Research Article

Effectiveness of Cardiac Rehabilitation for Patients after Coronary Artery Bypass Graft: Randomized Controlled Trial

Ali Suleiman Harbi[1], Kim Lam Soh[1*], Putri Yubbu[2], Kim Geok Soh[3]

1. Department of Nursing, Faculty of Medicine and Health Sciences, University Putra Malaysia (UPM), Seri Kembangan, Malaysia.
2. Department of Paediatrics, Faculty of Medicine & Health Sciences, University Putra Malaysia (UPM), Seri Kembangan, Malaysia.
3. Department of Sport Studies, Faculty of Educational Studies, University Putra Malaysia (UPM), Seri Kembangan, Malaysia.

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ABSTRACT

Introduction: Cardiac rehabilitation is a program designed to help patients adopt healthy lifestyle changes. This study aims to investigate the effectiveness of a comprehensive cardiac rehabilitation program (CCRP) on anxiety, depression, perceived health status (PHS) and 90-day readmission rate in patients who underwent coronary artery bypass grafting (CABG).

Materials and Methods: A total of 122 patients were randomized into two groups: The intervention group received CCRP. The program lasted for 12 weeks. Anxiety and depression were assessed using the hospital anxiety and depression scale (HADS) and PHS was assessed using the short form-36 health survey. The CCRP's effectiveness was measured using analysis of variance (ANOVA).

Results: The sample comprised 122 participants, of whom 85(69.7%) were male, with a mean age of 53.01±7.26 years. At baseline, the groups showed no significant differences. At 12 weeks and one month later, significant differences were observed between the groups for anxiety (F_1=937.69, P<0.001, partial η^2=0.90), depression (F_1=1036.00, P<0.001, partial η^2=0.91), physical component summary (PCS) (F_1=14.73, P<0.001, partial η^2=0.13) and mental component summary (MCS) (F_1=13.87, P<0.001, partial η^2=0.121) of PHS, respectively.

Conclusion: CCRP is an effective intervention that can significantly improve anxiety, depression, and PHS. Although the readmission rate difference was insignificant, it may have resulted in substantial rewards. The protocol of the present study was registered and approved in ClinicalTrials.gov PRS.

*** Corresponding Author:**
Kim Lam Soh, Professor.
Address: *Department of Nursing, Faculty of Medicine and Health Sciences, University Putra Malaysia (UPM), Seri Kembangan, Malaysia.*
Tel: *+60 (19) 9369893*
E-mail: *sklam@upm.edu.my*

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Introduction

Cardiovascular disease (CVD) is a prominent contributor to mortality and morbidity worldwide [1]. While the number of deaths related to CVD was 17.5 million in 2012, it increased to 17.9 million in 2016 and is expected to reach 22.2 million by 2030. Coronary artery bypass grafting (CABG) is the most common surgery applied globally. It has been confirmed to be one of the most efficient and long-lasting treatments for CAD [2]. To reduce post-CABG complications, improve quality of life, and avoid unplanned hospitalization for CABG patients, international associations, such as the American Heart Association (AHA) and the European Society of Cardiology recommended the use of cardiac rehabilitation programs (CRP) [3].

According to the AHA and the American College of Cardiology (ACC), cardiac rehabilitation (CR) is classified as a Class IA recommendation, and enrollment in CR is considered one of nine performance measures for secondary prevention [4]. As identified by the AHA and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR), the main components of CRP are education, exercise, and psychological support [5]. CRPs include three main phases: inpatient (phase I), early outpatient (phase II) and long-term outpatient CR (phase III) [3].

It is widely acknowledged that patients with CVD, including those undergoing CABG, experience anxiety and depression after acute cardiac events or major interventions [6]. Studies have shown that 34-35% of CABG patients experience moderate anxiety, and 15%-33% experience mild depressive symptoms [7-9]. Patients with persistent symptoms of anxiety and depression have poorer outcomes, which affect their recovery and reduce the benefits of treatment [10, 11].

