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*Article*

# Effect of Early Rehabilitation Exercise on Lower Limb Function and Psychological State After Coronary Artery Bypass Grafting: A Randomized Controlled Trial

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## Abstract

**Background**: While early rehabilitation exercise has been shown to improve cardiopulmonary function and functional outcomes after revascularization in individuals who have undergone coronary artery bypass grafting (CABG), further research is still needed to fully understand the importance of psychological status and limb functional rehabilitation following CABG. Therefore, the purpose of this study was to investigate the effects of early rehabilitation exercise on lower limb function and mental health after coronary artery bypass grafting. **Methods**: Eighty patients who underwent CABG were randomly divided into a routine exercise group and an early rehabilitation exercise group. The degree of lower limb swelling, the amount of incision complications, the first time the patient got out of bed after the operation, the length of postoperative hospital stay, activity tolerance and postoperative psychological state were compared between the two groups. **Results**: The incidence of postoperative lower extremity oedema was 30% in the early rehabilitative exercise group as compared to 52.5% in the routine exercise group. Between the two groups, there was a statistically significant difference ($p < 0.05$) in the incidence of postoperative lower limb edema as well as the amount of swelling in the thighs and ankles on postoperative days 1, 3, and 5. In the routine exercise group, the first time the patients got out of bed was 3.45 $\pm$ 1.09 days, and the length of postoperative hospitalization was 12.75 $\pm$ 5.06 days. In the early rehabilitation exercise group, the first time the patients got out of bed was 1.93 $\pm$ 0.57 days, and the length of postoperative hospitalization was 9.50 $\pm$ 2.92 days. There were statistically significant differences in these two indices between the two groups ($p < 0.05$). The activity tolerance of patients in the routine exercise group was 46.10 $\pm$ 19.09 min at 2 months after surgery and 69.88 $\pm$ 19.05 min at 3 months after surgery. The activity tolerance of patients in the early rehabilitation exercise group was 56.40 $\pm$ 17.42 min at 2 months after surgery and 105 $\pm$ 23.04 min at 3 months after surgery, and there was a significant difference in activity tolerance between the two groups at these time points following surgery ($p < 0.05$). In addition, there were statistically significant differences in the Patient Health Questionnaire-9, Generalized Anxiety Self-Assessment Scale-7 and Pittsburgh Sleep Quality Index scores between the two groups ($p < 0.05$). **Conclusions**: Early rehabilitation exercises can promote the recovery of lower limb function after CABG to a certain extent, shorten the postoperative bed rest time and hospital stay, and effectively improve postoperative psychological well-being and sleep quality.

## Keywords

exercise; cardiac rehabilitation; coronary artery bypass grafting; limb function; psychological state

## Introduction

Coronary artery bypass grafting (CABG) is one of the most commonly used treatments for coronary artery disease and can increase the myocardial blood supply, effectively eliminate or alleviate the symptoms of myocardial ischaemia and infarction, improve quality of life, and reduce the risk of death [1]. As a bypass vessel, the saphenous vein graft has the characteristics of suitable length, easy acquisition, suitable diameter, and easy anastomosis. It is one of the most commonly used vessels in coronary artery bypass grafting [2]. However, after saphenous vein harvesting, due to capillary damage, impaired venous drainage, and lymphatic and soft tissue trauma, the tendency of the surgical limb to experience swelling and local complications, such as lower limb oedema, pain, and numbness, increases [3]. These symptoms often lead to delayed wound healing and decreased activity tolerance and affect the recovery of limb function. It further affects the overall rehabilitation of patients [4–6]. Additionally, CABG patients are more likely to have negative emotions following surgery, including anxiety and sadness, which can impact their prognoses. These emotions include dread of disease, pressure from long-term hospitalization, postoperative quality of life, and health management issues [3].

