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Impact of behavior change theory-based nursing interventions on cardiac function recovery and quality of life among cardiac surgery patients with cardiopulmonary bypass

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Abstract

Background This study investigates the impact of nursing interventions, guided by behavior change theory, on the recovery of cardiac function and quality of life in patients undergoing cardiac surgery with cardiopulmonary bypass (CPB).

Methods A total of 120 patients scheduled for CPB in the Department of Cardiology at our hospital, from February 2021 to May 2023, were enrolled. According to the study protocol, patients were randomly assigned to either a control group ($n=60$) or an observation group ($n=60$) post-surgery. The control group received routine nursing care, while the observation group received nursing interventions based on behavior change theory, including health education, psychological support, and behavioral incentives. Informed consent was obtained from all patients. General patient data were collected from clinical records. Cardiac function was assessed using echocardiography. The wall motion score index (WMSI) and 6-minute walk distance (6MWD) were evaluated post-care. Serum levels of inflammatory cytokines TNF-α, IL-6, and IL-10 were measured via ELISA. Quality of life was assessed using the WHOQOL-BREF questionnaire, while anxiety and depression levels were evaluated using the HAM-A and HAM-D scales, respectively.

Results The baseline clinical characteristics and biochemical data of both groups were comparable ($P>0.05$). The observation group showed a significantly higher left ventricular ejection fraction (LVEF) compared to the control group ($P<0.05$), while both left ventricular end-systolic diameter (LVESD) and left ventricular end-diastolic diameter (LVEDD) were significantly lower ($P<0.05$). Additionally, the observation group had a significantly lower WMSI score and a longer 6MWD ($P<0.05$). Regarding inflammatory markers, TNF-α and IL-6 levels were significantly reduced in the observation group, while IL-10 levels were significantly elevated compared to the control group ($P<0.05$). In terms of quality of life, the observation group reported significantly higher scores in physical health, mental health, social

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relationships, and environmental factors ($P < 0.05$). Moreover, anxiety and depression levels were significantly lower in the observation group, as evidenced by reduced HAM-A and HAM-D scores ($P < 0.05$).

Conclusion Nursing care guided by behavior change theory significantly improves cardiac function and overall quality of life in patients recovering from cardiac surgery with CPB. This approach enhances LVEF, reduces left intraventricular diameter, lowers inflammatory cytokine levels, and improves mental health and social functioning. These findings underscore the importance of behavior change theory-based nursing interventions in optimizing postoperative recovery.

Keywords Behavior change theory, Nursing intervention, Cardiac surgery extracorporeal circulation, Cardiac function, Quality of life

Introduction

In the rehabilitation journey following cardiopulmonary bypass (CPB), patients face challenges not only at the physical level but also in psychological and behavioral aspects [1]. Recently, utilizing behavior change theory to guide nursing interventions has emerged as an effective approach to improving recovery outcomes and overall well-being. CPB is a common technique in cardiac surgery, with the primary clinical focus on restoring cardiac function and enhancing the patient's quality of life post-surgery [2–5]. The recovery of cardiac function not only affects physical health but also has a direct impact on patients' quality of life and psychological state. Thus, postoperative nursing care should aim not only at physical recovery but also at improving overall quality of life.

Behavior change theory provides a conceptual framework for understanding and promoting healthy behavioral changes [6]. This theory enables nurses in post-cardiac surgery care to guide patients in adopting and maintaining a healthy lifestyle, which includes regular physical activity, a balanced diet, and effective stress management. Targeted interventions such as health education, psychological support, and behavioral motivation play a key role in achieving this goal. In addition, psychological and social support are equally important in the rehabilitation process. Patients undergoing surgery often experience mental health challenges, such as stress and depression, which, if not addressed, may hinder their recovery and overall well-being [7–9]. Nursing interventions grounded in behavior change theory can provide essential psychological support, helping patients foster a positive outlook and strengthen their coping mechanisms during surgery and recovery [10, 11].