Perceived health status (PHS) encompasses physical and mental well-being, relating to people's personal beliefs and assessments of their general state of health based on their personal experiences and perceptions, their experience of healthcare services and knowledge of clinical indicators [12]. In recent years, clinical consideration of how patients perceive social, emotional, and physical health has increased, especially for managing chronic diseases, where complete recovery is unlikely [13]. In cardiovascular studies, PHS has been extensively used to indicate the effectiveness of pharmacological and non-pharmacological interventions. Evaluating the impact of any treatment on PHS has become a valuable measurement of that treatment [14, 15].

While the impact of CRPs on various outcomes in patients with CVD has been extensively studied, a critical review of the existing literature revealed some gaps and areas that need further research. First, despite widespread research on CAD patients, there is insufficient knowledge concerning CABG patients in the CR field. This unique population experiences distinct emotional and physical outcomes due to their complex condition before surgery and the nature of their treatment, which differs significantly from that of other CAD patients [16]. This lack of focus results in insufficient insight into CABG patients' recovery.

Second, many existing randomized controlled trials (RCTs) lack structured interventions that include all essential components of a comprehensive CR program (CCRP) (i.e. exercise training, risk factor modification, and psychological management) [17]. Third, despite extensive epidemiological literature validating the beneficial effects of stress management in improving cardiac health, it is not included as a part of routine CR [18].

Thus the present study seeks to address these gaps in the literature. Adopting a holistic interventional approach, the present study provides insights into the effectiveness of the CCRP in enhancing emotional and physical outcomes, offering an understanding of lifestyle modification. This study also highlights the benefits of incorporating stress management into the CCRP to enhance cardiac health. This study aimed to examine the effect of CCRP on anxiety, depression, PHS and 90 days for patients undergoing CABG.

Materials and Methods

Design

An RCT was performed to assess the effectiveness of the CCRP on PHS, anxiety, depression and 90-day readmission rates in CABG patients. This study was guided by the consolidated standards for reporting trials (CONSORT) guidelines, which provide a framework for the apparent and complete reporting of RCTs. Adherence to the CONSORT guidelines ensures that the trial design, conduct, analysis, and results are reported in a standardized manner.

