Original Article

Improvements in Six-Minute Walk Distance and Functional Status following Phase II Cardiac Rehabilitation

Panida Poolpipat and Rachawan Suksathien
Department of Rehabilitation Medicine, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand

ABSTRACT

Objectives: To evaluate changes in 6-minute walk distance (6MWD) and New York Heart Association (NYHA) functional class (FC) among patients participating in an outpatient phase II cardiac rehabilitation (CR) program

Study design: Retrospective analytic study

Setting: Maharat Nakhon Ratchasima Hospital, a tertiary care hospital in Thailand

Participants: A total of 112 patients enrolled in the CR program between January 2022 and September 2024 and who had at least two 6MWD results available were included. Patients with incomplete data were excluded.

Methods: Demographics and clinical data were collected from the medical records of the patients. The 6MWD and the FC were assessed before and after CR program. The program also included exercise prescription, lifestyle and risk-factor modification.

Results: 97 patients (86.6%) had coronary artery disease, and 14 (12.5%) had congestive heart failure. Overall, 61.6% (95% CI: 52.4, 70.1) showed a ≥ 10% improvement in 6MWD from baseline. Prior to the outpatient phase II CR program, 18 patients were in FC I, 78 were in FC II, and 16 were in FC III. After the implementation of the CR program, 83 patients were classified as FC I, and none remained in FC III. In a modified Poisson regression analysis, intermediate-risk patients were 1.6 times more likely to improve than low-risk patients, while a baseline 6MWD < 300 m was independently associated with greater improvement (adjusted prevalence ratio, 1.7).

Conclusions: Participation in a structured CR program was associated with significant improvements in 6MWD and FC, with 61.6% of patients achieving ≥ 10% improvement in 6MWD from baseline. Patients with lower baseline 6MWD (< 300 m) and moderate risk stratification appeared to derive greater improvements.

Keywords: cardiac rehabilitation, 6-minute walk test, outcomes, functional status

ASEAN J Rehabil Med. 2026; 36(3): 115-122.
doi: 10.67880/ajrm.2026.36.02

Introduction

Cardiac rehabilitation (CR) is a comprehensive intervention that includes physician-prescribed exercise, modification of cardiac risk factors, psychosocial assessment, and outcomes assessment.[1] There was evidence of significant improvement in functional capacity, quality of life,[2] and reduced cardiovascular mortality.[3] The European Society of Cardiology (ESC) and American Heart Association (AHA) both provide a Class IA recommendation that CR is an essential component of the treatment for patients with coronary artery disease (CAD)[4,5] and chronic heart failure.[6,7]

The Six-Minute Walk Test (6MWT) is one of the most widely used tools for assessing physical performance in CR programs. It is a simple, reliable measure that effectively reflects responsiveness to clinical changes following rehabilitation.[8] Multiple factors can influence 6MWT improvement in CR programs. Previous studies have demonstrated that the 6MWT shows improvement following CR.[9-11] Factors associated with an increase in the six-minute walk test distance (6MWD) include younger age,[12] absence of diabetes mellitus,[13] a higher number of attended rehabilitation sessions, and lower baseline physical function.[14] These findings highlight the importance of tailoring rehabilitation programs to optimize outcomes for different patient groups. According to the 2024 AHA guideline,[1] an improvement in the 6MWD of ≥ 10% from baseline is considered an appropriate clinical goal following CR.

The CR clinic at Maharat Nakhon Ratchasima Hospital was established in 2022 and has been providing CR services since then. The program included assessment, 6MWT, home-based exercise prescription, guidance on exercise precautions, and lifestyle and risk-factor modification. However, a systematic evaluation of rehabilitation patients' clinical outcomes has not yet been conducted. This study aims to assess 6 MWD and functional class (FC) after phase II CR to help develop ideas for effective rehabilitation strategies to improve service delivery in the future.

Correspondence to: Panida Poolpipat, MD, FRCPhysiatrT; Department of Rehabilitation Medicine, Maharat Nakhon Ratchasima Hospital, 49 Changphueak Road, Nai Mueang Subdistrict, Mueang District, Nakhon Ratchasima 30000, Thailand; E-mail: Panida.po@cpird.in.th

Received: March 16, 2026 Revised: May 9, 2026 Accepted: May 12, 2026

Methods

This retrospective analytic study was conducted at the outpatient CR clinic, Maharat Nakhon Ratchasima Hospital. The study received approval from the Ethics Committee of Maharat Nakhon Ratchasima Hospital on January 22, 2026 (Project ID: 012/2026, approve January 22, 2026).