At present, influenced by the concept of early mobilization, doctors and nurses are also paying increasing attention to the benefits of early postoperative mobilization for patients. Previous studies have shown that early rehabilitation exercise after coronary artery bypass grafting has the following benefits: (1) improving coronary blood flow and increasing the left ventricular ejection fraction and cardiac output, which are beneficial for increasing the systemic importance and blood supply of organs [7]; (2) increasing vital capacity and lung ventilation, which are conducive to the trachea and bronchial secretions and prevent the occurrence of pulmonary complications [8]; (3) improving the recovery of gastrointestinal function and preventing abdominal distension and constipation caused by a rising diaphragm [9]; and (4) preventing the occurrence of deep vein thrombosis and muscle atrophy and improving lower limb muscle strength.

However, it can be difficult for some patients to achieve the goal of early exercise because most CABG patients are older and frequently have additional problems, such as loss of limb function or weakening of the muscles due to insufficient collateral circulation [10]. This jeopardizes the outcome of cardiac rehabilitation and surgery. As an important part of stage I cardiac rehabilitation for CABG patients, early rehabilitation exercise can effectively reduce the incidence of postoperative complications, such as pneumonia, atrial fibrillation, multiple effusions and atelectasis; improve postoperative cardiopulmonary function and quality of life [11]; and promote the realization of early ambulation activities. While early rehabilitation exercise has been shown to improve cardiopulmonary function and functional outcomes after revascularization in individuals who have undergone CABG, further research is still needed to fully understand psychological status and limb functional rehabilitation following CABG. Furthermore, for patients who have undergone CABG, clinical medical staff tend to focus more on the impact of early rehabilitation exercise on cardiac function and haemodynamics while ignoring the importance of early functional rehabilitation of the lower limbs. Due to the characteristics of CABG surgery, the thoracic movement of patients is limited after surgery, and the gas exchange process is affected, reducing lung function and subsequently decreasing postoperative limb function [11]. Therefore, early rehabilitation exercise of the limb after CABG is important. However, the main measures currently used to improve the limb function of CABG patients include elevating the limb; applying elastic bandage pressure dressings; observing peripheral circulation; and requiring patients to perform leg muscle contraction movements and activities at the ankle, knee, and toe joints. The nursing outcome is not optimal. The probability of limb swelling and incision complications is high. Due to poor recovery of limb function, some patients find it difficult to achieve the goal of early ambulation [6]. Research has indicated that, following surgery, the majority of CABG patients report problems with their lower extremities rather than problems at the location of the sternal lesion [12]. Patients who have not recovered their limb function are unable to achieve the goal of early ambulation, which has an impact on the nursing outcome [10].

Therefore, through a randomized controlled trial, this study adopted active and passive exercise modes to carry out intensive lower limb function training. Our goal was to explore the influence of early rehabilitation exercise on lower limb function and the psychological state of patients after CABG to provide feasible intervention strategies for the functional rehabilitation of patients after CABG.

## Materials and Methods

### *Participants*

The convenience sampling method was used. This single-centre randomized controlled trial was performed from September 2021 to March 2022 at the Department of Cardiovascular Surgery, the First Affiliated Hospital of Anhui Medical University. The primary inclusion criteria for the participants were: (1) had undergone elective or initial isolated CABG; (2) had a saphenous vein graft collected for CABG with or without the radial artery and internal mammary artery; (3) had a New York Heart Association cardiac function classification between I and III without oedema before admission; and (4) were between 50 and 80 years of age. The exclusion criteria for the participants were: (1) previous nervous system disease; (2) lumbar diseases or hip or knee joint diseases that may affect walking ability; (3) lower extremity arterial and venous thrombosis, disease history or surgical history; (4) cardiac surgery at the same time; and (5) stay in the intensive care unit (ICU) for $\geq$3 days.

Finally, 80 patients were included in the study. Eligible patients were randomized into two groups: the early rehabilitation exercise group (ERE group, n = 40) and the usual exercise group (UE group, n = 40) using a coin toss. The baseline characteristics, such as age, sex, incision length and history of diabetes, were similar between the two groups, as shown in Table 1.