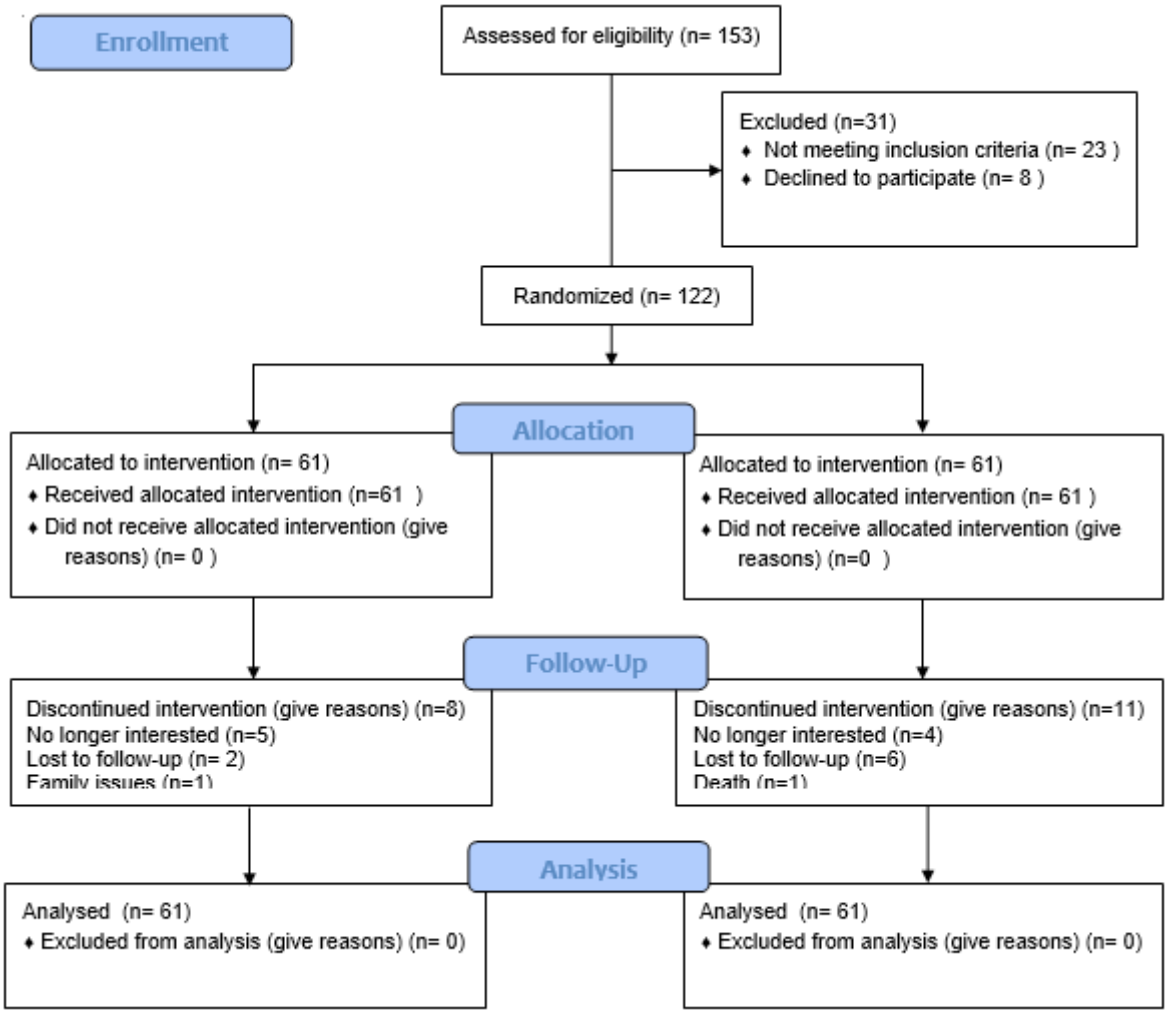

Figure 1. CONSORT flow chart

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Location and setting

The present study was conducted at two hospitals in Amman, Jordan: Al Bashir Hospital and Prince Hamzah bin Al-Hussien Hospital. These are the two leading government hospitals in the capital city.

Inclusion and exclusion criteria

The selection criteria outlined below were designed to ensure the participants' safety and capability to participate in the study. They were also established to ensure alignment with ethical standards. Therefore, patients were eligible to participate in this study if they met the following inclusion criteria:

1) Aged >18 years; 2) Have undergone CABG; 3) Free from electrocardiograph (ECG) abnormalities; 4) Able to read and write in Arabic; 5) Able to use a smartphone and access the Internet; 6) Having a family member who can help, supervise, and care for them; 7) Agree to participate and sign the informed consent form voluntarily.

Patients were excluded if they had physical or mental problems that limited their participation in the study (such patients require tailored CRPs to fit their needs) or if they complained of dyspnea or fatigue while performing ordinary daily activities (which renders them class III or IV according to the New York Heart Association classification), because the exercise component may be unsafe for such patients.

Sampling method and randomization

Participants were randomly recruited to participate in this study using the block randomization method with a block size of two. Every second, eligible patients were asked to participate if they agreed to. A closed-envelope approach randomly allocated participants to the intervention or control groups. The closed envelope con-

tained two papers, one for the intervention group and another for the control group. The participants were asked to choose one paper from the closed envelope, determining their group.

Sample size

The sample size was calculated based on a previous study [19]. The calculation was performed four times for the following outcomes: Anxiety, depression, PHS physical component, and PHS mental component. A large sample size ensured adequate participants for all measured outcomes. With a desired two-tailed significance level (alpha) of 5% and a power of 0.80, it was calculated that 47 participants were necessary per group. Consequently, the required number of participants for the present study was 94 to offset a potential dropout rate of 30%, to increase the chances of required participant retention until the end of the study, and to provide essential analytical power to interpret the statistical results. The final sample size for this study was 122 (61 per group). Figure 1 shows the CONSORT flowchart of the sampling and recruitment processes.

Measurement tools

Anxiety and depression were measured using the hospital anxiety and depression scale (HADS). It has two subscales: One for anxiety (HADS–A) and one for depression (HADS–D). Its 14 items (seven items for each subscale) are rated using a four-point Likert scale (0-3). Each subscale was scored separately by summing its seven items to produce a total score of (0-21). Higher scores indicate worse symptoms. A study by Terkawi et al. examined the validity of the Arabic version of the HADS in 110 surgical patients. It revealed that the Cronbach's α coefficient was 0.83 for the HADS-A subscale and 0.77 for the HADS-D subscale [20].