Participants

All patients enrolled in the CR clinic phase II program between 1 January 2022 and 30 September 2024 were identified from the hospital database, and their electronic medical records were reviewed. Inclusion criteria were: age ≥ 18 years, a diagnosis of CAD, congestive heart failure, valvular heart disease, or complete heart block on a permanent pacemaker (NYHA-FC 1,2,3), participation in at least two CR sessions, and availability of at least two 6MWT measurements. Patients were enrolled in the CR program following medical or surgical treatment, including guideline-directed medical therapy, percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), or valve surgery, as appropriate. Patients with incomplete data were excluded, including those without available low-density lipoproteins (LDL) results or documented home-based exercise records. After the inclusion-exclusion screening, data were collected from medical records using case record forms. The pilot study showed that 20 patients (66.7%) achieved ≥ 10% improvement in 6MWD from baseline. According to the Cochran's formula Z2/2P(1-P)/d2, the significance level was set to 0.05, and the estimation error of P was 0.67, indicating that at least 98 subjects were needed. The estimated proportion (P) for sample size calculation was obtained from a pilot sample randomly selected from outpatient clinic records. The pilot sample was used for this purpose and was not included in the final analysis.

Procedure

Data were collected from medical records using case record forms, including demographic and clinical variables: age, sex, body mass index (BMI), underlying comorbidities, diagnosis, smoking status, risk stratification, and major cardiovascular events within 1 year. Baseline and final measurements of heart rate, blood pressure, FC, 6MWD, and LDL were recorded. In addition, the type and duration of the most recent exercise session as well as the frequency of exercise sessions were documented.

The 6MWT was performed at the first follow-up visit after hospital discharge, provided there were no contraindications. The final 6MWT used for analysis was the last available assessment before discharge from the CR program. New York Heart Association (NYHA) FC was determined by a physiatrist according to standardized criteria, based on patients' reported symptoms (e.g., dyspnea, fatigue) and their reported functional limitations during daily activities. The evaluation was conducted at baseline before participation in the CR program.

Risk stratification was based on the AACVPR[15] criteria using non-exercised testing findings. Patients were classified as low risk if they had a resting left ventricular ejection fraction (LVEF) ≥ 50%, an uncomplicated myocardial infarction or complete revascularization, absence of complex ventricular arrhythmias at rest, absence of heart failure, and no signs or symptoms of post-event or post-procedure ischemia. Moderate risk was defined as an LVEF of 35.0 to 49.9%. Patients who did not meet the criteria for low- or moderate-risk were classified as high risk. LVEF was assessed after the latest cardiac event and before enrollment in the CR program, and was used for risk stratification. The number of attended CR sessions was categorized into two groups (2-3 sessions and > 3 sessions). The cut-off for categorizing CR session attendance was determined based on the median distribution of attended CR sessions in the study population.

The outpatient CR program (phase II) at Maharat Nakhon Ratchasima Hospital primarily consists of an initial hospital-based assessment followed by a structured home-based exercise program. Each patient undergoes a comprehensive evaluation by physiatrists, including a 6MWT. Based on this assessment, individualized counseling is provided, covering home exercise prescription, self-monitoring of exercise intensity (using the rating of perceived exertion [RPE], consistent with the level achieved during the in-hospital assessment), exercise precautions, lifestyle and risk factor modification, and dietary guidance. Patients are advised to perform home-based exercise 3 to 5 days per week, with gradual increases in duration (approximately 10 to 20% per week or 1 to 2 minutes per session), while maintaining the prescribed intensity level. The first follow-up is scheduled 4 to 6 weeks after discharge from admission, with subsequent follow-ups at approximately 1 to 3-month intervals, depending on patient availability and clinical status. These follow-ups are conducted at the hospital to reassess functional capacity and adjust the exercise prescription as needed. Patients are instructed to stop exercise immediately if warning symptoms occur, such as chest pain, dyspnea, dizziness, light-headedness, or presyncope. Patients are discharged from the program once they can safely perform exercise and daily activities at or near their usual level, or once they have achieved the predefined goals.