This study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University (number: Quick-PJ2023-10-36), and all participants signed informed consent prior to participation.

### *Design and Intervention*

#### Research Method

Method of randomization: A randomized numerical method was used to divide the participants into observation and control groups.

**Table 1. Comparison of baseline data between the two groups.**

| Items | UE Group ($n$ = 40) | ERE Group ($n$ = 40) | $t/\chi^2/Z$ | $p$-value |
|---|---|---|---|---|
| Age (years) | 61.93 ± 9.51 | 65.28 ± 8.10 | –1.696 | 0.094 |
| Sex | | | 0.069 | 0.793 |
| Male | 30 (75.0%) | 31 (77.5%) | | |
| Female | 10 (25.0%) | 9 (22.5%) | | |
| Preoperative EF (%) | 58.10 ± 5.39 | 57.95 ± 7.63 | 0.102 | 0.919 |
| Smoking history | | | 0.202 | 0.653 |
| No | 21 (52.5%) | 23 (57.5%) | | |
| Yes | 19 (47.5%) | 17 (42.5%) | | |
| Incision length (cm) | 16.71 ± 3.71 | 18.59 ± 5.45 | –1.800 | 0.076 |
| Postoperative ICU stay (day) | 2 [1, 2] | 1 [1, 2] | –0.556 | 0.578 |
| Diabetes mellitus | | | 0.474 | 0.491 |
| No | 26 (65.0%) | 23 (57.5%) | | |
| Yes | 14 (35.0%) | 17 (42.5%) | | |

EF, ejection fraction; UE, usual exercise; ERE, early rehabilitation exercise; ICU, intensive care unit.

Blinding method: A single-blinded experiment was performed on the patients. A attending physician was invited to help adjust the beds of patients so that the patients in the intervention group and the experimental group were placed in different and distant wards to reduce the incidence of data contamination.

Sample size calculation: Our sample size was calculated based on the following formula: $n = \left[Z^2_{\alpha/2}P(1-P)\right]/\delta^2$: $\alpha = 0.05$ $Z^{\alpha/2} = 1.96$, $\delta = 0.1$. The incidence of lower extremity complications after coronary artery bypass grafting was 33%. Considering the 10% error factor, the final sample size was N = 90, and the samples were distributed according to the principle of 1:1, with 45 people in each group. Nevertheless, only 80 participants in the trial fulfilled the exclusion requirements; therefore, 80 CABG patients were ultimately included and randomized 1:1 to the usual activity group or the early rehabilitative exercise group.

## Intervention Method

Patients in the UE group received routine care, including cough training, enhanced nutrition, anticoagulant use to prevent blood clots, and limb elevation. We encouraged all patients to attempt bedside standing or walking exercises from postoperative days 2–3. However, only patients in the ERE group received a progressive lower limb strengthening exercise program, which included:

(1) After awakening in the ICU, patients in the ERE group performed ankle dorsiflexion and plantar flexion exercises, inversion and eversion of the foot, knee flexion and extension exercises, hip abduction, adduction, and flexion;

(2) In the general ward, patients began leg elevation exercises and attempted weight-bearing, gradually increasing from 0.5 kg until the patient could tolerate the maximum weight;

(3) Walking exercises were added on postoperative days 2–3, with at least 5 walks per day, each lasting at least 10 minutes or up to the maximum tolerated by the patient.

After discharge, all patients received standard guidance on post-CABG care and home walking. In accordance with the evaluation results of cardiopulmonary function and risk factors before discharge, the standard guidelines for CABG postoperative care included the application of nutrition, exercise, self-monitoring, wound care, medication advice, and regular follow-up plans.