The short form 36 health survey questionnaire (SF-36) was used to measure PHS. The SF-36 is a popular generic measure designed to evaluate health status [21]. It is a brief yet inclusive measure of the PHS [22]. In Jordan, the psychometric properties of the SF-36 were assessed by Khader et al. who found that the reliability of the Arabic SF-36 was satisfactory, with Cronbach's α coefficients for all eight SF-36 scales being greater than 0.70 [23]. The SF-36 health survey consists of 36 items, with eight scales providing two component summaries: physical component summary (PCS) and mental component summary (MCS).

Recruitment

The potential participants were male and female CABG patients aged >18. No limitations were applied regarding educational, marital, or employment status, except that participants had to be literate in Arabic to ensure they understood the study materials. In addition, participants had a family member supervise and care for them while completing the intervention tasks.

Patients undergoing CABG have routine clinical appointments two weeks after discharge, during which physicians undertake a complete assessment, including a general physical examination, inspection of the surgical site, and history of recent symptoms after discharge, such as chest pain, palpitations, fatigue, or dyspnea. The assessment included ECG, blood samples and echocardiography analyses. Based on this assessment, the decision regarding the patient's eligibility to participate in the study was made. Those who agreed to participate were asked to sign the informed consent form and randomly allocated to either the intervention or control group. This process continued until the required sample size was recruited.

Intervention group

The intervention group received the following program CCRP

The CCRP is a 12-week program comprising exercise training, lifestyle and risk factor modification, stress management, and telephone follow-up. According to current international guidelines, exercise prescription is guided by the frequency, intensity, time, and type model [17]. Endurance exercise intensity was assessed using the Borg rating of perceived exertion (RPE) scale [17, 24-26]. Initially, the participants performed one supervised exercise session, in which they were taught how to rate their exertion and monitored for exertional angina symptoms. The rehabilitation program was designed at moderate intensity, corresponding to a score of 12-14 on the Borg RPE scale [17, 25]. Patients who achieved moderate intensity without experiencing symptoms of exertional angina were considered eligible for the rehabilitation program. This approach ensures safe and comfortable performance throughout the program.

The exercise part included a group of exercises gradually increasing in intensity (mild to moderate) and duration (30-60 minutes). There are three sessions weekly, each starting with five minutes of warm-up and ending with five minutes of cooling down. Exercises were delivered as short videos through the WhatsApp application,

Table 1. CCRP

Exercise Training					
Week	**Exercise Type**	**Repetition**	**Session/Week**	**Intensity**	**Duration**
2	Alternating supine leg raise Seated knee extension Ankle pumps Elbow bending	10	5 sessions/ weeks	Mild	30 min
3, 4	Front and side arm raising Elbow bending Shoulder rotation Slow walking	10	5 sessions/ weeks	Mild	30 min
5, 6	Front and side arm raising Elbow bending Shoulder rotation Hip rotation Step box+brisk walking	15	5 sessions/ weeks	Moderate	45 min
7, 8	Front and side arm raising Elbow bending Shoulder and hip rotation Step box+brisk walking	15	5 sessions/ weeks	Moderate	45 min
9, 10	Front and side arm raising Neck flexion and extension Shoulder and hip rotation Elbow bending Step box+brisk walking	20	5 sessions/ weeks	Moderate	60 min
11, 12	Front and side arm raising Neck flexion and extension Shoulder and hip rotation Elbow bending Step box+brisk walking	20	5 sessions/ weeks	Moderate	60 min

Lifestyle and Risk Factor Modification				
Week	**Topics**	**Session/Week**	**Delivery**	**Duration**
1-12	Unsafe movements, get out of bed Standing up, cuffing, bathing Potential complications Healthy dietary patterns dehydration Surgical wound care Adherence to medications Monitoring hypertension and hyperglycemia The importance of sleeping Warning sign/when to seek help Social involvement and family support	2 sessions	A) Face-to-face tutorial B) Smartphone application C) Brochure	8-15 min