Statistical analysis

Descriptive statistics were used to summarize patient characteristics, including frequency, percentage, mean, standard deviation, and median (IQR). The chi-square test was used to compare qualitative variables. The 6MWD, heart rate, and LDL levels between the first and last follow-up visits were analyzed using paired t-tests, whereas changes in FC were evaluated using Fisher's exact test with a statistical significance level set at $p < 0.05$. The differences between the improved and not-improved groups were analyzed using the chi-square test. Modified Poisson regression was used to estimate prevalence ratios for the binary outcome of achieving ≥ 10% improvement in 6MWD. Variables that were significant in the univariable analysis and clinically relevant variables potentially associated with improvement in 6MWD were included in the multivariable model.

Result

A total of 598 patients participated in the outpatient CR program between January 1, 2022 and September 30, 2024. Of these, 65 had incomplete data, 157 had contraindications to CR or were unable to undergo 6MWT assessment, 236 had only one 6MWT measurement, and 28 were still in follow-up. The remaining 112 patients (76 men and 36 women; mean age, 59.8 years) were included. Among these patients, the diagnoses included CAD (86.6%), congestive heart failure (12.5%), and heart block (0.9%) (Table 1). Of the patients with CAD, 49 underwent post-PCI complete revascularization, 44 underwent post-PCI incomplete revascularization, and 4 underwent coronary artery bypass graft. Overall, 55.3% were classified as high-risk for CR, 11.6% as moderate-risk, and 33.1% as low-risk. 75.9% were receiving β-blockers. The duration of participation in the CR clinic was a median of 4 months (IQR: 3–6). Most patients 90 (80.4%) used walking as their exercise. 51 (45.5%) exercised for ≥ 30 minutes per day, and 107 (95.5%) exercised on ≥ 3 days per week. At the 1-year follow-up, 3.6% experienced rehospitalization, 0.89% died, and 95.5% had no cardiovascular events.

Overall, 61.6% of patients (95% CI: 52.4, 70.1) showed an improvement in 6MWD of ≥ 10% from baseline. Among patients with a pre-CR 6MWD < 300 m, 82.5% showed improvement, compared with 50% among those with 6MWD ≥ 300 m. In addition, none of the patients who exercised fewer than 3 days per week showed improvement, whereas 64.5% of those exercising ≥ 3 days per week did. These differences were statistically significant. In contrast, sex, age, diabetes mellitus, diagnosis, and risk stratification did not show significant differences. (Table 2).

After CR, 74.1% (95% CI: 65.3, 81.3) were in FC I, 25.9% (95% CI: 18.7, 34.7) were in FC II, and no patients remained in FC III. Resting heart rate significantly decreased from 76.6 (SD = 12.8) to 72 (SD = 13.6) ($p < 0.01$). The 6MWD increased significantly from 312.8 (SD = 105.3) to 377.9 (SD = 93.1) ($p < 0.01$). LDL levels decreased significantly from 118.1 (SD = 40.6) to 83.7 (SD = 28.2) ($p < 0.01$) (Table 3).

When stratified by demographic factors, no differences in mean 6MWD were observed across sex, age groups, or diagnoses. However, when stratified by risk categories, a difference was noted. The intermediate-risk group demonstrated a mean pre- to post-CR difference of 105 m (SD = 43.1), which was greater than that observed in the low- and high-risk groups, with mean differences of 50.5 m and 65.4 m, respectively (Table 4).

Table 1. Clinical characteristics of the patients (n = 114)

Characteristics	Number (%)
Age (year)[1]	59.8 (11.6)
Male	76 (67.7)
Diagnosis	
SVD	36 (32.1)
DVD	29 (25.9)
TVD	32 (28.6)
Congestive heart failure	14 (12.5)
Heart block	1 (0.89)
Cardiovascular risk factor	
DM	35 (31.1)
HT	62 (55.3)
DLP	55 (49.1)
Smoking habit	
No smoking	72 (64.3)
History of smoking	39 (34.8)
Current smoking	1 (0.89)
BMI	
< 18.5	9 (8.0)
18.5-22.9	34 (30.4)
≥ 23	69 (61.6)
Baseline LVEF	
< 35%	34 (30.3)
35-49%	32 (28.6)
≥ 50%	46 (41.1)
Baseline FC	
1	18 (16.1)
2	78 (69.6)
3	16 (14.3)

[1]Mean (SD); SVD, single vessel disease; DVD, double vessel disease; TVD, triple vessel disease; DM, diabetic mellitus; HT, hypertension; DLP, dyslipidaemia; BMI, body mass index; LVEF, left ventricular ejection fraction; FC, functional class

Univariate analysis revealed baseline 6MWD was statistically significantly associated with improvement in 6MWD. Other factors potentially associated with improvement in 6MWD, including risk stratification, the number of CR sessions attended, and age, were further evaluated using modified Poisson regression analysis. Intermediate-risk patients were 1.6 times more likely to demonstrate improvement than low-risk patients. Additionally, a baseline 6MWD < 300 meters was independently associated with greater improvement (adjusted prevalence ratio 1.7) compared with a baseline 6MWD ≥ 300 meters (Table 5).