The objective of this study is to evaluate the impact of nursing interventions based on behavior change theory on improving cardiac function and quality of life in patients undergoing cardiac surgery with CPB. Through a detailed comparison and analysis of outcomes between patients receiving behavior change theory-guided nursing interventions and those receiving standard nursing care, this study aims to provide enhanced and efficient nursing support following heart surgery. Ultimately, the goal is to promote patient rehabilitation and improve overall quality of life.

Materials and methods

General information

A total of 120 patients, aged between 52 and 68 years, with an average age of 63.27 ± 4.45 years, scheduled for cardiopulmonary bypass (CPB) in the Department of Cardiology at our hospital between February 2021 and May 2023, were enrolled in this study. The sample size was calculated using the following formula: $N = Z^2 \times \{P \times (1\text{-}P)\}/E^2$, where N represents the sample size, Z is a statistical measure ($Z = 1.96$ for 95% confidence level or $Z = 1.64$ for 90%), E denotes the margin of error, and P refers to the probability value. A total of 120 samples was deemed appropriate for this quantitative research. All procedures involving human participants adhered to the ethical standards of the institutional and/or national research committee and the 1964 Declaration of Helsinki, including its later amendments. The study was approved by the Ethical Committee of The First Hospital of Hebei Medical University, and informed consent for the scientific use of medical data was obtained from all patient guardians.

Inclusion criteria

Adults aged 18 to 65 of any gender, scheduled to undergo coronary artery bypass under CPB for cardiac surgery, were eligible for inclusion. Preoperative cardiac function was assessed according to the New York Heart Association (NYHA) functional classification (Level I to III). Patients were excluded if they had undergone heart surgery within the past year, and all drugs used prior to surgery were standard coronary vasodilators. Inflammatory factor levels before surgery were within normal ranges. Eligible patients had not participated in other clinical trials in the previous six months and were required to fully understand the research content, be willing to participate, and provide informed consent.

Exclusion criteria

Patients with severe cognitive impairment or mental illness that impeded their ability to comprehend the study or follow the procedures were excluded, as well as those with severe liver or kidney dysfunction or uncontrolled diabetes. Patients with significant preoperative bleeding tendencies or blood disorders, or those who had undergone major surgeries within six months of the scheduled surgery, were also excluded. Additionally, patients planning to undergo major surgeries during the study period or those who refused to sign the informed consent were excluded from participation.

Group intervention method

Post-surgery, patients were divided into two groups based on the research protocol: the control group ($n = 60$) and the observation group ($n = 60$). The control group received standard care, which included routine health education, dietary guidance, bowel training, and wound care during hospitalization. Before discharge, patients were advised on follow-up schedules and home care precautions. Monthly telephone follow-ups and home visits every two months were conducted for six months post-discharge to assess home care needs and resolve any nursing problems.

The observation group received nursing interventions guided by behavior change theory, which included health education, psychological support, and behavioral encouragement. A behavior change theory guidance group was established, and all members underwent psychological training. Regular symposia facilitated the exchange of learning experiences and intervention refinements. Interventions included face-to-face interviews twice a week during hospitalization (30 min each) and family visits post-discharge. Family visits were conducted once a week during the first month, bi-weekly during the 2nd and 3rd months, once every three weeks during the 4th and 5th months, and every four weeks in the 6th month (20 min each time). The intervention emphasized phases of behavior change, using techniques such as awareness enhancement, decision balancing, and motivational communication to guide patients through anal training and recovery. Feedback listening, inductive questioning, and conflict analysis were utilized to address contradictions between health behaviors and recovery goals. Maintenance of healthy behaviors was supported through family involvement, and a patient club was organized every two months for experience sharing.

Echocardiographic examinations

Echocardiography was used to assess left ventricular ejection fraction (LVEF), left ventricular end-systolic diameter (LVESD), and left ventricular end-diastolic diameter (LVEDD). Two-dimensional echocardiography (2D-Echo) captured multiple views, with measurements of LVEDD and LVESD recorded in millimeters at the end of diastole and systole. LVEF was calculated using the Simpson method based on two-dimensional images. The Wall Motion Score Index (WMSI) was calculated by assessing 16 standardized heart segments, assigning scores from 1 (normal motion) to 4 (paradoxical motion), and dividing the total score by the number of segments, with higher values indicating more severe irregularities.

