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The impact of cardiac rehabilitation program on work ability in patients following percutaneous coronary intervention (PCI): A retrospective cohort study

Hanieh Najafloo[1], Salman Khazaei[2], Lobat Majidi[3], Azadeh Mozayani Monfared[4], Seyed Kianoosh Hosseini[4*], Saeid Ghiasvandi[5]

1- Student Research Committee, Hamadan University of Medical Sciences, Hamadan, Iran
2- Research Center for Health Sciences, Hamadan University of Medical Sciences, Hamadan, Iran
3- Department of Physical Medicine and Rehabilitation, School of Medicine, Sina (Farshchian) Educational and Medical Center, Hamadan University of Medical Sciences, Hamadan, Iran
4- Department of Cardiology, School of Medicine, Farshchian Cardiovascular Subspecialty Medical Center, Hamadan University of Medical Sciences, Hamada, Iran
5- Farshchian Hospital, Hamadan University of Medical Sciences, Hamadan, Iran

Correspondence:

Seyed Kianoosh Hosseini;
Farshchian Heart Center, Hamadan University of Medical Sciences, Hamadan, Iran;
Email: k.hoseini86@gmail.com

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Abstract

BACKGROUND: Cardiac rehabilitation (CR) is a critical intervention for reducing complications after cardiovascular procedures such as percutaneous coronary intervention (PCI). One of the key outcomes used to evaluate the effectiveness of CR programs is improvement in patients' work ability. This study aimed to assess the impact of a structured CR program on work ability in patients undergoing PCI.

METHODS: A retrospective study was conducted, comparing 36 patients who participated in a structured CR program following PCI with 36 patients who did not receive rehabilitation. The CR program included educational and exercise components, delivered over four weeks with three sessions per week. Work ability was evaluated three months post-intervention using a standardized questionnaire. Statistical analyses, including independent t-tests and correlation assessments, were performed to examine the relationship between CR participation and work ability.

RESULTS: The two groups were comparable in terms of age, gender, and underlying medical conditions ($p > 0.05$). Notably, 80% of patients in the CR group demonstrated good to excellent work ability, compared with only 25% in the control group ($p < 0.001$). The mean work ability score was significantly higher in the CR group than in the control group (mean difference = 7.55, $p < 0.001$).

CONCLUSION: Participation in a cardiac rehabilitation program significantly improves work ability in patients following PCI. These findings highlight the importance of integrating CR into post-PCI care. Future research should focus on randomized clinical trials incorporating diverse rehabilitation protocols and extended follow-up periods to further validate these results.

Keywords: Cardiac Rehabilitation; Coronary Angioplasty; Work Ability

Introduction

Ischemic heart disease (IHD) is among the most common and life-threatening chronic conditions worldwide[1,2]. In some regions, the prevalence of IHD is notably high, contributing to 46% of all-cause mortality and an incidence rate of 181.4 per 100,000 individuals[3]. Patients diagnosed with IHD frequently experience a spectrum of debilitating symptoms, such as chest pain, reduced tissue perfusion, activity intolerance, ineffective coping strategies, anxiety, and significant psychological distress[4]. These issues not only impair patients' quality of life but also place a considerable socioeconomic burden on both individuals and healthcare systems[5].

The development of IHD is strongly associated with a combination of modifiable and non-modifiable risk factors. Non-modifiable factors include advanced age, male gender, and a family history of cardiovascular disease[6]. Modifiable risk factors—such as elevated blood lipid levels, hypertension, visceral obesity, diabetes, smoking, physical inactivity, and psychosocial stress are critical contributors to disease progression[6]. Effective management of IHD requires a comprehensive approach, integrating pharmacological treatments, interventional procedures, surgical interventions, risk factor modification, and lifestyle adjustments[7].

Percutaneous coronary intervention (PCI) is a widely used revascularization strategy for patients with IHD who remain symptomatic despite optimal medical therapy or who present with significant ischemia and suitable coronary anatomy[8]. PCI is also the primary treatment for acute myocardial infarction (AMI)[9]. Although PCI has proven effective in alleviating clinical symptoms and improving quality of life, many patients continue to face functional limitations and challenges in resuming occupational activities post-procedure[10]. This highlights the need for complementary interventions to address these ongoing issues.

