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REVIEW

Barriers and Facilitators to Adherence to Exercise-Based Cardiac Rehabilitation Among Coronary Artery Disease Patients: A Scoping Review

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Background: Exercise-based Cardiac Rehabilitation (EBCR) is widely recognized as a crucial intervention for improving the health outcomes of patients with coronary artery disease (CAD). However, its implementation remains insufficient in many regions, and patient adherence to EBCR is generally low. This limitation hinders the full potential of rehabilitation, necessitating a deeper exploration of the factors influencing exercise adherence and the development of targeted intervention strategies.

Objective: This study aims to identify the barriers and facilitators affecting ERCR adherence among CAD patients and provide intervention recommendations for clinical practice.

Methods: A systematic search was conducted across nine databases, including PubMed, Cochrane Library, Embase, Web of Science, EBSCO, CNKI, Wanfang, VIP, and CBM. Using the Theoretical Domains Framework and the COM-B model, a thematic analysis was performed to categorize influencing factors identified in the included studies. These factors were mapped onto the Behaviour Change Wheel, and the APEASE criteria were applied to determine appropriate intervention functions. Finally, Behaviour Change Techniques were matched to these intervention functions.

Results: Seventeen studies were included, identifying multiple core domains of the Theoretical Domains Framework influencing EBCR adherence. The most significant domains were social influences, beliefs about consequences, and environmental context and resources. The primary barrier was patients' negative attitudes toward EBCR, whereas the most prominent facilitator was a strong social support network.

Conclusion: This study systematically analyzed the determinants of EBCR adherence based on the Theoretical Domains Framework and COM-B model, constructing theoretically supported intervention strategies and providing new insights for optimizing EBCR implementation. Through precise Behaviour Change Techniques mapping, the proposed personalized interventions can enhance patients' motivation for rehabilitation, improve EBCR adherence, and offer empirical support for future EBCR intervention design and implementation.

Keywords: exercise-based cardiac rehabilitation, theoretical domain framework, behavior change wheel, behavior change technique, barriers, facilitators, adherence

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Introduction

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide. According to the World Health Organization (WHO), in 2019, CVDs accounted for approximately 17.9 million deaths, representing 32% of global mortality.[1] Data from the China Health and Family Planning Statistical Yearbook 2021 indicate a significant urban–rural disparity in coronary artery disease (CAD) mortality rates, with age-standardized mortality rates of 126.91 per 100,000 person-years in urban areas and 135.88 per 100,000 person-years in rural areas in 2020.[2] Since 2005, the annual growth rate of acute myocardial infarction (AMI) mortality has reached 8.2%, making CAD the leading cause of disability and death in China.[3] Despite its well-documented benefits, exercise-based cardiac rehabilitation (EBCR) remains underutilized. EBCR has been shown to reduce CAD-related mortality by approximately 25% and hospital readmission rates by 18%.[4,5] However, the global dropout rate from cardiac rehabilitation (CR) is as high as 56%.[6,7] In China, the outpatient participation rate in CR for CAD patients is below 8%,[8] and CR coverage remains under 30%.[5] This highlights a dual challenge: low CR participation rates and persistently high mortality.

CR is a multidisciplinary intervention involving exercise training, medication management, nutritional guidance, psychological support, and smoking cessation programs.[9,10] Among these components, exercise training is the cornerstone of CR.[11,12] Its efficacy follows a dose–response relationship, requiring precise intensity control to balance risk and benefit.[13,14] Unlike passive medical interventions (eg, pharmacotherapy), exercise training uniquely improves physiological function through active patient engagement. Evidence suggests that EBCR can reduce major adverse cardiovascular events (MACE) by 18%,[15–17] lower all-cause mortality by 20%–56%,[18–21] and alleviate anxiety and depression.[22–25] Recognizing its importance, leading organizations such as the American Heart Association,[26] the European Society of Cardiology,[27] and the Chinese Association of Rehabilitation Medicine[11] have issued consensus guidelines emphasizing individualized aerobic exercise prescriptions that integrate resistance training, with continuous monitoring of heart rate variability and metabolic equivalents to ensure safety. However, there remains a substantial gap between clinical guidelines and real-world practice. Global EBCR participation rates are below 35%, with a dropout rate of up to 39% within three months.[28] Identifying and analyzing the barriers to sustained EBCR participation is crucial for optimizing intervention strategies, improving program feasibility, and achieving long-term health benefits.