Discussion

In this study, 61.6% of patients demonstrated improvement in 6MWD after completing CR. According to the 2024 AHA guideline,[1] an improvement in the 6MWD of ≥ 10.0% from baseline is considered an appropriate clinical goal following CR. To date, no studies have compared outcomes using this ≥ 10% threshold; therefore, this analysis is among the first to apply it. Previous studies have primarily compared absolute 6MWD values before and after CR participation.

Table 2. General characteristics and patient variables comparing patients with ≥ 10% and < 10% improvement following CR

Variables	≥ 10% improvement (n = 69)	< 10% improvement (n = 43)	*p*-value
Age (year)			0.54
< 60	28 (58.3)	20 (41.7)	
≥ 60	41 (64.1)	23 (35.9)	
Diagnosis			0.32
CAD	62 (63.9)	35 (36.1)	
Congestive heart failure	7 (50.0)	7 (50.0)	
DM			0.15
Yes	25 (71.4)	10 (28.6)	
No	44 (51.1)	33 (42.9)	
Risk stratification			0.21
Low	19 (51.4)	18 (48.7)	
Intermediate	10 (76.9)	3 (23.1)	
High	40 (64.5)	22 (35.5)	
Pre-CR 6MWD			< 0.01
< 300	33 (82.5)	7 (17.5)	
≥ 300	36 (50.0)	36 (50.0)	
Functional class			0.25
1	9 (50.0)	9 (50.0)	
2	52 (66.7)	26 (33.3)	
3	8 (50.0)	8 (50.0)	
Number of attended CR sessions			1.00
2-3	44 (61.9)	27 (38.1)	
> 3	25 (61.0)	16 (39.0)	
Exercise adherence (days/week)			< 0.01
< 3	0 (0.0)	5 (100.0)	
≥ 3	69 (64.5)	38 (35.5)	

CAD, coronary artery disease; DM, diabetic mellitus; CR, cardiac rehabilitation; 6MWD, six-minute walk distance

Table 3. Clinical outcomes pre-CR and post-CR

Variables	Pre-CR, mean (SD)	Post-CR, mean (SD)	*p*-value
SBP	130 (21)	129.7 (19.4)	0.89
DBP	76.1 (11.8)	75.3 (11.9)	0.44
HR	76.6 (12.8)	72 (13.6)	< 0.01
6MWD	312.8 (105.3)	377.9 (93.1)	< 0.01
Functional class			< 0.01
1	18 (16.1)	83 (74.1)	
2	78 (69.6)	29 (25.9)	
3	16 (14.3)	0 (0.0)	
LDL	118.1 (40.6)	83.7 (28.2)	< 0.01

CR, cardiac rehabilitation; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; 6MWD, 6-minute walk distance; LDL, low-density lipoprotein

A systematic review[16] found strong evidence that the 6MWT was responsive to change in clinical status following CR, with an estimated mean difference in 6MWD of 60.4 m (95% CI: 54.6, 66.3 m; $p < 0.01$). This is consistent with our study's findings, which showed a mean improvement of 65.1 m (SD = 7.4, $p < 0.01$).

Analysis of factors associated with improvement revealed that patients with a baseline 6MWD of less than 300 meters demonstrated greater improvement, likely due to their lower baseline functional capacity. In addition to pharmacological therapy, participation in exercise-based CR contributed to improved exercise capacity. Beyond central cardiac recovery, exercise-based CR provides additional benefits through peripheral and skeletal muscle adaptations. These adaptations include improved peripheral vascular function, increased oxidative muscle fiber composition, and reduced skeletal muscle wasting. Peripheral adaptations, particularly within skeletal muscle, are considered the primary mechanisms underlying improvements in peak oxygen consumption.[17] In contrast, patients with a baseline 6MWD of ≥ 300 meters did not demonstrate a clear improvement, consistent with the categorization proposed by Wicks JR.[12]

However, those with a pre-6MWT distance ≥ 300 meters showed a pre- to post-6MWD increase of 14.2 to 18%, although individual comparisons to their own baseline were not performed. In addition, the 6MWT is a submaximal exercise test, which may limit the detectable change in patients with already high baseline 6MWD values.

