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

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

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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

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 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 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 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

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;

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)

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 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 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 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.

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

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 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 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 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 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 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-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 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.

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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.

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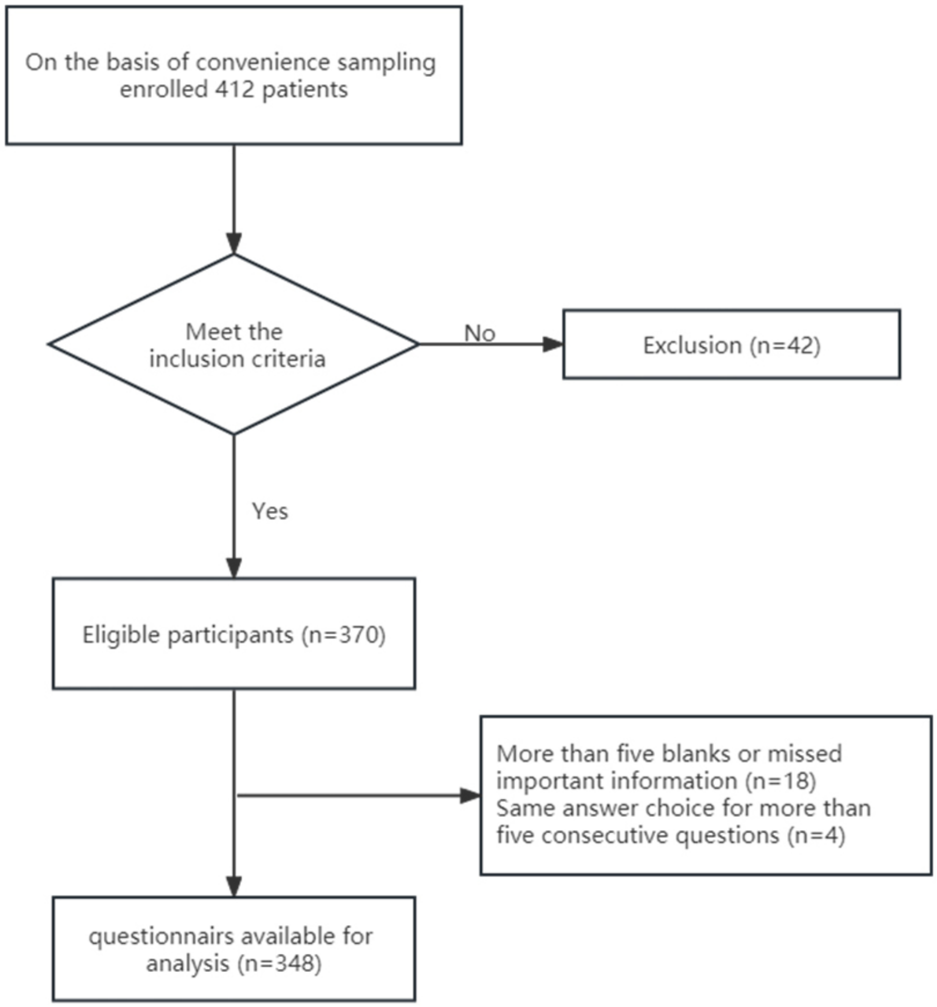

Figure1.Flow diagram of participants

228x244mm (96 x 96 DPI)

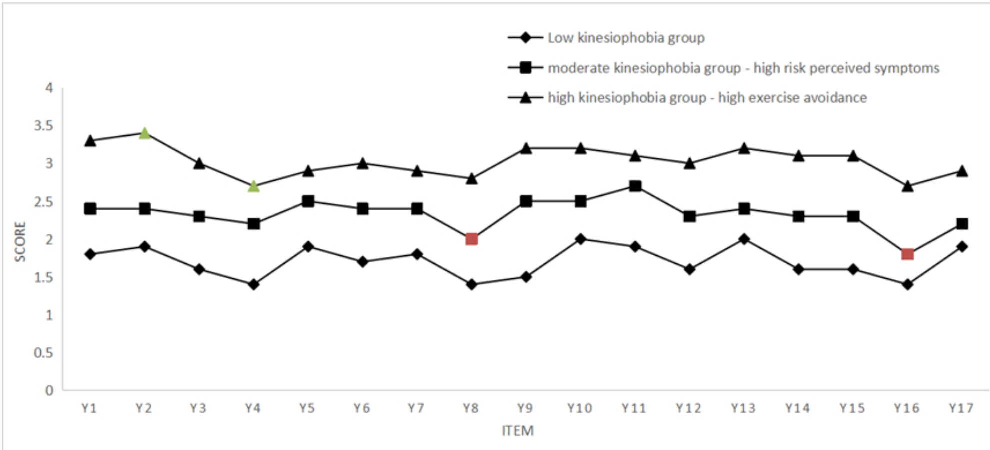

Figure2.Latent profile analysis classification

146x66mm (150 x 150 DPI)

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)

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**

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**

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

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

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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: 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 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 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 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 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:

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.