Approximately 45% of patients with IHD are of working age[11]. A study involving 107 patients found that the rate of return to work within 12 months following acute coronary syndrome (ACS) ranges between 67% and 93%, regardless of the initial treatment strategy[12]. However, several barriers to returning to work have been identified, including older age, physically demanding jobs, high depression scores, and poor physical fitness[13,14]. Unemployment following a cardiac event is associated with adverse outcomes, such as psychosocial distress, increased comorbidities, and a higher risk of recurrent cardiovascular events.

Cardiac rehabilitation (CR) is a structured, multidisciplinary program designed to improve cardiovascular health and support recovery in patients with cardiovascular disease (CVD). CR typically includes supervised physical exercise, lifestyle counseling (e.g., dietary changes and smoking cessation), patient education, and psychological support[15]. Evidence from a large-scale study indicates that participation in CR significantly reduces CVD-related mortality[16].

Findings on the impact of CR on return-to-work rates have been inconsistent. For example, a study on ACS patients found that CR participation did not significantly influence return-to-work rates, with younger age, shorter hospitalization duration, and higher pre-event income identified as the strongest predictors of occupational resumption[17]. However, other studies have demonstrated that CR can positively influence work-related outcomes by improving physical fitness, reducing psychological distress, and enhancing overall functional capacity. For instance, a systematic review and meta-analysis found that patients who participated in CR programs were 1.5 times more likely to return to work compared with those who did not, emphasizing the role of structured exercise and psychosocial support in facilitating occupational reintegration[18]. Additionally, another study highlighted that CR participants experienced significant improvements in work ability scores, attributed to better cardiovascular health, reduced fatigue, and increased self-efficacy[19].

These findings suggest that while individual factors such as age and socioeconomic status play a role, CR can provide substantial benefits in enabling patients to resume work, particularly

when programs are tailored to address both physical and psychological barriers. Despite these mixed findings, previous research suggests that CR programs following PCI can enhance physical fitness, psychosocial well-being, perceived recovery, and overall health status, potentially improving work ability. Given the limited number of studies specifically examining the impact of CR on work ability in PCI patients, this study aims to evaluate the effect of a structured cardiac rehabilitation program on the work ability index in patients undergoing PCI, compared with a control group.

Materials and Methods

This retrospective study was conducted from October 2022 to August 2023 at Farshchian Heart Hospital in Hamadan, affiliated with Hamadan University of Medical Sciences. The aforementioned hospital is a treatment, educational, and research center in the west of Iran, performing procedures such as coronary angioplasty, cardiac surgeries, and primary angioplasty for heart attacks, and is a member of the national heart attack program (247 program).

The study population comprised patients who underwent PCI and were subsequently referred to the cardiac rehabilitation unit. The rehabilitation process started 4–8 weeks after PCI. Participants were categorized into two groups based on their engagement in rehabilitation sessions: one group completed a minimum of 12 rehabilitation sessions, while the other group did not participate in any sessions. Inclusion criteria encompassed patients aged 30 to 80 years who had undergone coronary angioplasty and were referred for cardiac rehabilitation. Exclusion criteria included diagnoses of delirium, delusion, or dementia. Data collection was performed using a two-part instrument. The first part involved a checklist for extracting demographic and clinical information from patient records, including gender, age, educational background, and medical history. The second part utilized the Work Ability Index (WAI) questionnaire, a validated tool for assessing work ability. Work ability reflects the interplay between individual characteristics, occupational demands, functional capacity, and health status. The validity and reliability of the WAI questionnaire have been established in prior research, including a 2019 study by Mazloumi et al. involving 750 industrial workers[20].

The WAI questionnaire evaluates work ability across seven domains: current work ability compared to lifetime best, work ability relative to job demands, number of diagnosed comorbidities, functional limitations due to illness, sick leave and absenteeism over the past year, predicted work ability over the next two years, and mental capacity. The WAI scores are categorized as follows: 7–27 (poor), 28–36 (moderate), 37–43 (good), and 44–49 (excellent). After an extensive search in the literature, no similar study was found that actually calculated the work ability score in two groups of people with and without cardiac rehabilitation. Therefore, the researchers conducted a pilot study on nine patients who did not participate in rehabilitation sessions at all and nine patients who participated in rehabilitation sessions. The mean and standard deviation of the work ability score in the non-participating group was 27.22±2.47, and in the participating group was 28.78±1.46. Considering a power of 90% and a type I error level of 0.05, the sample size was calculated as 36 people for each study group.