6MWD test

The 6-minute walk distance (6MWD) test was conducted in a 30-meter-long corridor with clear markings. Patients were instructed to walk at their own pace and take breaks if necessary. Medical staff documented the distance traveled and monitored physical responses. The total distance covered within six minutes was recorded to assess patients' physical endurance and functional status.

ELISA detection of inflammatory factors

Enzyme-linked immunosorbent assay (ELISA) was used to measure serum concentrations of inflammatory markers TNF-α, IL-6, and IL-10. Blood samples were collected under sterile conditions, centrifuged to separate the serum, and stored at -80 °C for subsequent analysis.

WHOQOL-BREF scale

Patients' quality of life was assessed using the WHOQOL-BREF questionnaire [12], which includes 26 questions on life experiences over the past two weeks, scored using a 1–5 Likert scale. Data were reviewed for completeness, and original scores were converted into standard scores for comparison across the four domains: physical health, mental health, social relationships, and environment.

HAM-A and HAM-D

The severity of anxiety and depression post-nursing intervention was assessed using the Hamilton Anxiety Scale (HAM-A) [13] and the Hamilton Depression Scale (HAM-D) [14]. HAM-A consists of 14 items assessing symptoms such as nervousness, with scores ranging from 0 to 4 for each item. HAM-D consists of 17 items evaluating depressive symptoms, with similar scoring. Higher scores on both scales indicate greater severity.

Statistical analysis

Results were presented as mean ± standard deviation (SD), and statistical analysis was performed using SPSS 25.0. Comparisons between groups were conducted using independent sample t-tests, with a significance level set at $P < 0.05$.

Table 1 Statistics of Patient General records

Parameters	Control group ($n=60$)	Observation group ($n=60$)	T value / χ^2 value	P value
Gender (male/female)	38/22	40/20	4.014	0.339
Age (years)	63.05 ± 4.24	63.78 ± 5.11	3.226	0.105
BMI (kg/m^2)	22.41 ± 1.85	22.57 ± 2.04	5.617	0.641
Hemoglobin (g/dL)	13.56 ± 1.18	13.74 ± 1.25	2.834	0.266
LDL cholesterol (mg/dL)	102.36 ± 15.44	105.55 ± 12.31	3.149	0.715
Hypertension (%)	11 (18.33%)	13 (21.66%)	5.003	0.588
Diabetes (%)	8 (13.33%)	10 (16.66%)	2.241	0.342
Smoking (%)	17 (28.33%)	15 (25.00%)	3.023	0.619
Drinking (%)	13 (21.66%)	15 (25.00%)	1.452	0.336

Table 2 Echocardiographic analysis ($\bar{x} \pm s$)

Groups	LVEF (%)	LVESD (mm)	LVEDD (mm)
Control group (n = 60)	56.35 ± 4.26	38.26 ± 0.53	55.82 ± 1.68
Observation group (n = 60)	63.54 ± 5.38	34.51 ± 0.44	51.26 ± 1.37
T value	13.295	11.441	15.026
P value	0.001	0.003	0.001

Table 3 Comparison between WMSI and 6MWD ($\bar{x} \pm s$)

Groups	WMSI	6MWD (m)
Control group ($n=60$)	1.95 ± 0.23	376.47 ± 15.18
Observation group ($n=60$)	1.16 ± 0.14	423.55 ± 17.62
T value	10.556	17.431
P value	0.004	0.001