Patients who exercised at least 3 days per week were more likely to show improvement in 6MWD than those who exercised less frequently, suggesting a potential dose–response relationship between exercise adherence and functional improvement. This finding is consistent with recommen-

Table 4. 6MWD according to demographic characteristics

Variables	Pre-CR 6MWD, mean (SD), m	Post–CR 6MWD, mean (SD), m	Mean change in 6MWD, mean (SD), m
Male	332.4 (100.6)	394.2 (82.9)	61.8 (44.6, 79.0)
Female	271.6 (104.4)	343.6 (104.7)	72 (43.3, 100.7)
Age			
< 60	351 (99.2)	416.2 (77.2)	65.2 (40.8, 89.6)
≥ 60	284.2 (101.6)	349.2 (94.2)	65 (46.4, 83.6)
Diagnosis			
CAD	309 (107.4)	376.1 (94.2)	67.2 (51.5, 82.8)
Congestive heart failure	336 (92.8)	390.4 (90.9)	54.4 (4.5, 104.3)
Risk stratification			
Low	320.6 (121.7)	371.1 (98.4)	50.5 (24.5, 76.5)
Intermediate	311.9 (119.7)	416.9 (117.9)	105 (61.9, 148.1)
High	308.4 (92.5)	373.8 (83.5)	65.4 (45.6, 85.3)

6MWD, Six-minute Walk distance; CR, cardiac rehabilitation; CAD, coronary artery disease

Table 5. Factors associated with patients' improvement in 6MWD

Factors	Unadjusted PR (95%CI)	Adjusted PR (95%CI)	*p*-value
Risk stratification			
Low	1	Ref.	
Intermediate	1.5 (1.0, 2.3)	1.6 (1.0, 2.5)	0.04
High	1.3 (0.9, 1.8)	1.3 (0.9, 1.8)	0.16
Pre-CR 6MWD			
≥ 300	1	Ref	
< 300	1.7 (1.3, 2.2)	1.7 (1.3, 2.3)	< 0.01
Number of attended CR sessions			
2-3	1	Ref	
> 3	1.0 (0.7, 1.3)	1.0 (0.8, 1.4)	0.82
Age			
< 60	1	Ref	
≥ 60	1.1 (0.8, 1.5)	0.9 (0.7, 1.3)	0.60

6MWD, Six-minute Walk distance; CR, cardiac rehabilitation

dations from the AHA guideline,[1] which advocates regular aerobic exercise 3 to 5 days per week to improve cardiovascular fitness and functional capacity.

Although most patients were classified as high-risk based on LVEF, the majority were in FC II. This apparent discrepancy is not unexpected, as LVEF reflects underlying cardiac systolic function, whereas FC represents patients' symptomatic status and functional capacity. Consequently, patients with reduced LVEF may still present with relatively mild symptoms, particularly in stable or optimally managed conditions.

Regarding FC, improvements were observed, with patients moving to FC I–II. This is consistent with previous findings showing that patients participating in CR achieved NYHA class II.[18] Resting heart rate (RHR) significantly decreased from 76.6 (SD = 12.8) to 72 (SD = 13.6) bpm ($p < 0.01$), consistent with previous studies[19] showing that regular exercise leads to RHR reduction.[20] However, 75.9% of patients were receiving β-blockers, which also contributed to the observed decrease in RHR through titration of β-blocker therapy. The observed reduction in LDL can be attributed to both exercise[21] and concurrent statin therapy. In patients with acute coronary syndrome, those with baseline LDL levels greater than 55 mg/dL all received statin treatment.

During CR visits, patients received counselling on home-based exercise with self-monitoring; follow-ups were scheduled approximately every 1 to 3 months. Because many patients lived far from the centre and were unable to attend weekly follow-ups for exercise titration as per a centre-based program, monitoring safety after the home-based program was crucial. At the 1-year follow-up, 3.6% of patients experienced rehospitalization, and 0.89% died. When comparing the risk of total mortality with home-based CR, the number of deaths was 24 per 1,000 (95% CI: 13, 43) during follow-up of up to 1 year, showing no significant difference.[22] In addition, there were 4 rehospitalizations among 108 patients (3.7%),[23] which is comparable to the findings of our study.