The cardiac rehabilitation protocol at this center consists of a 4-week program with 12 sessions, each lasting 75 minutes (3 sessions per week). Each session includes 20 minutes of warm-up, 35 minutes of aerobic exercise, and 20 minutes of cool-down. The patients' left ventricular ejection fraction was assessed before the program using echocardiography, and an initial exercise test was performed. All exercise sessions were supervised by a physician, a physiotherapist, and a trained CCU nurse. Data collection was performed retrospectively through reviewing patient records and supplemented, when necessary, by telephone or in-person interviews that included demographic data, medical history, clinical examination, and

medication history. Approximately three months after the last rehabilitation session, patients in the intervention group were contacted and invited to the clinic to complete the WAI questionnaire. For the control group, which consisted of patients who had been referred to but did not participate in the rehabilitation sessions, the WAI questionnaire was also completed at a similar post-PCI time interval through direct contact and invitation, ensuring comparable timing between groups.

The reasons for non-participation in the cardiac rehabilitation program were identified through qualitative data collection involving direct communication with patients. Specifically, after reviewing patient records, follow-up telephone or in-person interviews were conducted with those who did not participate in the program. During these interactions, patients were asked openly about the barriers preventing their participation. The responses were then categorized into common themes such as long distance to the rehabilitation center, lack of follow-up reminders, time constraints, financial difficulties, lack of motivation, and inadequate explanation at referral. The identified categories represent the most frequently reported barriers among the study participants.

After collection, data were entered into SPSS software version 23. First, the Kolmogorov-Smirnov test was used to check the normality of the data distribution. For data analysis, descriptive statistics, including mean and standard deviation for quantitative variables and frequency and percentage for qualitative variables, were used to describe the study population. To compare the work ability score between the two study groups and between the two genders in patients undergoing rehabilitation, the t-test was used. The correlation between the work ability score and patients' age was assessed using Pearson's correlation coefficient test. A p-value of less than 0.05 was considered statistically significant.

Results

In this study, 36 patients who underwent PCI and participated in cardiac rehabilitation were compared with 36 PCI patients without a history of attending cardiac rehabilitation programs. The mean age of the studied patients was 58.42 ± 6.27 years, ranging from 43 to 70 years. The mean age in the cardiac rehabilitation group was 58.36 years, and in the control group was 58.47 years (P=0.94). In the rehabilitation group, 80.56% of the patients were male, while in the control group, 66.67% were male. The Chi-square test showed no significant difference between the two groups in terms of gender distribution (P=0.18).

In the rehabilitation group, the highest prevalence of diseases was related to hypertension, dyslipidemia, and DM, with 75%, 61.11%, and 36.11% of cases, respectively. In this group, no cases of liver disease, BPH, ileus, NAFLD, rheumatoid arthritis, UC, CVA, or cholecystitis were observed. In the control group, the highest prevalence of diseases was related to hypertension, dyslipidemia, and pulmonary disease, in 58.33%, 55.56%, and 52.75% of patients, respectively. Regarding the history of the examined diseases, except for pulmonary disease, which was significantly higher in the control group (52.78% compared to 13.89%, P<0.001), no significant difference was found between the two groups for any other condition (P>0.05) (Table 1).

Regarding the return-to-work questionnaire, no significant differences were found between the two groups in terms of the number of comorbidities (2.89 ± 0.92 in the rehabilitation group vs. 2.81 ± 1.24 in the control group, P=0.75) and the prediction of work ability in the next two years (6.25 ± 1.5 in the rehabilitation group vs. 6.75 ± 1.5 in the control group, P=0.75). However, scores related to the estimation of current work ability compared to the best work ability during life, estimation of current work ability relative to job demands, functional impairment due to illnesses, use of sick leave and absenteeism in the past year, mental abilities, and overall work ability score were significantly higher in the rehabilitation group (P<0.001) (Table 2).