## *Observation Indicators and Evaluation Criteria*

### Limb Function

(1) Main indicators: (i) The degree of postoperative lower extremity limb swelling: Leg circumference was measured at four time points: one day before surgery and 1, 3, and 5 days after surgery. We measured the leg circumference at three positions: 15 cm above the patellar cartilage, 10 cm below the patellar cartilage and 3 cm above the ankle. At each point, we measured the data twice and recorded the average value. (ii) Limb incision complications at 1, 2 and 3 months after the operation: Based on medical records.

(2) The following secondary indicators were measured: (i) the time to first ambulation after the operation; (ii) postoperative hospital stay; and (iii) activity tolerance

at 1, 2 and 3 months after the operation (the maximum duration of a patient's exercise training session).

### Psychological State

(1) Depressive symptoms were screened and assessed using the 9-item Patient Health Questionnaire (PHQ-9) [13], which consists of 9 items. The total score ranged from 0 to 27, with higher scores indicating more severe depressive symptoms.

(2) Generalized anxiety symptoms were screened and assessed using the Generalized Anxiety Self-Assessment Scale (GAD-7) [14], which consists of seven items with a total score of 0 to 21, with higher scores indicating more severe generalized anxiety symptoms.

(3) Sleep quality was assessed by the Pittsburgh Sleep Quality Index (PSQI) [15], which consists of 23 items, and the total score ranges from 0 to 21, with a higher score indicating worse sleep quality.

### *Data Analysis*

The sample size of 20 participants per group was calculated to be sufficient, with a power of 80% and an alpha of 5%, based on the main observation (leg circumference postoperatively at 1, 3, and 5 days). SPSS 25.0 statistical software (IBM Corp., Armonk, NY, USA) was used for data processing. Normally distributed measurement data are described as the means (SD), and comparisons between groups were performed by two independent sample *t* tests. The median and interquartile range (median [$P_{25}$, $P_{75}$]) were used to characterize normally distributed data, and a nonparametric test was applied to compare groups. The frequency and percentage of the count data were reported, and group comparisons were made using the chi-square test. $p < 0.05$ was considered to indicate statistical significance.

## Results

### *Comparison of Baseline Data between the Two Groups*

According to the findings, there were 10 females (25.0%) and 30 males (75.0%) in the UE group, with an average age of 61.93 ± 9.51 years. The ERE group consisted of 9 females (22.5%) and 31 males (77.5%), with an average age of 65.28 ± 8.10 years. There were no discernible differences in the baseline clinical data between the two groups ($p > 0.05$; Table 1).

### *Comparison of Postoperative Lower Limb Swelling between the Two Groups*

The incidence of postoperative lower limb swelling in the UE group was greater than that in the ERE group ($p < 0.05$). Both the UE and ERE groups experienced a gradual decrease in the degree of lower limb swelling; however, on the 1st, 3rd, and 5th days following surgery, the UE group experienced more severe thigh and ankle swelling ($p < 0.05$) than did the ERE group. The degree of calf swelling did not significantly differ between the two groups ($p > 0.05$; Table 2).

### *Comparison of Postoperative Limb Incision Complications between the Two Groups*

There was no significant difference in the incidence of postoperative limb incision complications between the two groups ($p > 0.05$), but compared with those in the UE group, the patients in the ERE group had better postoperative lower limb incision complications and wound healing (Table 3).

### *Comparison of the First Ambulation Time, Postoperative Hospital Stay and Postoperative Activity Tolerance between the Two Groups*

There was no significant difference in activity tolerance between the two groups 1 month after surgery ($p > 0.05$). However, compared with those in the ERE group, the patients in the UE group had longer bed rest and postoperative hospital stays and worse activity tolerance at 2 and 3 months after surgery ($p < 0.05$; Table 4).

### *Comparison of Postoperative Psychological State between the Two Groups*

The psychological state of the two groups improved after the intervention. Compared with those in the UE group, the PHQ-9, GAD-7 and PSQI scores in the ERE group improved after the intervention ($p < 0.05$; Table 5).