Stress Management Using Breathing Control				
Week	**Steps**	**Session/Week**	**Delivery**	**Duration**
1-12	1) Sit in a calm place, relax, and focus on breathing 2) Inhale slowly through the nose, counting to three 3) Hold breathing for a count of three 4) Exhale through pursed lips, counting to five 5) Pause until you feel comfortable 6) Repeat the technique	3 sessions	Smartphone application	10 min
1-12	Each week includes 1 phone call follow-up			
1-12	Each week includes 1 resting day			

Table 2. Comparison at baseline

Variables	No. (%)			X^2	df	P
	Sample	Control Group	Intervention Group			
Gender Female Male	37(30.3) 85(69.7)	20(33) 41(67)	17(28) 44(72)	349	1	0.694
Marital status Married Single Divorced Widowed	112(91.8) 4(3.3) 3(2.5) 3(2.5)	56(50) 1(25) 2(66.7) 2(66.7)	56(50) 3(75) 1(33.3) 1(33.3)	0.1.667	3	0.644
Smoking status Current smoker Ex-smoker Non-smoker	54(44.3) 29(23.8) 39(32)	26(48.1) 18(62.1) 17(43.6)	28(51.9) 11(37.9) 22(56.4)	2.405	2	0.300
Comorbidities DM HTN CRF	72(59) 65(53.3) 76(62.3)	36(50) 34(52.3) 38(50)	36(50) 31(47.7) 38(50)	0.000 0.296 1	1 1 1	1.000 0.717 0.574
Education level Below high school High school Undergraduate Postgraduate	38(31.1) 66(54.1) 17(13.9) 1(0.8)	21(55.3) 34(51.5) 5(29.4) 1(100)	17(44.7) 32(48.5) 12(70.6) 0	4.364	3	0.225

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Abbreviations: PCS: Physical component summary; MCS: Mental component summary; DM: Diabetes mellitus; HTN: Hypertension; CRF: Chronic renal failure

providing details regarding appropriate performance techniques, body positions, repetitions, warm-ups, and cool-downs. It comprises various kinds of exercises, such as supine leg raises, seated knee extension, walking, brisk walking, side walking, step box, trunk rotation, arm raising, elbow flexion and extension, neck flexion and extension and hip rotation. The exercise intensity was determined using the talk test. The participants were instructed not to perform moderate-intensity exercise.

The lifestyle and risk factor modification part aims to provide participants with essential knowledge that supports a healthy lifestyle and controls modifiable risk factors. It includes several health education topics, such as healthy dietary patterns, potential complications, surgical wound care, adherence to prescribed medications, and the importance of sleep. The stress management component was implemented utilizing a structured regimen of breathing exercises designed to enhance relaxation, alleviate stress, and improve well-being. Participants in the intervention group received a training video on how to perform breathing control techniques. They were instructed to perform the technique for 10 minutes thrice weekly. Table 1 presents the program details.

Control group

Participants in the control group received usual care (general instructions and advice from physicians and nurses) without a structured program or educational materials. After signing the informed consent, they were asked to complete the SF-36, HADS, and the sociodemographic data sheet; for the control group, these instruments were completed at baseline, 12 weeks, and one month later. The participants in the control group received the entire program after the end of the study.

Data analysis

Inferential and descriptive statistics were used to describe the study variables and answer the research questions using SPSS software, version 23. Before analysis, data were checked and treated for outliers, missing data and wild coding. Exploratory data analyses were performed to determine the normality of the data using skewness, Kurtosis, and Shapiro-Wilk tests. Frequencies and percentages were used to describe categorical variables, while continuous variables were presented as Mean±SD.

Table 3. Effect of CCRP on outcomes

Outcomes	Effect Type	df	F	P	Partial η^2
Anxiety	Within-group effect	2	28.41	<0.001	0.220
	Between-group effect	1	937.69	<0.001	0.903
	Interaction effect	1.17	60.84	<0.001	0.376
Depression	Within-group effect	2	54.598	<0.001	0.351
	Between-group effect	1	1036.00	<0.001	0.911
	Interaction effect	2	4.64	0.011	0.044
PCS	Within-group effect	2	6.24	0.012	0.06
	Between-group effect	1	14.73	<0.001	0.13
	Interaction effect	1.09	45.77	<0.001	0.312
MCS	Within-group effect	2	22.33	<0.001	0.181
	Between-group effect	1	13.87	<0.001	0.121
	Interaction effect	1.17	45.77	<0.001	0.312

PCS: Physical component summary; MCS: Mental component summary.