The overall results showed that patients in the rehabilitation group had a better status in terms

Table 1. Baseline characteristics of patients in rehabilitation and control groups

Characteristic	Rehabilitation Group (n=36)	Control Group (n=36)	P-value
Age (years)	58.36 ± 6.27	58.47 ± 6.27	0.94
Gender			
Male	29 (80.56%)	24 (66.67%)	0.18
Female	7 (19.44%)	12 (33.33%)	
History of chronic disease			
Diabetes Mellitus	13 (36.11%)	11 (30.56%)	0.62
Hypertension	27 (75.00%)	21 (58.33%)	0.13
Dyslipidemia	22 (61.11%)	20 (55.56%)	0.63
Pulmonary Disease	5 (13.89%)	19 (52.78%)	<0.001
Kidney Disease	3 (8.33%)	7 (19.44%)	0.17
Cancer	1 (2.78%)	1 (2.78%)	1.00
Liver Disease	0 (0.00%)	4 (11.11%)	0.12
Benign Prostatic Hyperplasia	0 (0.00%)	1 (2.78%)	1.00
Non-Alcoholic Fatty Liver Disease	0 (0.00%)	2 (5.56%)	0.49
Rheumatoid Arthritis	0 (0.00%)	1 (2.78%)	1.00
Ulcerative Colitis	0 (0.00%)	0 (0.00%)	-
Cerebrovascular Accident	0 (0.00%)	0 (0.00%)	-
Cholecystitis	0 (0.00%)	0 (0.00%)	-

Table 2. Work Ability Index scores in PCI patients in rehabilitation and control groups

Questionnaire Dimensions	Rehabilitation Group	Control Group	P-Value
Current work ability compared to lifetime best (Score: 0–10)	8.5 ±1.11	6.58 ± 1.95	<0.001
Work ability in relation to job demands (Score: 0–10)	8.9 ± 1.19	6.64 ± 1.75	<0.001
Number of diagnosed comorbidities (Score: 1–7)	2.89 ± 0.92	2.81 ± 1.24	0.75
Work impairment due to illness (Score: 1–6)	4.94 ± 0.71	3.61 ± 1.2	<0.001
Sick leave in the past year (Score: 1–5)	3.72 ± 0.81	3.11 ± 0.62	<0.001
Estimated work ability in 2 years (Score: 1–7)	6.25 ± 1.5	6.75 ± 1.5	0.16
Mental resources (Score: 1–4)	3.89 ± 0.32	3.08 ± 0.64	<0.001
Total score (Overall WAI: Score: 7–49)	39.13 ± 4.37	31.58 ± 6.76	<0.001

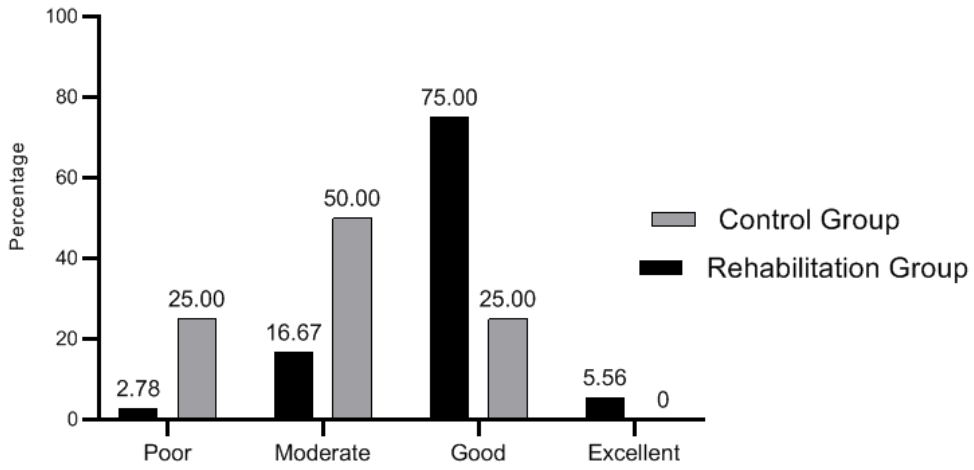

Figure 1. Classification of work ability status in PCI patients in rehabilitation and control groups

of work ability. Only one patient in this group was in poor condition, while in the control group, nine patients (25%) were in poor condition. In the rehabilitation group, 75% of the participants were in good condition, whereas only 25% of patients in the control group were in good condition. Two patients from the rehabilitation group were in excellent work ability status, while none of the patients in the control group had such a status (P<0.001) (Figure 1).

