia iliaca catheter technique does not impair ambulatory ability within a clinical pathway for total hip arthroplasty. *Korean J Anesthesiol*. 2016;69(4):368-75.

58 Feng S, Xie B, Li Z, et al. Retrospective Study on the Application of Enhanced Recovery After Surgery Measures to Promote Postoperative Rehabilitation in 50 Patients With Brain Tumor Undergoing Craniotomy. *Front Oncol*. 2021;11:755378.

59 Daskivich TJ, Houman J, Lopez M, et al. Association of Wearable Activity Monitors With Assessment of Daily Ambulation and Length of Stay Among Patients Undergoing Major Surgery. *JAMA Netw Open*. 2019;2(2):e187673.

60 Piao JJ, Gu Y, Ling Y, et al. Mediating effect of kinesiophobia between self-efficacy and physical activity levels in post-CABG patients: protocol for a prospective, multicentre, cross-sectional study in China. *BMJ Open*. 2022;12(7):e062013.

61 Du S, Hu L, Bai Y, et al. The Influence of Self-Efficacy, Fear-Avoidance Belief, and Coping Styles on Quality of Life for Chinese Patients with Chronic Nonspecific Low Back Pain: A Multisite Cross-Sectional Study. *Pain Pract*. 2018;18(6):736-47.

62 Schwarzer R, Antoniuk A, Gholami M. A brief intervention changing oral self-care, self-efficacy, and self-monitoring. *Br J Health Psychol*. 2015;20(1):56-67.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

63 Lin AW, Dollahite JS, Sobal J, et al. Health-related knowledge, beliefs and self-efficacy in women with polycystic ovary syndrome. *Hum Reprod*. 2018;33(1):91-100.

64 ZYT SY. Influence Path of Self-efficacy and Coping Methods on Self-care Behaviors of Patients with Chronic Cardiac Failure. *Nursing Journal Of Chinese Peoples Liberation Army*. 2017;2023-12-21.

65 Meng Y, Deng B, Liang X, et al. Effectiveness of self-efficacy-enhancing interventions on rehabilitation following total hip replacement: a randomized controlled trial with six-month follow-up. *Journal of Orthopaedic Surgery and Research*. 2022;17(1).

66 Kroemeke A, Sobczyk-Kruszelnicka M. Interaction effect of coping self-efficacy and received support in daily life of hematopoietic cell transplant patient-caregiver dyads. *PLoS One*. 2021;16(11):e0260128.

67 Egerton T, Bennell KL, McManus F, et al. Comparative effect of two educational videos on self-efficacy and kinesiophobia in people with knee osteoarthritis: an online randomised controlled trial. *Osteoarthritis Cartilage*. 2022;30(10):1398-410.

68 Asiri F, Reddy RS, Tedla JS, et al. Kinesiophobia and its correlations with pain, proprioception, and functional performance among individuals with chronic neck pain. *PLoS One*. 2021;16(7):e0254262.

69 Johan W.S. Vlaeyen SJL. Fear-avoidance and its consequences in chronic musculoskeletal pain:

a state of the art. *Pain*. 2000;85 (2000) 317-332.

70 Giusti EM, Lacerenza M, Manzoni GM, et al. Psychological and psychosocial predictors of chronic postsurgical pain: a systematic review and meta-analysis. *Pain*. 2021;162(1):10-30.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

71 Tan M, Liu Y, Zhao R, et al. The effect of pain social support on kinesiophobia in older patients with rheumatoid arthritis: The mediating role of self-perceived burden. *Geriatr Nurs*. 2023;50:52-7.

72 Keessen P, Latour CHM, van Duijvenbode ICD, et al. Factors related to fear of movement after acute cardiac hospitalization. *BMC Cardiovasc Disord*. 2020;20(1):495.

73 SY X. The theoretical basis and application of social support questionnaire. *clinical Psychol medical*. 1994;(1994) 4:98–100.

74 C P Langford JB, J P Maloney, P P Lillis. Social support:a conceptual analysis. *Journal of advanced nursing*. 1997;25,95-100.

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Enseignement Superieur (ABES) .