## Discussion

Cardiac rehabilitation is an important part of postoperative cardiac surgery rehabilitation, which refers to a series of interventions to ensure that patients with heart disease achieve the best physical, psychological and social status with a positive effect on improving and maintaining cardiovascular health [16]. Cardiac rehabilitation includes medication, nutritional counselling, smoking cessation, risk factor intervention, stress management, and exercise rehabilitation, of which exercise rehabilitation is an essential component [17,18]. In this study, early rehabilitation exercise for the limb of the vascular bridge side of patients after CABG effectively reduced the degree of swelling of the limb of the vascular bridge side, shortened the bed time and length of hospital stay, improved postoperative activity tolerance, improved postoperative anxiety and depression, and improved perceptual control ability. Early rehabilitation exercise can improve the limb function and postoperative psychological state of CABG patients.

**Table 2. Comparison of postoperative lower limb swelling between the two groups.**

| Items | UE Group ($n$ = 40) | ERE Group ($n$ = 40) | $t/\chi^2$ | $p$-value |
|---|---|---|---|---|
| Swelling of the lower limbs (e.g.) | 21 (52.5%) | 12 (30.0%) | 4.178 | 0.041 |
| Day1 Suprapatellar variation (cm) | 1.42 ± 1.06 | 0.79 ± 0.45 | 3.454 | 0.001 |
| Day1 Subpatellar variation (cm) | 1.48 ± 1.31 | 1.01 ± 1.68 | 1.380 | 0.171 |
| Day1 Ankle change (cm) | 1.19 ± 0.75 | 0.61 ± 0.49 | 4.097 | <0.001 |
| Day3 Suprapatellar variation (cm) | 1.35 ± 1.03 | 0.62 ± 0.45 | 4.112 | <0.001 |
| Day3 Subpatellar variation (cm) | 1.31 ± 1.12 | 0.95 ± 1.72 | 1.110 | 0.270 |
| Day3 Ankle change (cm) | 1.05 ± 0.71 | 0.45 ± 0.48 | 4.467 | <0.001 |
| Day5 Suprapatellar variation (cm) | 1.22 ± 1.16 | 0.36 ± 0.45 | 4.414 | <0.001 |
| Day5 Subpatellar variation (cm) | 1.13 ± 1.32 | 0.52 ± 2.45 | 1.376 | 0.173 |
| Day5 Ankle change (cm) | 0.82 ± 0.72 | 0.26 ± 0.56 | 3.868 | <0.001 |

**Table 3. Comparison of postoperative limb incision complications between the two groups.**

| Items | UE Group ($n$ = 40) | ERE Group ($n$ = 40) | $\chi^2$ | $p$-value |
|---|---|---|---|---|
| Numbness in the lower limbs (e.g.) | 14 (35.0%) | 9 (22.5%) | 1.526 | 0.217 |
| Wound infection (e.g.) | 3 (7.5%) | 1 (2.5%) | 1.053 | 0.305 |
| Poor wound healing (e.g.) | 4 (10.0%) | 1 (2.5%) | 1.920 | 0.166 |
| 1 month postoperative incision complications (e.g.) | 19 (47.5%) | 15 (37.5%) | 0.818 | 0.366 |
| 2 month postoperative incision complications (e.g.) | 12 (30.0%) | 8 (20.0%) | 1.067 | 0.302 |
| 3 month postoperative incision complications (e.g.) | 8 (20.0%) | 3 (7.5%) | 2.635 | 0.105 |

**Table 4. Comparison of the first ambulation time, postoperative hospital stay and postoperative activity tolerance between the two groups.**

| Items | UE Group ($n$ = 40) | ERE Group ($n$ = 40) | $t$ | $p$-value |
|---|---|---|---|---|
| The first ambulation time after surgery (days) | 3.45 ± 1.09 | 1.93 ± 0.57 | 7.863 | <0.001 |
| Postoperative hospital stay (days) | 12.75 ± 5.06 | 9.50 ± 2.92 | 3.520 | 0.001 |
| 1 month postoperative activity tolerance (min) | 38.28 ± 17.93 | 35.28 ± 10.55 | 0.914 | 0.363 |
| 2 month postoperative activity tolerance (min) | 46.10 ± 19.09 | 56.40 ± 17.42 | –2.521 | 0.014 |
| 3 month postoperative activity tolerance (min) | 69.88 ± 19.05 | 105 ± 23.04 | –7.431 | <0.001 |