Results

Comparison of patient general data

Based on medical records, the control group included 38 males and 22 females, with an average age of 63.05 ± 4.24 years and a mean BMI of 22.41 ± 1.85 kg/m^2. Within this group, there were 11 cases of hypertension, 8 cases of diabetes, 17 smokers, and 13 individuals who consumed alcohol. The observation group, consisting of 40 males and 20 females, had an average age of 63.78 ± 5.11 years and an average BMI of 22.57 ± 2.04 kg/m^2. This group also included 13 cases of hypertension, 10 cases of diabetes, 15 smokers, and 15 individuals who consumed alcohol. No statistically significant differences were observed between the two groups regarding these general characteristics, including clinical data and initial biochemical assessments ($P>0.05$). (Table 1)

Echocardiographic analysis

Echocardiographic evaluation of heart function revealed that the observation group had a significantly higher LVEF and lower LVESD and LVEDD compared to the control group ($P<0.05$). These findings suggest that the nursing intervention based on behavior change theory led to improved clinical outcomes in the observation group. (Table 2)

Comparison between WMSI and 6MWD scores

Post-nursing care, the WMSI score of the observation group was significantly lower than that of the control group ($P<0.05$), while the 6MWD in the observation group was significantly higher than in the control group ($P<0.05$). (Table 3)

Analysis of inflammatory markers

The observation group exhibited lower serum levels of TNF-α and IL-6, and a higher level of IL-10 compared to the control group ($P<0.05$), indicating a reduction in inflammation due to the intervention. (Fig. 1; Table 4)

The figure illustrates the comparison of serum levels of inflammatory markers between the control and observation groups. The observation group exhibited significantly lower levels of TNF-α (24.15 ± 2.63 pg/mL) and IL-6 (46.22 ± 3.86 pg/mL), along with a higher level of IL-10 (31.51 ± 3.28 pg/mL) compared to the control group, which had TNF-α levels of 38.45 ± 4.27 pg/mL, IL-6 levels of 57.39 ± 4.15 pg/mL, and IL-10 levels of 22.46 ± 2.55 pg/mL.

WHOQOL-BREF scores

Patients in the observation group demonstrated higher scores across all domains of the WHOQOL-BREF questionnaire, indicating a better quality of life ($P<0.05$). (Fig. 2; Table 5)

This figure presents the scores of the WHOQOL-BREF questionnaire across four domains—physical health, mental health, social relations, and environment—comparing the control and observation groups. Patients in the observation group reported significantly higher quality of life scores in all domains: physical health (4.47 ± 0.33), mental health (4.26 ± 0.25), social relations (4.11 ± 0.20), and environment (3.98 ± 0.16) compared to the control

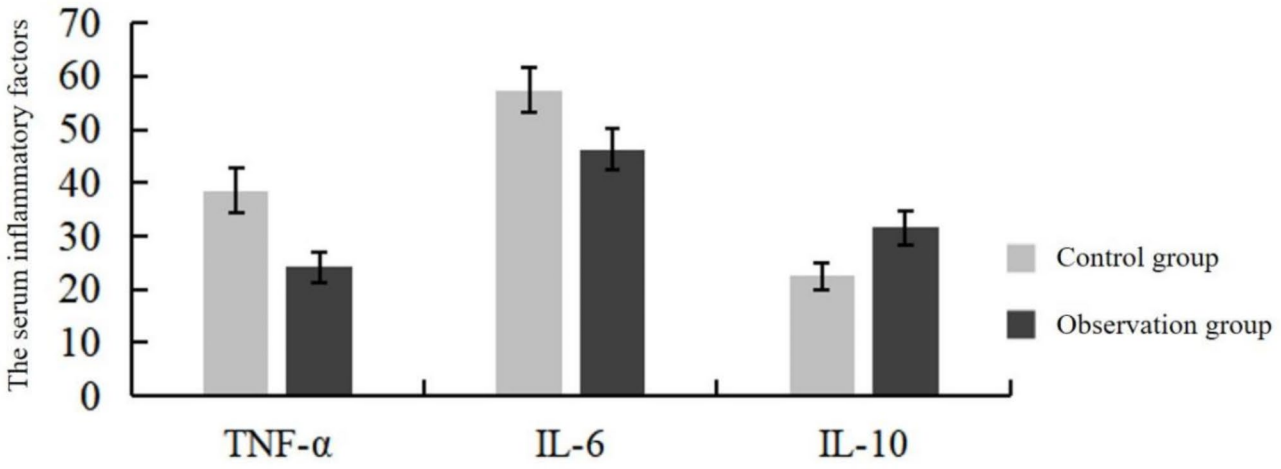

Fig. 1 Analysis of serum inflammatory markers

Table 4 Analysis of inflammatory markers ($\bar{x} \pm s$)