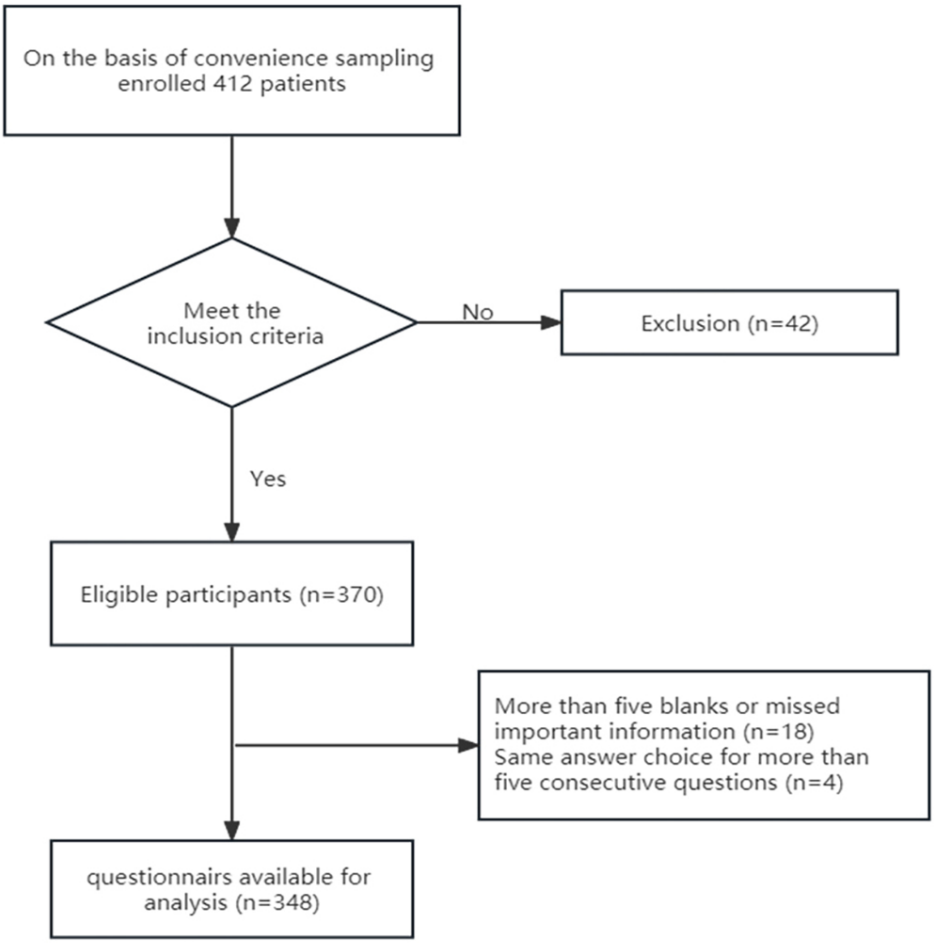

Figure 1. Flow diagram of participants

90x90mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

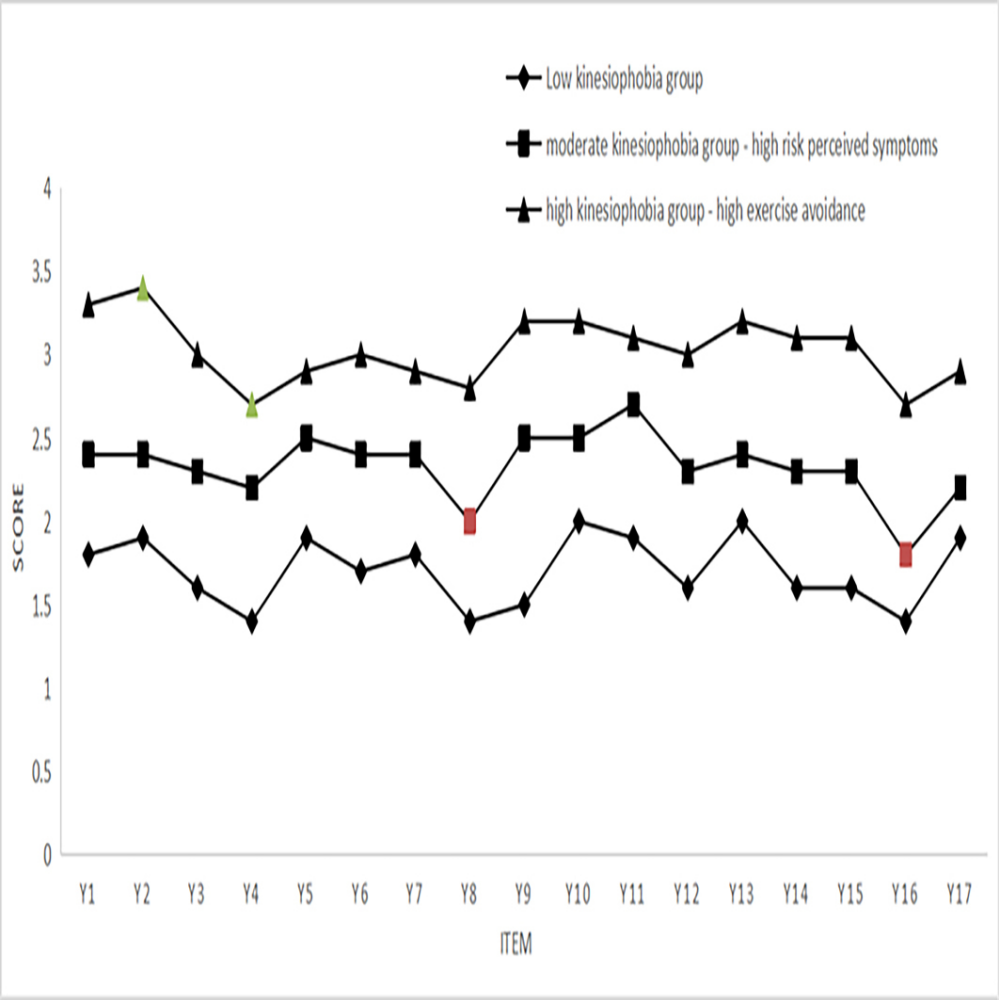

Figure 2. Latent profile analysis classification

90x90mm (300 x 300 DPI)

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) .
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Supplementary table 1 Characteristics of study population (n = 348)

Characteristics	
Age	
18-45	32（9.20%）
46-65	151（43.39%）
66-75	165（47.41%）
Sex	
Male	248（71.26%）
Female	100（28.74%）
Educational level	
Primary school or lower	176 (50.57%)
High school	127 (36.49)
University and above	45 (12.93)
Marital status	
Married	312(89.66%)
Unmarried	36 (10.34%)
Average monthly income (RMB)	
≤1500	49 (14.08%)
1501-3500	122 (35.06%)
3501-5500	96 (27.59%)
≥5500	81 (23.28%)
Current residence	
Village	111 (31.90%)
City	237 (68.10%)
Smoking	
Never	139 (39.94%)
Past	183 (52.59%)
Current	26 (7.47%)
Alcohol	
Never	142 (40.80%)
Past	173 (49.71%)
Current	33 (9.48*)
Surgical approach	
Conventional surgery	247 (70.98%)
Sternum sparing	101 (29.02%)
Postoperative time (Months)	
3-6	165 (45.19%)
7-12	119 (34.44%)
13-18	53 (16.30%)
19-24	11 (3.33%)

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .

Supplementary table 2 Model fitting indexes of all potential classification of kinesiophobia after cardiac surgery under extracorporeal circulation

Number of Class	1	2	3	4
AIC	17674.014	16629.692	16442.350	16294.501
BIC	17810.812	16838.911	16723.991	16648.565
aBIC	17702.922	16673.903	16501.865	16369.321
LMRT(P)	—	**0.000**	**0.031**	**0.131**
BLRT(P)	—	0.000	0.000	0.000
Entroy	—	**0.814**	**0.873**	**0.888**
Sample proportion (%) per Class	—	0.576/0.423	0.206/0.426/0.368	0.177/0.373/0.419/0.031

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.
Enseignement Superieur (ABES) .

Supplementary table 3. Single-factor analysis of potential classification impact factors (n = 348)