**Table 5. Comparison of postoperative psychological state between the two groups.**

| Items | | UE Group ($n$ = 40) | ERE Group ($n$ = 40) | $t$ | $p$-value |
|---|---|---|---|---|---|
| PHQ-9 score | Before the intervention | 5.53 ± 1.75 | 5.13 ± 2.13 | 0.918 | 0.362 |
| | After the intervention | 4.60 ± 2.00 | 3.80 ± 1.22 | 2.145 | 0.035 |
| GAD-7 score | Before the intervention | 5.48 ± 1.39 | 5.13 ± 1.79 | 0.986 | 0.327 |
| | After the intervention | 5.10 ± 1.58 | 4.13 ± 1.56 | 2.779 | 0.007 |
| PSQI score | Before the intervention | 8.38 ± 1.93 | 7.90 ± 1.28 | 1.298 | 0.198 |
| | After the intervention | 7.71 ± 2.17 | 6.55 ± 1.84 | 2.591 | 0.011 |

PHQ-9, the Patient Health Questionnaire-9; GAD-7, Generalized Anxiety Self Assessment Scale-7; PSQI, Pittsburgh Sleep Quality Index scores.

At present, there is no unified conclusion on the timing of the start of early rehabilitation exercise. Our study argues that, for patients undergoing CABG, it is necessary and feasible to carry out early rehabilitation exercise of the limbs. Studies have shown that venous thrombosis occurs 24 h after cardiac surgery, and most cases of thrombosis occur in the limb gastrocnemius vein [19]. In addition, CABG is a large-scale surgery, and surgery lasts 4 to 6 h, which means that some patients are physically immobile for a long period of time during the operation; if not timely, physical activity may increase the risk of limb complications. Therefore, early postoperative patients in the ICU should start limb

function exercise in a timely manner. This period is characterized by passive exercise, which is the main way nurses perform functional exercise. Some studies have found that a single passive exercise has limitations. Long-term inability to perform autonomous activities can easily lead to disuse atrophy and fatigue of lower limb muscles. Therefore, with the worsening of the disease, patients should be encouraged to gradually transition from passive exercise to active exercise. In this way, it can promote the effective circulation of lower limb blood and restore lower limb muscle strength, and the limb activity achieved by active functional exercise is more in line with the needs of daily human activities, which can lay a foundation for the smooth progress of early get-out-of -bed activities [20]. This study showed that early limb movement rehabilitation training on the basis of routine exercise can reduce the degree of limb swelling on the side of the vascular bridge in patients with CABG after surgery, especially in the thigh and ankle, and has a significant advantage compared with patients who only receive routine exercise. Although there was no significant difference in the incidence of incision complications in the operative limbs between the two groups, patients who received early exercise rehabilitation had greater numbness, poorer healing of the lower limbs, and complications 1 to 3 months after surgery. In addition, compared with patients who only received regular exercise, patients who received early exercise rehabilitation had an earlier time to leave bed, a shorter postoperative hospital stay, and increased activity tolerance 2 to 3 months after surgery. All these indicators indicate that early exercise rehabilitation can enhance the postoperative rehabilitation of CABG patients. This may be because, in the specific implementation process of the early exercise rehabilitation training in this study, the transition from passive exercise to active exercise was also reflected, and the use of foot flexion and extension, straight leg elevation and circular rotation enhanced the main weight-bearing muscle group of the lower limb, strengthened muscle contraction, promoted blood return of the lower limb, and effectively established local collateral circulation. It could effectively avoid pain caused by limb flexion, incision splitting, bleeding and other problems [21,22]. On the other hand, it also enhanced the strength of the quadriceps muscle, accelerated blood circulation, reduced inflammation, and relieved oedema or haematoma in the incision area. At the same time, the progressive nature of early rehabilitation exercise in the present study is also more in line with the rehabilitation needs of patients' motor neurons. Under progressive feedback stimulation, the excitability of neurons in the motor pathway could be gradually enhanced, the movement ability of limbs could be improved, and the tolerance of postoperative activities could be improved.