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 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.

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.

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 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）.

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

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 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 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 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 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 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.

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.

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.

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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.

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Patient and public involvement

Consent obtained directly from patient(s).

Figure 1. Flow diagram of participants

Figure 2. Latent profile analysis classification

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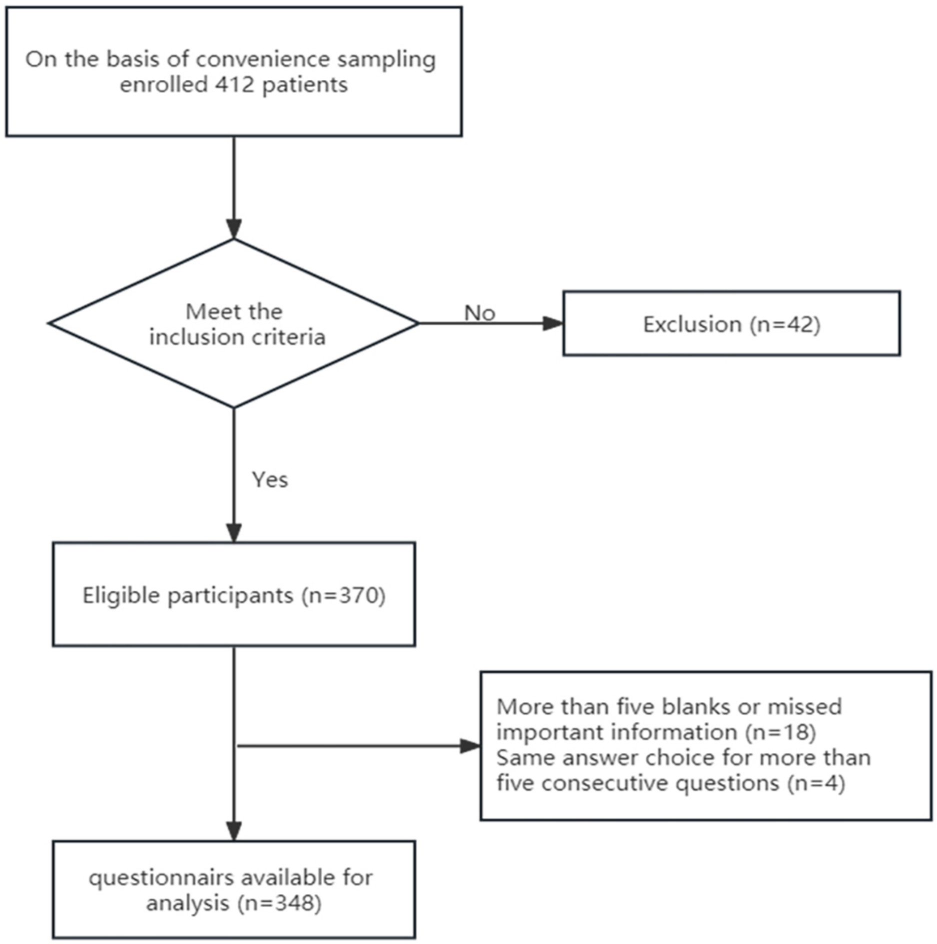

Figure 1. Flow diagram of participants

90x90mm (300 x 300 DPI)