Table 3. Comparison of work ability domain scores in PCI patients in the rehabilitation group by gender

Questionnaire Dimensions	Rehabilitation Group			Control Group		
	Male	Female	P-Value	Male	Female	P-Value
Current work ability compared to lifetime best	8.65 ± 0.97	7.86 ±1.46)	0.09	6.83 ±1.90	6.08 ± 1.02	0.28
Work ability in relation to job demands	9.00 ± 1.15	8.50 ±1.35)	0.32	6.75 ±1.68	6.42 ±1.94	0.60
Number of diagnosed comorbidities	2.67 ± 0.87	2.57 ±1.33)	0.32	3.0 ±1.29	2.42 ±1.08	0.19
Work impairment due to illness	5.00 ± 0.76	4.71 ±0.49)	0.35	3.75 ±1.19	3.33 ±1.23	0.33
Sick leave in the past year	3.72 ± 0.88	3.71 ±0.49)	0.98	3.21 ±0.66	2.92 ±0.51	0.19
Estimated work ability in 2 years	6.28 ± 1.53	6.14 ±1.46)	0.84	5.88 ±1.48	5.5 ±1.57	0.49
Mental resources	3.93 ± 0.26	3.71 ±0.49)	0.11	3.21 ±0.66	2.83 ±0.58	0.10
Total score	39.59 ± 4.25	37.21 ±4.68	0.20	32.61 ±7.08	29.54 ±5.81	0.20

Note: Data are presented as mean ± standard deviation. PCI = Percutaneous Coronary Intervention.

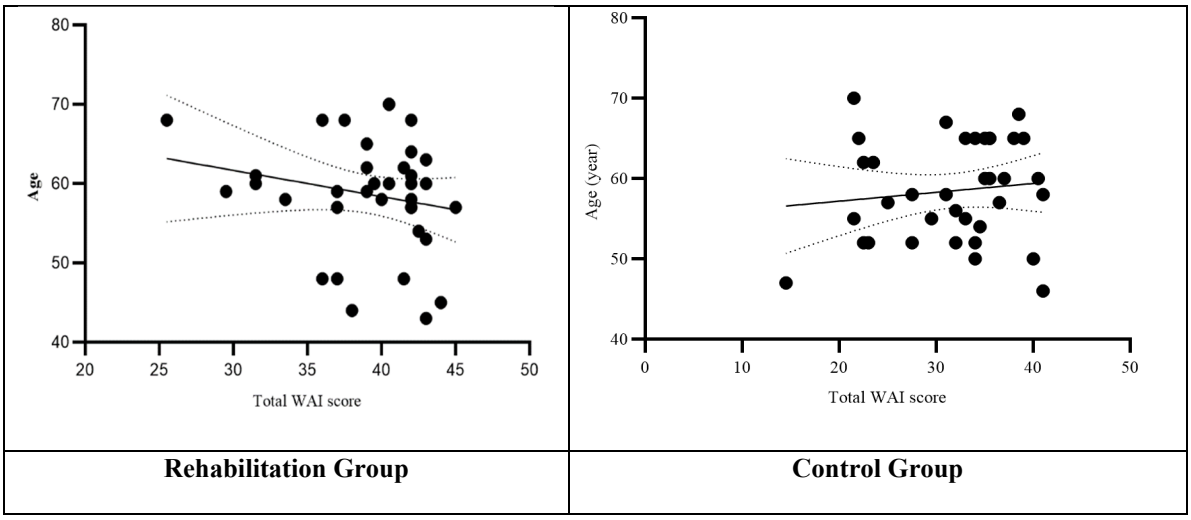

Figure 2. Correlation between work ability score and age in PCI patients in the rehabilitation and control groups

Table 3 compares the scores of work ability domains and the overall work ability score in PCI patients in both groups, categorized by gender. In both groups all domains related to work ability, as well as the overall work ability score, men achieved higher scores. However, none of these comparisons were statistically significant (P>0.05).

Figure 2 shows the correlation between work ability score and age in PCI patients in the rehabilitation group, indicating an inverse correlation. This means that as age increases, the work ability score decreases. However, this relationship is not statistically significant (r = -0.20, P = 0.24). In the control group, the work ability score slightly increases with age, but this correlation is also not statistically significant (r = 0.12, P = 0.49).

The most common reasons were the long distance to the rehabilitation center (27.77%) and lack of follow-up reminders (22.22%). Other notable factors included lack of time (16.66%), financial difficulties (8.33%), lack of motivation (8.33%), and insufficient explanation at referral to the CR department (5.55%). Less frequent reasons included physical disabilities, pain and discomfort, or diabetic complications, each accounting for 2.77% of cases. These findings emphasize the need to address logistical, communication, and motivational barriers to enhance patient participation in cardiac rehabilitation programs (Figure 3).