Anxiety, depression, and sleep disorders usually affect the efficacy of CABG, which increases the difficulty of the operation and also aggravates postoperative complications and increases adverse events. The majority of CABG patients are middle-aged or older, and few of them are aware of CABG. It is more likely to result in perioperative anxiety, depression, and other negative psychological conditions when combined with traumatic stress, anaesthesia, pain, bed rest, medications, and other circumstances. This further impairs their treatment confidence and compliance with rehabilitation exercises. Research indicates that, during the initial fortnight following coronary artery bypass grafting (CABG), patients may encounter a range of consequences, including altered sleep patterns, postoperative pain, altered perception of everyday tasks, anxiety, depression, and other issues that may impede their ability to recover functionally [23]. Consistent with the findings of Pourafkari *et al*. [24] and Jain *et al*. [25], this study demonstrated that early rehabilitative exercise following CABG can significantly reduce postoperative depression and anxiety and enhance sleep quality.

In summary, early combined functional exercise is beneficial for the rehabilitation of limb function after coronary artery bypass grafting. To a certain extent, it can alleviate limb swelling, promote wound healing, and accelerate patient recovery. Second, early rehabilitation exercise can decrease the first ambulation time and postoperative hospital stay, increase activity tolerance, save medical expenses, and effectively improve the postoperative psychological state and sleep quality while reducing the incidence of anxiety and depression. Therefore, early rehabilitation exercise should be carried out quickly for patients after CABG in clinical practice.

## Conclusions

The findings of the study demonstrate that early postoperative physical activity, including foot dorsiflexion, rotation, and straight leg elevation, along with a combination of active and passive exercises, can contribute to the swift recovery of limb function in transplants to a certain degree. Moreover, this approach results in a decrease in both the length of postoperative bed rest and hospital stay. Conversely, early rehabilitation training does not have a significant impact on patients' anxiety levels or sleep quality. Following CABG surgery, early rehabilitation exercise is crucial for improving both psychological health and limb function recovery. It can lessen the amount of swelling in the limbs following surgery; shorten the duration of hospital stay and bed rest after surgery; increase activity tolerance; and successfully relieve anxiety, depression, insomnia, and other negative psychological states. It can also enhance quality of life and the outcome of rehabilitation following surgery.

However, there were some limitations in the study, such as the small sample size, the lack of a longer-term follow-up to assess the sustainability of the improvements in lower limb function and psychological well-being, the

universality of the study results needs to be further studied, and the sustainability of the improved study outcomes needs to be further verified. Therefore, increasing the sample size should be considered in future multicentre randomized controlled studies with longer-term follow-up to better validate the results and explore the effect of the intensity and frequency of functional exercise on limb function rehabilitation after coronary artery bypass grafting.

## Availability of Data and Materials

The datasets used and/or analyzed during the currentstudy are available from the corresponding author on rea-sonable request.

## Author Contributions

HM and SH-Writing, Data collection, Statistics and Draft. CZ-Design, Reviewing. HM, SH and RZ-Data collection, MY and JY-Statistics. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

## Ethics Approval and Consent to Participate

This study obtained approval from the local ethics committee of The First Affiliated Hospital of Anhui Medical University and complied with ethical standards (ID: Quick-PJ2023-10-36), as per the Declaration of Helsinki. All participants provided written informed consent prior to participating.


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## Conflict of Interest

The authors declare no conflict of interest.

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