In the intermediate-risk patient group, greater improvements were observed compared with the low-risk group because they were already in the middle range. This is likely due to their baseline EF being within the moderate range; after CR and medical therapy, their symptoms improved, allowing for greater gains. In contrast, patients in the low-risk group already had good baseline 6MWD, so the difference was smaller, while those in the high-risk group had more limited improvement post-CR due to higher baseline risk.

Access to CR services: A total of 598 patients were included, of whom 236 (39.5%) had only one 6MWT measurement, indicating suboptimal follow-up for outcome collection. Some patients missed scheduled follow-ups, consistent with previous reports[19], which showed 41.4% of patients missing follow-ups. Inadequate follow-up in CR remains a challenge worldwide. A study in Thailand identified barriers to CR attendance, including family and work commitments, transport-related factors, and the costs of attending CR.[24] These barriers were addressed in our program by providing a home-based exercise approach, allowing patients to exercise and titrate at home. Additional follow-up beyond the provided program could include the use of telemedicine to reduce barriers related to cost and transportation.

Regarding diagnoses, 86.6% of patients had CAD, 12.5% had congestive heart failure, and among CAD patients, 4.1% had undergone CABG following referral by cardiothoracic surgeons. This proportion was lower than that of post-PCI or CAG patients, whom cardiologists referred. The differences in referral proportions may be explained by the initiation of the CR program at Maharat Hospital, where the CR team conducted conferences to present the program to Cardiologists, securing their cooperation in referring cases to CR. Follow-up care for CABG cases, however, remained relatively low, which is consistent with previous research showing that a lack of communication related to CR between health care providers themselves and with patients contributed to poor CR uptake.[24]

The main limitations of our study include its retrospective design based on medical record review. In addition, we were unable to fully exclude potential confounding factors, such as receipt of standard medical therapy and recovery following interventional procedures, which may have influenced some of the observed outcomes. We were unable to systematically exclude all comorbid conditions that may affect gait or exercise capacity. Based on available data, a small number of patients had a history of stroke with full recovery (n = 7) and osteoarthritis (n = 1), while data on spinal canal stenosis were not available. These conditions may act as confounding factors and could influence 6MWT performance, thereby limiting the extent to which observed changes reflect purely cardiovascular improvement. This study included only patients with at least two 6MWT results. As a result, patients who were unable to attend the second assessment or dropped out early were excluded, which may introduce selection bias. This may limit the generalizability of the findings and potentially overestimate the observed improvements.

Future studies should prospectively analyse and focus on expanding access to CR services, including the integration of telemedicine and the development of reimbursement models that support telemedicine-based care.

Conclusions

Participation in a structured CR program was associated with significant improvements in 6MWD and FC, with 61.6% of patients achieving ≥ 10% improvement in 6MWD from baseline. Patients with lower baseline 6MWD (< 300 m) and moderate risk stratification appeared to derive greater improvements, suggesting that CR may be beneficial even in those with limited initial exercise tolerance. Future controlled trials are needed to definitively isolate the benefits of the CR program from the natural history of patient recovery.

Conflicts of interest declaration

The authors confirm that there is no conflict of interest related to the manuscript.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation and tables, with the exception of Grammarly for basic spell-checking.

Acknowledgments

We would like to thank Dr. Kunyaluk Narungsri for her help with statistical analysis.

Funding

This research project was supported by the Centre for Research and Service System Development, Maharat Nakhon Ratchasima Hospital.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article.

Author contributions

Panida Poolpipat: conceptualization, methodology, investigation, data curation, writing-original draft,

Rachawan Suksathien: supervision, validation, writing-review & editing.

References

1. Brown TM, Pack QR, Aberegg E, Brewer LC, Ford YR, Forman DE, et al. Core components of cardiac rehabilitation programs: 2024 update: A scientific statement from the American Heart As-

sociation and the American Association of Cardiovascular and Pulmonary Rehabilitation. Circulation [Internet]. 2024 Oct 29 [cited 2025 Mar 27];150(18). Available from: https://pubmed.ncbi.nlm.nih.gov/39315436/ doi: 10.1161/CIR.0000000000001289