Variables		LKG (%)[1]	MK-HRPSG[2](%)	HK-HEAG[3](%)	F/χ^2	P
Gender	Male	47(65.52)	110(74.42)	100(78.57)	3.694	0.055
	Female	25(34.48)	38(25.58)	28(21.43)		
Age	18-45	20（27.78）	71（47.97）	49(38.28)	7.582	**<0.05**
	46-65	42（58.33）	58（39.19））	42(32.81)		
	66-75	10（13.89）	19（12.84）	37(28.90)		
Educational level	Primary school or lower	39（54.16）	101（68.24）	85(66.40)	1.391	0.250
	High school	25（34.72）	28（18.92）	35(27.34)		
	University and above	8（11.12）	19（12.84）	8(6.26)		
Marital status	Married	64(89.66)	131(88.37)	119(92.86)	1.860	0.157
	Unmarried	8(10.34)	17(11.63)	9(7.14)		
Vocational type	Brainwork	29(40.27)	21(13.95)	36(28.57)	1.208	0.300
	Physical labor	22(30.56)	50(33.78)	36(28.57)		
	Retirement	21(29.17)	77(52.27)	56(42.86)		
Average monthly income (RMB)	≤1500	14(19.44)	42(28.38)	25(19.53)	0.133	0.940
	1501-3500	10(13.88)	56(37.84)	24(18.75)		
	3501-5500	22(30.56)	27(18.24)	40(31.25)		

[1] low kinesiophobia group(LKG）
[2] moderate kinesiophobia - high risk perceived symptoms group (MK-HRPSG)
[3] high kinesiophobia - high exercise avoidance group(HK-HEAG)

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

	≥5500	26(36.12)	23(15.54)	39(30.47)		
Current residence	Village	20(27.59)	43(29.05)	23(17.97)	3.319	0.069
	City	52(72.41)	105(70.95)	105(82.03)		
Smoking	Never	31(43.06)	24(16.21)	46(35.94)	0.513	0.599
	Past	35(48.61)	63(42.57)	68(53.12)		
	Current	6(8.33)	61(41.22)	14(10.94)		
Alcohol	Never	37(51.72)	62(41.86)	50(39.29)	1.376	0.254
	Past	30(41.38)	71(48.84)	64(50.00)		
	Current	5(6.90)	15(9.30)	14(10.71)		
Surgery	Coronary artery bypass graft	67(93.06)	118(79.73)	119(92.86)	0.448	0.504
	Valvular surgery	5(6.94)	30(20.27)	9(7.14)		
Surgical approach	Conventional surgery	48(68.97)	117(79.07)	87(67.86)	0.063	0.802
	Sternum sparing	24(31.03)	31(20.93)	41(32.14)		
Postoperative time (Months)	3-6	28(38.89)	40(27.03)	27(21.09)	6.257	**<0.05**
	7-12	17(23.61)	49(33.10)	66(51.56)		
	13-18	19（26.39）	48(32.43)	23(17.97)		
	19-24	8（11.12）	11(7.44)	12(9.38)		
Self-efficacy		46.62±7.51	50.08±6.55	55.68±4.26	4.704	**<0.05**
Fatigue		44.20±5. 41	43.71±5.45	43.15±4.96	0.905	0.581
Pain		5.26±1.28	6.55±1.51	7.31±1.54	12.572	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Anxiety & depression	11.59±4.35	12.16±6.23	12.82±6.31	1.090	0.347
Social support	36.95±8.27	47.35±8.41	49.14±8.25	5.156	**<0.05**

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2024-083909 on 23 January 2025. Downloaded from http://bmjopen.bmj.com/ on June 13, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Supplementary table 4 Multiple Logistic regression analysis of potential classification factors

		Moderate kinesiophobia -high risk perceived symptoms				High kinesiophobia -high exercise avoidance			
		B	Standard error	Wald χ^2	*p*	B	Standard error	Wald χ^2	*p*
Age	18-45	0.565	0.486	1.274	0.261	1.554	1.301	1.876	0.189
	46-65	2.245	0.855	6.545	0.014	2.016	0.876	5.223	0.021
	66-75	1.186	0.866	1.798	0.174	1.667	0.613	6.211	0.013
Postoperative time (Months)	3-6	-2.267	0.465	16.956	＜0.001	-3.246	0.655	20.366	＜0.001
	7-12	-1.506	0.438	12.122	＜0.001	-2.922	0.721	17.627	＜0.001
	13-18	-1.236	0.403	8.262	0.018	-1.965	0.668	8.874	0.016
	19-24	-0.783	0.519	2.235	0.127	-1.865	0.626	8.487	0.012
Self-efficacy		-3.134	0.671	8.332	0.017	-2.554	1.626	1.688	0.032
Pain		1.887	0.609	10.596	0.016	1.732	0.633	11.227	0.011
Social support		-1.102	0.421	7.306	0.026	-1.174	0.846	1.936	0.176

For peer review only

Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies. Enseignement Superieur (ABES) .