Group	TNF-α (pg/mL)	IL-6 (pg/mL)	IL-10 (pg/mL)
Control group (n = 60)	38.45 ± 4.27	57.39 ± 4.15	22.46 ± 2.55
Observation group (n = 60)	24.15 ± 2.63	46.22 ± 3.86	31.51 ± 3.28
T value	10.773	14.216	9.004
P value	0.003	0.001	0.005

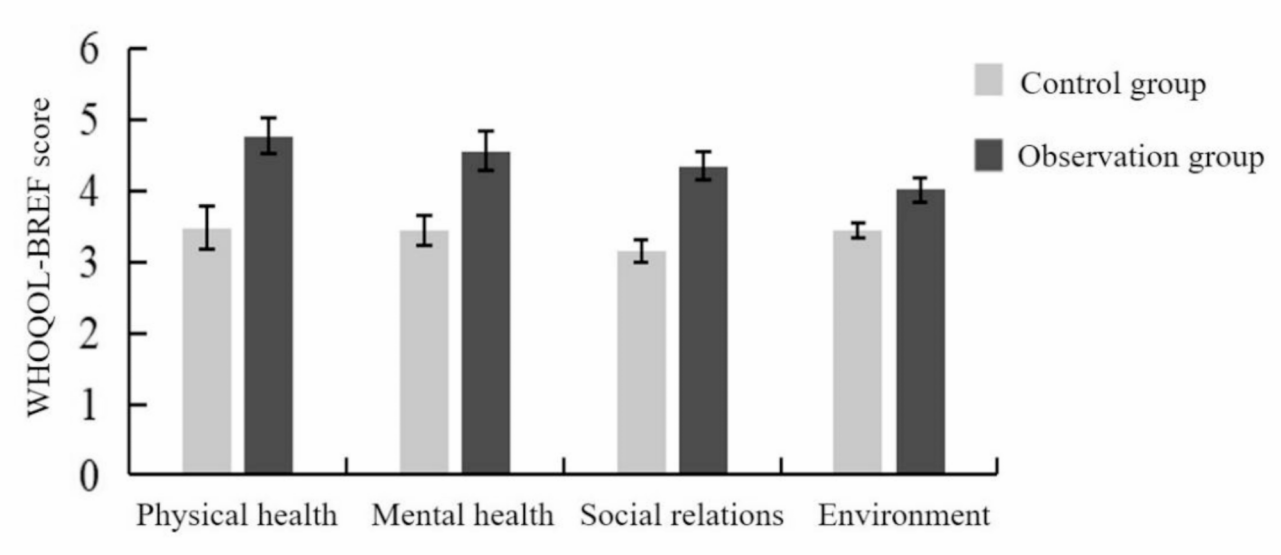

Fig. 2 WHOQOL-BREF scores

Table 5 WHOQOL-BREF scores ($\bar{x} \pm s$)

Groups	Physical health	Mental health	Social relations	Environment
Control group (n = 60)	3.58 ± 0.29	3.57 ± 0.19	3.67 ± 0.15	3.42 ± 0.10
Observation group (n = 60)	4.47 ± 0.33	4.26 ± 0.25	4.11 ± 0.20	3.98 ± 0.16
T value	11.718	16.334	18.209	14.357
P value	0.002	0.001	0.001	0.001

Table 6 HAM-A and HAM-D scores ($\bar{x} \pm s$)

Groups	HAM-A	HAM-D
Control group ($n=60$)	41.55 ± 3.68	43.55 ± 3.26
Observation group ($n=60$)	33.26 ± 2.37	31.59 ± 2.14
T value	15.771	13.253
P value	0.001	0.001

group (3.58 ± 0.29, 3.57 ± 0.19, 3.67 ± 0.15, and 3.42 ± 0.10, respectively).