2. Molloy C, Long L, Mordi IR, Bridges C, Sagar VA, Davies EJ, et al. Exercise-based cardiac rehabilitation for adults with heart failure. Cochrane Heart Group, editor. Cochrane Database Syst Rev [Internet]. 2024 Mar 7 [cited 2025 Mar 27];2024(3). Available from: https://pubmed.ncbi.nlm.nih.gov/38451843/ doi: 10.1002/14651858.CD003331.pub6
3. Dibben GO, Faulkner J, Oldridge N, Rees K, Thompson DR, Zwisler AD, et al. Exercise-based cardiac rehabilitation for coronary heart disease: a meta-analysis. Eur Heart J [Internet]. 2023 Feb 7 [cited 2025 Mar 20];44(6):452–69. Available from: https://pubmed.ncbi.nlm.nih.gov/36746187/ doi: 10.1093/eurheartj/ehac747
4. Virani SS, Newby LK, Arnold SV, Bittner V, Brewer LC, Demeter SH, et al. 2023 AHA/ACC/ACCP/ASPC/NLA/PCNA Guideline for the management of patients with chronic coronary disease: A report of the American Heart Association/American College of Cardiology Joint Committee on clinical practice guidelines. Circulation [Internet]. 2023 Aug 29 [cited 2025 Mar 27];148(9). Available from: https://www.ahajournals.org/ doi: 10.1161/CIR.0000000000001168
5. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. 2023 ESC guidelines for the management of acute coronary syndromes. Eur Heart J [Internet]. 2024 Feb [cited 2025 May 27]; 44(38):3720–826. Available from: https://pubmed.ncbi.nlm.nih.gov/38291910/ doi: 10.1714/4191.41785
6. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Böhm M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J [Internet]. 2021 Sep 21 [cited 2025 May 30];42(36):3599–726. Available from: https://pubmed.ncbi.nlm.nih.gov/35083827/ doi: 10.1002/ejhf.2333
7. Heidenreich PA, Bozkurt B, Aguilar D, Allen LA, Byun JJ, Colvin MM, et al. 2022 AHA/ACC/HFSA Guideline for the management of heart failure: A report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation [Internet]. 2022 May 3 [cited 2025 Mar 27];145(18). Available from: https://www.ahajournals.org/doi/10.1161/CIR.0000000000001063
8. Bellet RN, Adams L, Morris NR. The 6-minute walk test in outpatient cardiac rehabilitation: validity, reliability and responsiveness--a systematic review. Physiotherapy [Internet]. 2012 Dec [cited 2025 Mar 27]; 98(4):277-86. Available from: https://pubmed.ncbi.nlm.nih.gov/23122432/ doi: 10.1016/j.physio.2011.11.003.
9. Sutpasanon Teweesak, Choosakde Apijaree. Outcome of phase II post-percutaneous intervention cardiac rehabilitation program at Sawanpracharak Hospital, Nakhon Sawan Province. Sawanpracharak Med J [Internet]. 2021 [cited 2025 Mar 30];18(2):103–13. Available from: https://thaidj.org/index.php/smj/article/view/9953
10. Solak O, Yaman F, Ulasli AM, Eroglu S, Akci O, Ozkececi G, et al. Improvement in quality of life, functional capacity, and depression level after cardiac rehabilitation. Türkiye Fiz Tip Ve Rehabil Derg [Internet]. 2015 Aug 4 [cited 2025 Mar 27];61(2):130–5. Available from: https://ftrdergisi.com/uploads/sayilar/293/buyuk/130-135y
11. Rodphothong P RS, Pasanam J. The 6-min walk test and quality of life in heart patients paticipated cardiac rehabilitation clinic, King Chulalongkorn Memorial Hospital. Chulalongkorn Med J [Internet]. 2017 Nov [cited 2025 May 27];61(6):731–43. Available from: https://he05.tci-thaijo.org/index.php/CMJ/article/view/487
12. Wicks JR, Turner GT, Leslie SL, Jayasinghe R. Changes observed in the 6-minute walk test in response to exercise-based cardiac rehabilitation. Exerc Med [Internet]. 2022 Mar 28 [cited 2025 Mar 27];6:2. Available from: https://exercmed.org/journal/view.php?viewtype=pubreader&number=42 doi: 10.26644/em.2022.002