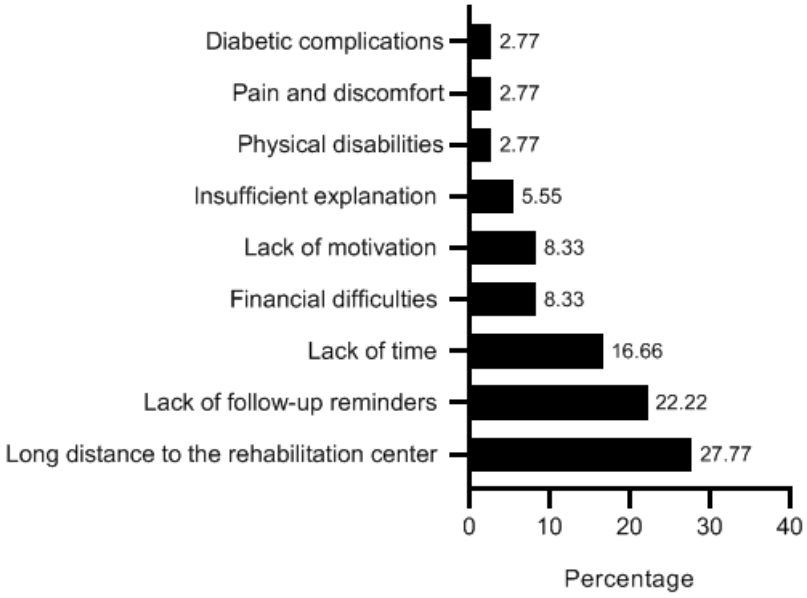

Figure 3. Reasons for non-participation in CR program

Discussion

The findings of the present study demonstrate that cardiac rehabilitation significantly improved the WAI scores in PCI patients compared to the control group. Specifically, 2.78% of patients in the rehabilitation group were classified as having poor work ability, compared to 25% in the control group. In addition, 75% of patients in the rehabilitation group were classified as having good work ability, while this percentage was only 25% in the control group. Notably, dimensions such as "current work ability compared to lifetime best," "work ability relative to job demands," "work impairment due to illness," "sick leave usage in the past year," and "mental resources" showed significantly higher scores in the rehabilitation group than in the control group.

The positive impact of CR on patients undergoing PCI is supported by recent studies. The CR program significantly improves physical fitness in PCI patients. These improvements in physical fitness are critical for enabling patients to resume occupational activities, particularly in physically demanding roles[21]. In addition to physical benefits, CR has been shown to enhance psychological well-being in PCI patients. Participation in CR after coronary revascularization is associated with reductions in anxiety and depression scores, as measured by standardized psychological assessments. These findings could play a vital role in addressing mental health barriers to RTW[22].

Functional capacity, another key outcome of CR, has also been shown to improve in PCI patients. CR participants after coronary revascularization exhibited greater improvements in functional capacity compared to non-participants. Enhanced functional capacity enables patients to perform daily activities and occupational tasks more effectively, probably reducing the risk of disability[23]. A recent study showed that participation in the CR program after cardiovascular events facilitates the return-to-work process. This underscores the importance of CR in addressing both physical and psychological barriers to occupational reintegration[24].

The estimated prevalence of work ability after rehabilitation varies across studies. A systematic review and meta-analysis by Sadeghi et al.[25] reported that work ability prevalence was 66% among patients undergoing cardiac rehabilitation and 58% among those who did

not. Additionally, outpatient rehabilitation patients had a prevalence of 72%, compared to 62% for hospitalized patients. Work ability was higher among office workers (72%) than manual laborers (63%). However, this study lacked data on patient occupations, limiting conclusions regarding the impact of rehabilitation based on job type.

The rehabilitation program in the present study included educational and exercise sessions, which positively impacted work ability outcomes. A Cochrane review[26] examined various interventions aimed at improving return-to-work rates in coronary artery disease patients compared to usual care or no intervention. While person-centered physical fitness programs showed increased return-to-work rates within six months to one year, results were not statistically significant and lacked strong evidence certainty. Other interventions, such as psychological counseling, workplace-centered guidance, and combined approaches, demonstrated better chances of facilitating return-to-work outcomes.

Age and gender did not show significant correlations with work ability in this study. Hu et al.[27] identified factors influencing work ability after three months in young coronary artery disease patients receiving PCI and care programs. Their results highlighted that male gender, ejection fraction ≥ 50%, brain-based job types, social support, and jobs requiring both mental and physical effort enhance work ability. Studies have emphasized that work ability is a dynamic process that tends to decline over time among patients[28].