Anxiety and depression scores

The HAM-A and HAM-D scores in the observation group were significantly lower than those in the control group ($P<0.05$), indicating that patients who received the intervention experienced less anxiety and depression. (Table 6)

Discussion

Nursing intervention guided by behavior change theory is an innovative approach that integrates psychological principles into nursing practice. It aims to enhance patients' health and facilitate rehabilitation through the promotion of behavior and lifestyle modifications. This form of intervention acknowledges that modifying health behaviors is a complex process, necessitating thorough consideration of individual motivations, attitudes, beliefs, and environmental factors. In the realm of cardiac surgery rehabilitation, behavior change theory can aid patients in gradually embracing a healthier lifestyle, encompassing adherence to a balanced diet, regular exercise, smoking cessation, and stress management [15–18].

Nursing intervention plans typically involve setting specific health objectives, providing educational materials, fostering self-monitoring abilities, and bolstering self-efficacy. By setting incremental exercise objectives, patients can systematically improve their physical strength and endurance. Providing education on the significance of nutritious eating habits can empower patients to make healthier dietary decisions. Furthermore, beyond promoting physiological health behaviors, behavior change theory emphasizes the importance of addressing patients' psychological well-being. Nursing interventions can assist patients in managing post-surgery anxiety and depression through the provision of psychological support and coping strategies, thereby enhancing their overall quality of life [19, 20].

This study examines the impact of nursing intervention guided by behavior change theory on the recovery of cardiac function and quality of life in individuals who have undergone CPB surgery. The enhancement of LVEF signifies improved heart pumping efficiency, which is a highly favorable outcome for patients post-heart surgery. This improved blood circulation efficiency enables the heart to supply adequate blood to all parts of the body more effectively, ultimately enhancing patients' overall physiological function and activity levels [21, 22]. Conversely, the reduction in LVESD and LVEDD indicates a decreased burden on the heart and potential improvement in ventricular wall thickness, thereby reducing the risk of further heart disease development [23, 24].

In this study, nursing intervention based on behavior change theory demonstrated a significant positive impact on patients' cardiac function following CPB surgery. Particularly noteworthy was the substantial increase in LVEF among patients in the observation group, alongside significant reductions in LVESD and LVEDD. These improvements directly reflect enhanced heart pumping capacity and optimized heart structure, serving as crucial indicators in the heart rehabilitation process.

These physiological enhancements are likely attributable to various aspects of nursing intervention. Firstly, health education empowers patients by enhancing their understanding of their illness and postoperative recovery process, thereby fostering their willingness to adhere to healthy lifestyle recommendations. For instance, engaging in appropriate physical activity, maintaining a balanced diet, and managing weight effectively are all vital for heart function recovery. Secondly, psychological support aids in promoting physical recovery by alleviating patients' anxiety and depression, thus improving their overall psychological well-being. By reducing psychological stress, not only does patients' quality of life improve, but the likelihood of heart disease occurrence also decreases.

WMSI serves as a pivotal index for evaluating ventricular wall motion via echocardiography. A lower WMSI value indicates improved motion of the ventricular wall, signifying more effective systolic function of the heart. This outcome suggests an increase in the patient's heart muscle strength, consequently leading to improved cardiac function. Such improvements are crucial for post-heart surgery patients as they directly influence the quality and pace of recovery.

Furthermore, the elevation in 6MWD also signifies enhancements in patients' physical strength and endurance. 6MWD, a straightforward physical endurance test, is utilized to assess an individual's exercise endurance and cardiopulmonary function [25]. Following heart surgery, patients typically experience a decrease in their 6-minute walk distance; however, the observed increase in this measure within the monitored group suggests an enhancement in patients' overall physical stamina and resilience. This improvement may be linked to better heart function and patients' positive response to nursing intervention based on behavior change theory.