Table 4. Comparison of outcomes between the intervention and control groups at the three time points

Outcome	Time-point	Mean±SD		P
		Control Group	Intervention Group	
Anxiety	Baseline	12.50±3.44	12.59±4.57	0.92
	at 12-week	12.52±4.22	9.89±4.33	<0.001
	at 1 month	13.52±4.22	7.25±3.89	<0.001
Depression	Baseline	12.40±4.71	11.96±4.61	0.64
	at 12-week	11.74±4.03	9.19±4.21	<0.001
	at 1 month	9.40±2.93	7.25±0.56	<0.001
PCS	Baseline	50.55±8.65	48.82±9.55	0.339
	at 12-week	42.82±11.04	51.62±11.69	<0.001
	at 1 month	42.82±13.50	57.19±11.84	<0.001
MCS	Baseline	50.02±12.91	50.19±11.60	0.94
	at 12-week	50.12±10.91	54.93±12.24	0.038
	at 1 month	47.52±10.27	65.40±12.57	<0.001

PCS: Physical component summary; MCS: Mental component summary.

*Significant at α=0.05 (2-tailed).

At baseline, the two groups were compared using an independent t-test for continuous variables and a chi-square for categorical variables. Repeated-measures analysis of variance (ANOVA) was employed to assess the effectiveness of the CCRP at 12 weeks and one month later on anxiety, depression, and PHS (MCS and PCS) after assessing all assumptions. An independent t-test was used to compare the 90-day readmission rates between the two groups. The significance level was P≤0.05, with 95% confidence intervals (CI) between the two groups.

Results

Participant characteristics and group comparison at baseline

The sample comprised 122 participants, 103 of whom completed the study. The CONSORT flow chart (Figure 1) illustrates the randomization process and the number of participants. Eighty-five participants were male (69.7%), with a Mean±SD age of 53.01±7.26 years. A total of 112 participants were married (91.8%), and 66 had a high school education (54.1%). The largest cohort was current smokers (n=54; 44.3%). No statistically significant differences (P>0.05) were observed between the two groups at baseline (Table 2).

Effect of CCRP on anxiety

The results of the repeated measures ANOVA demonstrated a statistically significant time (within-group) effect ($F_{2, 202}$=28.41, P<0.001, partial η^2=0.22). Additionally, the test of the between-group effect revealed a significant between-group effect (F_1=937.69, P<0.001, partial η^2=0.90). Furthermore, the results presented a statistically significant interaction (group×time) effect ($F_{2, 202}$=60.84, P<0.001, partial η^2=0.38) (Table 3).

At baseline, anxiety levels were similar between the control (12.50±3.44) and intervention groups (12.59±4.57) (P=0.92). At 12 weeks and 1 month, the intervention group had significantly lower anxiety levels (9.89±4.33) and (7.25±3.89) than the control group (12.52±4.22) and (13.52±4.22) (P<0.001) (Table 4).

Effect of CCRP on depression

The results from the repeated measures ANOVA showed a statistically significant time (within-group) effect ($F_{2, 202}$=54.60, P<0.001, partial η^2=0.35). Additionally, the test of the between-group effect revealed a significant group effect (F_1=1036.00, P<0.001, partial η^2=0.91). Moreover, the results presented a statistically significant interaction (group×time) effect ($F_{2, 202}$=4.644, P=0.011, partial η^2=0.04) (Table 3).

At baseline, depression levels were comparable between the control (12.40±4.71) and intervention groups (11.96±4.61) (P=0.64). At 12 weeks and 1 month, the intervention group had significantly lower depression levels (9.19±4.21 and 7.25±0.56) than the control group (11.74±4.03 and 9.40±2.93) (P<0.001) (Table 4).