13. Choe Y, Han JY, Choi IS, Park HK. Improvement of exercise capacity in patients with type 2 diabetes mellitus during cardiac rehabilitation. Eur J Phys Rehabil Med [Internet]. 2019 Jan [cited 2025 Mar 27];54(6). Available from: https://www.minervamedica.it/index2.php?show=R33Y2018N06A0981
14. Araya-Ramírez F, Briggs KK, Bishop SR, Miller CE, Moncada-Jiménez J, Grandjean PW. Who Is Likely to Benefit From Phase II Cardiac Rehabilitation? J Cardiopulm Rehabil Prev [Internet]. 2010 Mar [cited 2025 Apr 27];30(2):93–100. Available from: https://pubmed.ncbi.nlm.nih.gov/20216361/ doi: 10.1097/HCR.0b013e3181d0c17f
15. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for cardiac rehabilitation programs. 6th ed. Champaign (IL): Human Kinetics; 2020. 64-66 p
16. Bellet RN, Adams L, Morris NR. The 6-minute walk test in outpatient cardiac rehabilitation: validity, reliability and responsiveness--a systematic review. Physiotherapy [Internet]. 2012 Dec [cited 2025 May 27];98(4):277-86. Available from: https://pubmed.ncbi.nlm.nih.gov/23122432/ doi: 10.1016/j.physio.2011.11.003.
17. Pandey A, Shah SJ, Butler J, Kellogg DL Jr, Lewis GD, Forman DE et al Exercise intolerance in older adults with heart failure with preserved ejection fraction: JACC State-of-the-Art Review. J Am Coll Cardiol [Internet]. 2021 Sep 14 [cited 2025 Nov 30];78(11):1166-1187. Available from: https://pubmed.ncbi.nlm.nih.gov/34503685/ doi: 10.1016/j.jacc.2021.07.014.
18. Zhang Y, Cao H, Jiang P, Tang H. Cardiac rehabilitation in acute myocardial infarction patients after percutaneous coronary intervention: A community-based study. Medicine Baltimore [Internet]. 2018 Feb [cited 2025 Nov 30];97(8):e9785. Available from: https://pubmed.ncbi.nlm.nih.gov/29465559/ doi: 10.1097/MD.0000000000009785.
19. Sutpasanon T, Choosakde A. Outcome of phase II post-percutaneous intervention cardiac rehabilitation program at Sawanpracharak Hospital, Nakhon Sawan Province. Region 3 Medical and Public Health Journal [Internet]. 2021 May [cited 2025 Nov 4]; 18(2):103-13. Available from: https://thaidj.org/index.php/smj/article/view/9953.
20. Reimers AK, Knapp G, Reimers CD. Effects of exercise on the resting heart rate: A systematic review and meta-analysis of interventional studies. J Clin Med [Internet]. 2018 Dec 1 [cited 2025 Nov 4]; 7(12):503. Available from: https://pubmed.ncbi.nlm.nih.gov/30513777/ doi: 10.3390/jcm7120503.
21. Smart NA, Downes D, van der Touw T, Hada S, Dieberg G, Pearson MJ, Wolden M, et al. The effect of exercise training on blood lipids: A systematic review and meta-analysis. Sports Med [Internet]. 2025 Jan [cited 2025 Nov 30]; 55(1):67-78. Available from: https://pubmed.ncbi.nlm.nih.gov/39331324/ doi: 10.1007/s40279-024-02115-z.
22. McDonagh ST, Dalal H, Moore S, Clark CE, Dean SG, Jolly K, et al. Home-based versus centre-based cardiac rehabilitation. Cochrane Database Syst Rev [Internet]. 2023 Oct 27 [cited 2025 Nov 30];10(10): Available from: https://pubmed.ncbi.nlm.nih.gov/37888805/ doi: 10.1002/14651858.CD007130.pub5.
23. Reid RD, Morrin LI, Beaton LJ, Papadakis S, Kocourek J, McDonnell L, et al. Randomized trial of an internet-based computer-tailored expert system for physical activity in patients with heart disease. Eur J Prev Cardiol [Internet]. 2012 Dec [cited 2025 Nov 30]; 19(6):1357-64. Available from: https://pubmed.ncbi.nlm.nih.gov/21903744/ doi: 10.1177/1741826711422988.

24. Kotcharoen R, Tower M, Boyde M, Eley R. Facilitators and barriers to cardiac rehabilitation uptake among patients with coronary artery disease in Thailand: A Qualitative Study. ASEAN J Rehabil Med [internet]. 2024 May 1 [cited 2025 Dec. 2];34(2):85-94. available from: https://he01.tci-thaijo.org/index.php/aseanjrm/article/view/267521