These enhancements are not solely confined to the recovery of the heart itself but also extend to the quality of daily life and self-perception of patients. Patients

who experience improvements in their cardiac function and physical strength are more likely to regain their preoperative activity level, engage in social activities, find joy in life, and mitigate the risk of postoperative depression and anxiety. Consequently, nursing intervention based on behavior change theory not only exerts a positive impact on the physiological realm but also enhances patients' overall well-being on psychological and social fronts. The significance of comprehensive nursing approaches during cardiac rehabilitation is underscored by these findings, particularly emphasizing the importance of integrating behavioral and psychological assistance into nursing interventions.

This research revealed that patients in the observation group exhibited decreased serum levels of TNF-α and IL-6, pro-inflammatory factors, while the level of IL-10, an anti-inflammatory factor, increased based on biochemical parameters. These changes suggest that nursing intervention guided by behavior change theory may facilitate patient rehabilitation by modulating the inflammatory response [26]. TNF-α and IL-6 are cytokines known to promote inflammation and typically elevate in response to inflammation or stress, whereas IL-10 is a cytokine with anti-inflammatory properties that helps regulate the body's inflammatory response [27].

The alterations in these biochemical parameters indicate that nursing intervention may promote the rehabilitation process of patients after heart surgery by reducing pro-inflammatory reactions and reinforcing anti-inflammatory mechanisms. Additionally, following assessment with the WHOQOL-BREF scale, significant enhancements in physical health, mental health, social relations, and environment were observed among patients in the observation group across all four domains. This outcome underscores the comprehensive impact of nursing intervention based on behavior change theory, which not only advances patients' physical rehabilitation but also enhances their psychological well-being and social functioning.

Improving quality of life is a critical goal of rehabilitation after cardiac surgery, and these findings highlight the significant role of comprehensive nursing intervention in achieving this objective. Furthermore, the decrease in HAM-A and HAM-D scores provides additional evidence supporting the efficacy of nursing care in alleviating anxiety and depression among patients. Enhancing mental well-being is essential for advancing physical recovery, as it can bolster patients' motivation for rehabilitation, increase treatment adherence, and potentially impact physical recovery through psychological and physiological pathways.

The theory of staged behavior transformation includes five parts: unconscious period, conscious period, preparation period, action period, and maintenance period, covering three aspects: techniques, methods, and intervention methods. The alignment between behavioral change strategies and behavioral stages is of paramount importance. The nursing intervention guided by the theory of staged behavior uses face-to-face encouragement to guide conscious and unconscious patients in rehabilitation training. During the training process, patients were guided to think critically and intervened using strategies from the theory of staged behavior change, encouraging them to adhere to the training plan during the action period, building confidence in rehabilitation, and enhancing the effectiveness of rehabilitation treatment.

Patients in the maintenance period are easily influenced by the external environment and may give up healthy behaviors. The intervention program should involve the inclusion of family and friends at this stage, as their presence can foster patient motivation to adhere to behavioral changes. Additionally, with the support of family and friends, health education can be utilized to reinforce positive rehabilitation behaviors, thereby improving the effectiveness of rehabilitation training and enhancing the quality of life [28].

In conclusion, this research underscores the significant beneficial impact of incorporating behavior change theory into nursing interventions on the recovery of cardiac function and quality of life in patients undergoing CPB following heart surgery. This approach not only improves LVEF and reduces left ventricular diameter but also enhances overall patient health by reducing inflammatory markers. Additionally, significant improvements have been observed in patients' mental health, social functioning, and overall quality of life.

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Author contributions
YZ, WW and ZS designed the study, performed data acquisition, and drafted the manuscript. YD and ZW participated in data acquisition, reviewed and revised the manuscript. SG performed statistical analyses and participated in the draft of the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used in the study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study was approved by the Ethical Committee of The First Hospital of Hebei Medical University. The

informed consent for the scientifc use of medical data was obtained from all Patients' guardian.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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