Effect of CCRP on PHS (physical component)

The results revealed a statistically significant primary time (within-group) effect ($F_{1.09, 109.61}$=6.24, P=0.012, partial η^2=0.06). The test of between-group effect revealed a significant effect of group (F_1=14.73, P<0.001, partial η^2=0.13). Furthermore, the results presented a statistically significant interaction (group×time) effect ($F_{1.09, 109.61}$=44.96, P<0.001, partial η^2=0.31) (Table 3).

At baseline, PCSs were similar between the control (50.55±12.91) and intervention groups (48.82±9.55) (P=0.339). At 12 weeks and 1 month, the intervention group had significantly higher PCS scores (51.62±11.69) and 57.19±11.84) than the control group (42.82±11.04 and 42.82±13.50) (P<0.001) (Table 4).

Effect of CCRP on PHS (mental component)

For the MCS score, the results of repeated measures ANOVA revealed a statistically significant time (within-group) effect ($F_{1.17, 118.33}$=22.33, P<0.001, partial η^2=0.181). The test of the between-group effect revealed a significant effect of group (F_1=13.87, P<0.001, partial η^2=0.121). Additionally, the results showed a statistically significant interaction between (group×time) effects ($F_{1.17, 118.33}$=45.77, P<0.001, partial η^2=0.31) (Table 3).

At baseline, MCSs were similar between the control (50.02±12.91) and intervention groups (50.19±11.60) (P=0.94). At 12 weeks and 1 month, the intervention group had significantly higher MCS scores (54.93±12.24 and 65.40±12.57) than the control group (50.12±10.91 and 47.52±10.27) (P<0.001) (Table 4).

Effect of CCRP on 90-day readmission

The t-test results showed a non-statistically significant difference between the two groups (t_{120}=0.59, P=0.556). The mean 90-day readmission rates were (intervention group: Mean±SD, 0.26±0.63; control group: Mean±SD, 0.33±0.60). Table 4 summarizes the key variables studied among the groups at the three-time points, from baseline to 12 weeks.

Discussion

Effect of CCRP on anxiety and depression

Considering the impact of the CCRP on anxiety and depression, the results revealed a significant effect of the primary time, group, and group×time interaction, with improved outcomes among the IG in both anxiety and depression at the 12-week time point and one month later. A possible explanation for these results could be attributed to the inclusion of psychological support and stress management education in the CCRP. Studies have shown that patients who received stress management after cardiac events showed reduced anxiety and depressive symptoms compared to those who did not [27]. Such activities allow distraction, decrease painful sensations, improve relaxation and fatigue elimination, and help reduce anxiety and depression levels [28]. Moreover, the CCRP utilized in this study emphasized the importance of social support, which is linked to the alleviation of psychological disorders such as anxiety and depression [29].

Exercise training is a core component of the CCRP and adherence to a regular exercise program enhances physical fitness and improves psychological well-being [30]. The role of exercise in alleviating anxiety symptoms has been well documented in the literature [31]. Exercise has been suggested to reduce anxiety through different physiological mechanisms, including the regulation of inflammatory response, endothelial function enhancement, platelet aggregation diminution, and sympathetic-vagal activity balance [32].

Effect of CCRP on PHS (physical and mental)

The results demonstrated a significant effect of time, group, and group×time interactions, favoring the intervention group in both MCS and PCS. These results indicate a holistic enhancement in patients' general health perception and point to the crucial role that the CCRP can play in improving the physical and mental dimensions of patients' lives. The importance of these results is galvanized by the fact that they were self-reported, which means that the patients themselves evaluated their ability and feeling improvement.

Lower PHS is often experienced by patients after CABG, and persistent symptoms, such as pain and fatigue, decrease patients' ability to perform daily activities, undermining their self-perception, morale, and motivation to engage in former lifestyle activities, including physical activity. A CCRP is a multi-component program whereby different components can affect physical and mental health differently. Exercise is the cornerstone of CCRP, and a growing body of evidence suggests that exercise can positively impact health perceptions and mental health among patients after CABG, in addition to its biomedical health outcomes (according to conventional exercise-health indicators) [33, 34].