The timing of work ability assessment is another important consideration. In this study, work ability was evaluated three months post-rehabilitation, a period that may reflect peak physical and psychological recovery. A Danish study by Pedersen et al.[13] found that significant improvements in RTW rates were most evident between six and nine months post-PCI, suggesting that longer follow-up periods may be necessary to capture the full impact of CR on work ability. Nonetheless, the three-month assessment in this study underscores the early benefits of CR in preparing patients for RTW.

The findings of this study reveal key barriers to participation in CR programs among patients who have undergone PCI. The most commonly reported reasons for non-participation were long distance to the rehabilitation center and lack of follow-up reminders. Other significant factors included lack of time, financial difficulties, lack of motivation, and insufficient explanation during referral to the CR department. Less frequent barriers included physical disabilities, pain, discomfort, and diabetic complications. These findings align with recent studies highlighting similar challenges in CR enrollment and adherence. Distance from the rehabilitation center and transportation issues were among the obstacles to CR participation among coronary heart patients after reperfusion therapy, as reported in a scoping review[29]. In a registry-based cohort study, social and geographical factors were important issues influencing participation in CR programs in post-PCI patients[30].

The lack of follow-up reminders and insufficient explanation during referral further underscore the importance of effective communication and patient education in improving CR participation rates. A study by Marlien Varnfield et al.[31] demonstrated that smartphone-based structured referral systems and personalized reminders significantly increased CR enrollment and adherence. These findings suggest that addressing logistical, communication, and motivational barriers through targeted interventions—such as telehealth-based CR programs, financial support, and enhanced patient education—could improve participation rates and outcomes. The barriers identified in this study highlight the need for multifaceted strategies to enhance CR accessibility and engagement. Addressing these challenges through policy changes, patient-centered interventions, and innovative delivery models could significantly improve CR participation and, ultimately, patient outcomes.

When evaluating the effectiveness of

rehabilitation programs on any outcome, it is essential to consider confounding variables such as insurance status, geographic factors like accessibility, and socioeconomic status, all key determinants for participating in rehabilitation programs[32]. For example, participation may conflict with employment schedules or impose financial burdens on patients, potentially affecting consistent attendance. Medical parameters such as left ventricular function, residual ischemia, and heart rhythm stability; occupational characteristics such as shift patterns or job type; and psychosocial factors such as depression or perceived health status also influence the relationship between rehabilitation programs and work ability outcomes[33].

Conclusion

The findings of this study suggest that cardiac rehabilitation may positively impact work ability among PCI patients by enhancing their readiness for return-to-work and daily life activities. Variables such as age, gender, and comorbidities did not significantly affect the relationship between rehabilitation and work ability outcomes. Addressing barriers through policy changes, patient-centered interventions, and innovative delivery models could significantly improve CR participation and, ultimately, patient outcomes.

Limitation

This study has some limitations worth noting. Although there were no differences between groups regarding age, gender, or comorbidities, some confounding variables were unavailable for analysis; for instance, pulmonary disease prevalence among non-participants may have contributed to lower work ability scores independently of rehabilitation effects. Another limitation is that most of the factors contributing to non-adherence to cardiac rehabilitation programs, such as long distance to rehabilitation centers, lack of motivation, financial difficulties, physical limitations, and insufficient referral explanation, also negatively impact patients' ability to return to work and their WAI scores. These overlapping barriers introduce confounding effects that limit the ability of retrospective observational studies to isolate the true causal effect of CR on work ability. Therefore, while our findings suggest a positive association between participation in CR and improved work ability, only well-designed randomized clinical trials can definitively determine the causal impact of CR on work ability outcomes by effectively controlling for these confounders. Additionally, patient occupation types were not categorized despite their differing physical and mental demands, a topic warranting further investigation in future studies. Finally, this study was conducted at a single specialized referral hospital for cardiovascular diseases; similar conditions may not be available at all treatment centers, a factor potentially introducing selection bias into the findings.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

Study Conception or Design: SKH, HN, AMM, LM
Data Acquisition: SKH, HN, AMM, LM, SK, SG
Data Analysis or Interpretation: SKH, HN, SK
Manuscript Drafting: SKH, HN, AMM, LM, SK
Critical Manuscript Revision: AMM, LM, SG

All authors have approved the final manuscript and are responsible for all aspects of the work.

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