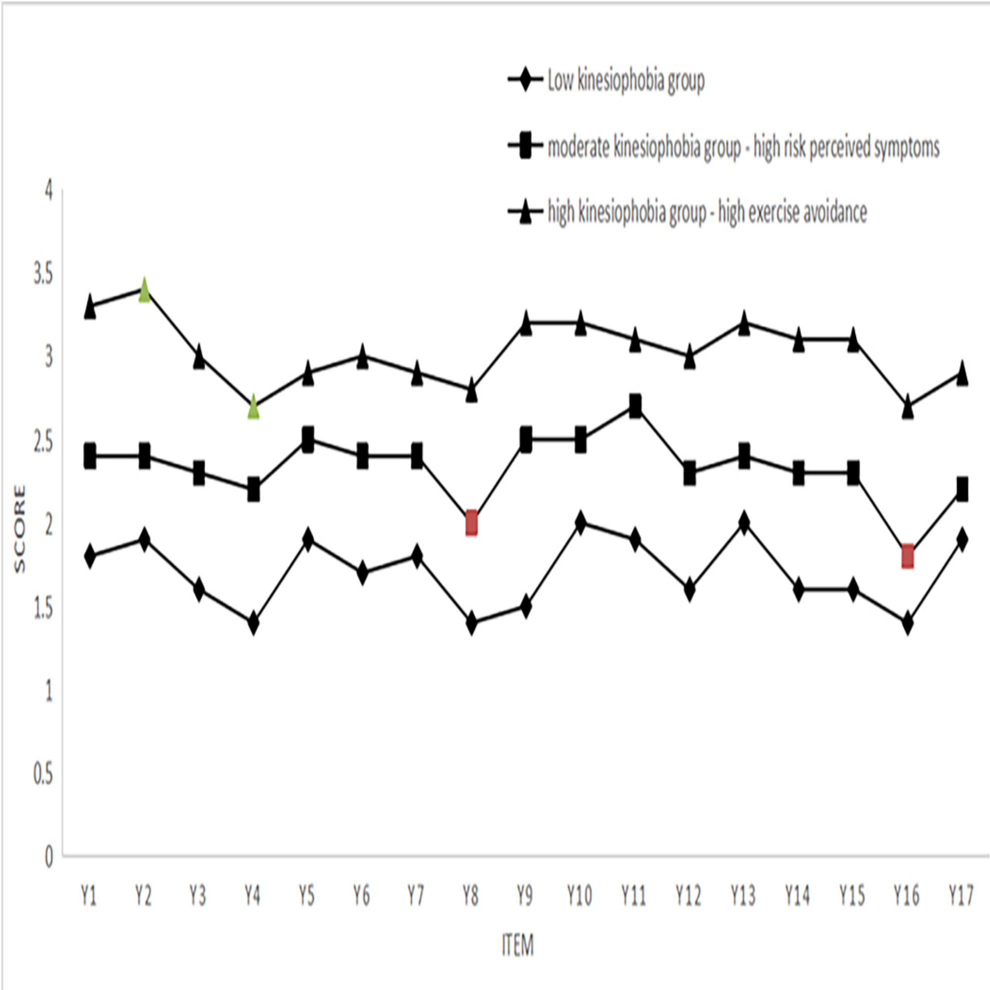

Figure 2. Latent profile analysis classification

90x90mm (300 x 300 DPI)

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%)

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)

	≥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**

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**

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

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

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

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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: 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 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 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 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 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 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 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 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.

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 ($x \pm s$), 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.

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 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 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 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 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

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-

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 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 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 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 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.

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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.

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Patient and public involvement

Consent obtained directly from patient(s).

Figure 1. Flow diagram of participants

Figure 2. Latent profile analysis classification

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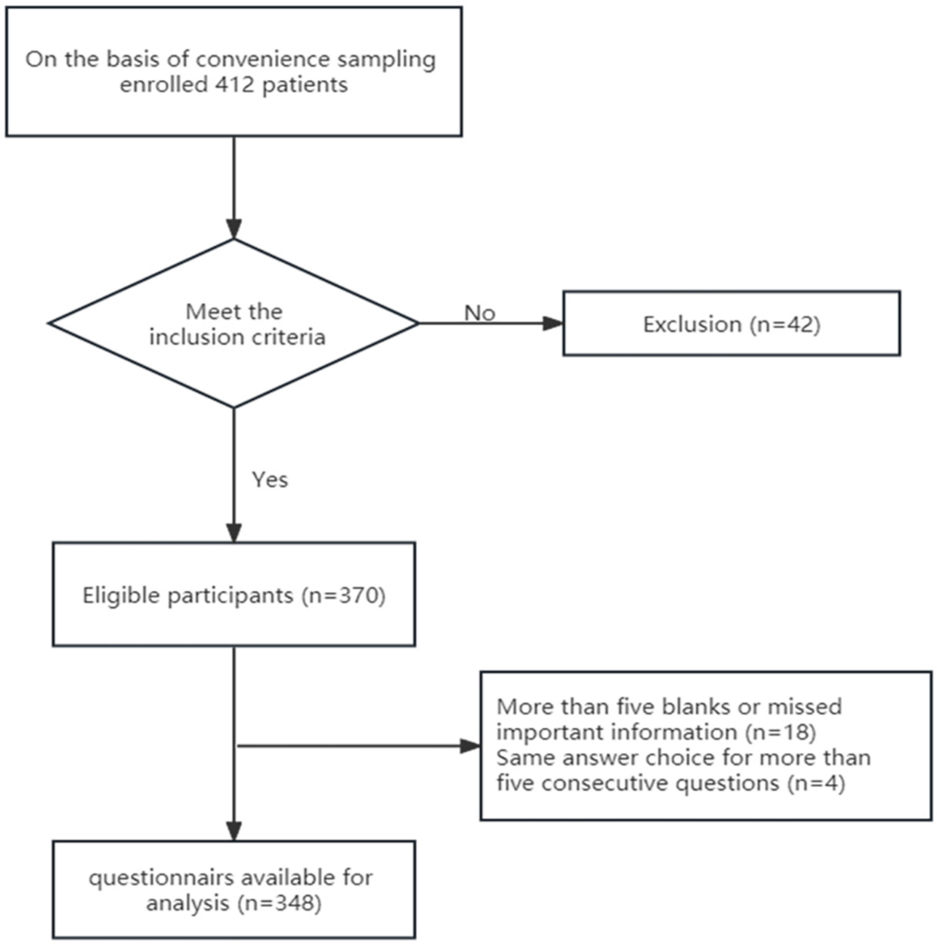