The main objectives of exercise training after CABG are to enhance cardiopulmonary function, improve vascular circulation and increase muscle endurance [35]. This physiological progression accelerates the recovery process and promotes confidence in overcoming postoperative barriers; consequently, it is reflected in patients' physical and mental well-being [33]. The gradual increase in exercise intensity and duration, as exercise intensity, plays a vital role in CR efficiency. Previous studies have suggested that moderate to high-intensity aerobic training patients reported better physical and mental health statuses than those who performed light or no training [36]. Adults with CVD should perform 150-300 minutes of moderate-intensity exercise per week or 75-150 minutes of high-intensity exercise per week unless they have contraindications [37].

Moreover, exercise training, lifestyle modification, and stress management magnify the impact of CCRP. Multiple universal guidelines recommend that CCRP comprise healthy lifestyle modification and psychological support in addition to exercise [38-40]. These integrated programs aid in controlling modifiable risk factors that may result in severe deterioration and revascularization.

Comparison of 90-day cardiac causes readmission rate

Regarding the 90-day cardiac cause readmission rate, the intervention group had a lower readmission rate than the control group, but this difference was not statistically significant. Despite the lack of statistical significance, this result suggests a substantial impact of CCRP on the 90-day readmission rate. Considering the burden of readmission on patients and healthcare systems, this impact has significant clinical benefits [41].

Reducing the readmission rate is a critical issue in the clinical setting, as it is considered a performance indicator for several healthcare outcomes, such as quality of care, patient satisfaction, resource utilization and coordination between various healthcare providers [42, 43]. The results of the present study demonstrate the critical role of the CCRP in reducing unplanned readmission rates. Therefore, implementing CCRP improves patient health status and enhances healthcare systems' efficiency.

Conclusion

Comprehensive CR is an effective intervention that can significantly improve anxiety, depression, and perceived health. Although the difference in the readmission rate for 90-day cardiac causes is not statistically significant, it may result in substantial rewards for patients and healthcare systems.

Research implications

This study offers valuable insights for decision-makers in the field of cardiac care in Jordan and the region, highlighting the benefits of the CCRP for CABG patients. CCRP advances postoperative outcomes by supporting medical and surgical treatment, lowering readmission rates, decreasing resource utilization, and improving overall quality of care. This cost-effective program is helpful for patients, their families, and healthcare professionals. Key results revealed CCRP's positive effect of CCRP on physical and psychosocial outcomes, addressing gaps in the current literature. The present study recommends expanding research to Phase III CCRPs, examining their long-term impact, and exploring cardiac-related readmissions through RCTs. Optimized learning and tailored CCRPs are imperative for healthcare professionals, particularly nurses, to refine patients' understanding of risk factors and encourage adherence to healthy lifestyles. This study comprises recommendations, guidelines, and educational materials from key cardiovascular organizations to aid in implementing the program.

Limitations

The results of the present study should be interpreted with caution due to some limitations that may have been encountered. First, although blinding between providers and participants is recommended in RCTs, complete blinding is typically impossible in rehabilitation studies because healthcare providers are in direct contact with the participants. The lack of blinding could influence the participants' behaviour and responses. Second, this study relied on self-reported outcome questionnaires, vulnerable to social desirability bias and under- or over-estimation of actual behaviours. However, validated tools can reduce the effects of such potential biases. Third, the results of this study may not be suitable for generalization to illiterate patients who have difficulty accessing readable materials.

Recommendations for practice and research

Healthcare systems are highly encouraged to establish CCRPs, which should be structured and tailored according to patients' needs, considering their clinical and sociodemographic characteristics. Additionally, healthcare systems are recommended to develop policies for discharge that include health education and focus treatment, particularly for high-risk patients, utilizing evidence-based practice in guidelines and universal predictive models, such as the Charleson comorbidity index score.

Tracking and monitoring systems can be implemented to monitor patients outside healthcare settings and elicit feedback. This will encourage patients' commitment to a healthy lifestyle and help detect complications before further deterioration. Moreover, social media is a practical and widely accessible method for distributing information and increasing patient awareness.

Furthermore, it is recommended that studies investigate the impact of CCRP on physiological indicators, such as cardiac biomarkers and echocardiographic parameters, among patients after CABG, as such outcomes objectively measure program effectiveness and can provide a clearer image of their outcomes.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Prince Hamzah Hospital, Amman, Jordan (Code: 3308/RESEARCH/HH) and it was registered at the Clinical Trials Gov PRS (Code: NCT06118918).

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

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