Figure 1. Flow diagram of participants

90x90mm (300 x 300 DPI)

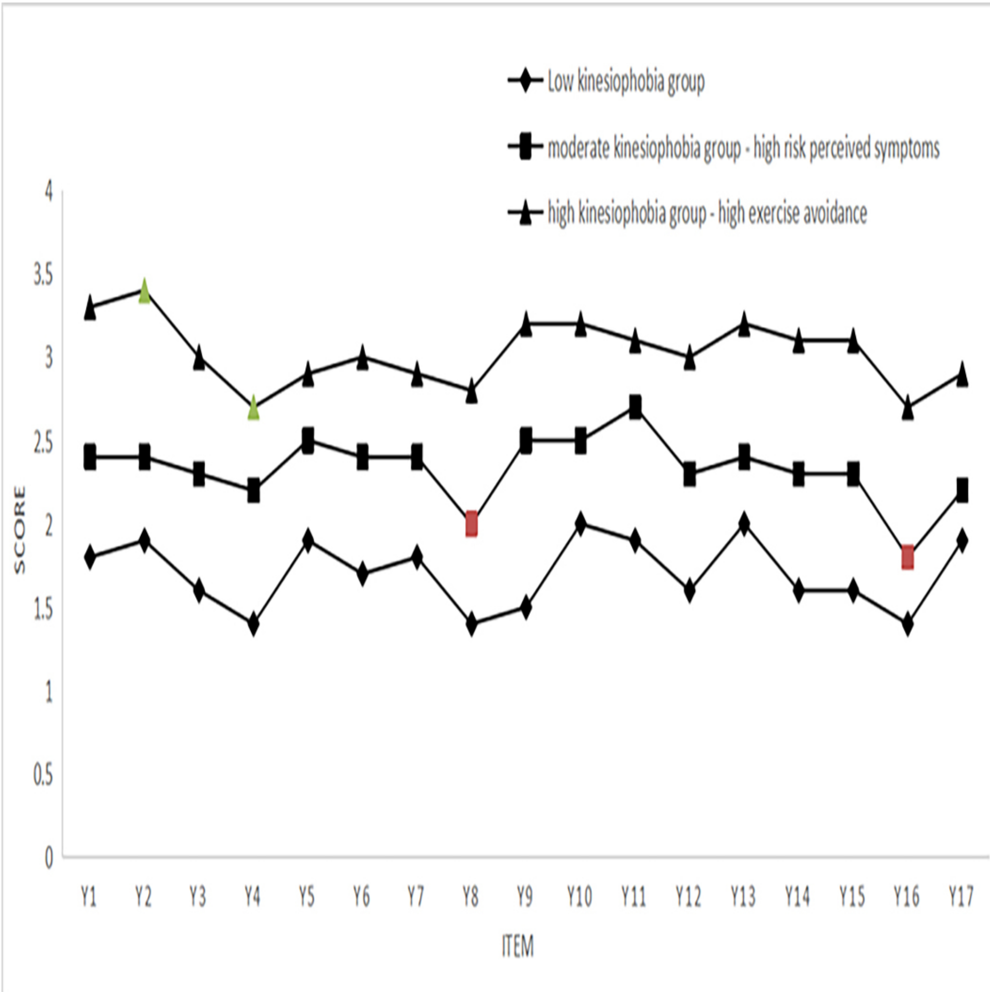

Figure 2. Latent profile analysis classification

90x90mm (300 x 300 DPI)

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%)

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

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)

	≥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**

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**

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