Although some studies have investigated EBCR adherence among CAD patients, several limitations persist: Narrow focus on individual-level factors—Previous research primarily describes patient-level barriers while overlooking external influences such as social environments and healthcare systems. Moreover, the lack of a theoretical framework has limited exploration of the behavioral mechanisms influencing EBCR participation.[29] Current intervention measures primarily focus on their effectiveness and safety, yet often overlook patients' subjective experiences, acceptance, and long-term adherence. This lack of a patient-centred comprehensive strategy limits their applicability in clinical practice, making them less effective in providing targeted guidance.[30,31] To address these gaps, this study integrates multiple theoretical frameworks to systematically analyze EBCR adherence factors and develop targeted interventions. Specifically, we employ: Theoretical Domains Framework (TDF) for a systematic categorization of behavioral determinants, covering 14 key domains to bridge existing theoretical gaps.[32,33] Capability–Opportunity–Motivation–Behaviour (COM-B) model,[33,34] which emphasizes the three-dimensional interaction of capability, opportunity, and motivation, allowing for an in-depth exploration of EBCR behavior mechanisms. Behaviour Change Wheel (BCW) to map behavioral determinants to intervention functions, ensuring a scientifically rigorous strategy selection process through nine intervention functions, such as education, persuasion, and enablement.[34,35]

This study adopts the PRISMA-ScR guidelines for a systematic scoping review with the following objectives: Systematically review the barriers and facilitators influencing CR adherence among CAD patients using thematic analysis. Map the extracted themes onto TDF and COM-B to construct a classification framework for EBCR adherence determinants. Identify intervention functions using BCW and match them with Behaviour Change Techniques (BCTs) to develop theoretically supported intervention strategies for clinical practice and healthcare policy development. This novel approach has been widely applied across various health behavior intervention studies, including physical activity,[36] dietary behaviors,[37] smoking cessation,[38–40] sexual health,[41] prescription behaviors,[42] diabetes management,[43] and

breastfeeding.[44] However, this is the first study to apply it to exercise-based cardiac rehabilitation, providing a robust theoretical foundation for intervention development and implementation.

Methods

Program and Registration

This study strictly adhered to the scoping review reporting guidelines proposed by Arksey and O'Malley and the PRISMA-ScR framework.[45–47] A systematic scoping review methodology was employed, and to ensure transparency and reproducibility, the study's methodological framework was published on the OSF (open science framework) for open registration, allowing for monitoring and validation by both academics and the public. (https://doi.org/10.17605/OSF.IO/PJE6Z).

Scope Review Defined Problems

Explore in-depth the influencing factors of CAD EBCR based on COM-B and TDF, and the intervention strategies developed based on BCW and BCT. (The TDF constructs are provided in Supplementary Material A, and Supplementary Material B contains the BCT Taxonomy (v1): 93 hierarchically-clustered techniques).

Search Strategy

A systematic search was conducted across nine databases: the China Biomedical Literature Database, China Knowledge Network, Wanfang Database, Wipu Database, PubMed, Web of Science, EBSCO, Embase, and the Cochrane Library. The search period spanned from the inception of each database to 14 October 2024, ensuring the inclusion of the most recent publications. The search strategy combined subject terms with free-text keywords, and detailed search forms are provided in the Supplementary Material C.

Inclusion and Exclusion Criteria

Eligible studies met the following criteria: i) Study type: Empirical studies using qualitative, quantitative, or mixed-methods approaches, observational studies (eg, cohort studies, case-control studies, cross-sectional studies), interventional studies (eg, randomized controlled trials (RCTs), quasi-experimental studies), and only original peer-reviewed research articles were included. ii) Topics: Factors influencing exercise therapy during the coronary cardiac rehabilitation phase. iii) Study population: Patients with CAD, and related medical personnel, etc. iv) Language: Studies published in Chinese or English.

The exclusion criteria were as follows: i) Nonoriginal studies, such as reviews, conference abstracts, or dissertations. ii) Duplicate or low-quality studies. iii) Studies without full-text access.

Literature Screening

The literature was imported into NoteExpress for systematic review. Two researchers independently screened titles and abstracts to exclude studies that did not meet the inclusion criteria. Uncertain or potentially eligible studies were retained for further review. The full texts of these studies were assessed in the second screening phase. Disagreements between reviewers were resolved by discussion with a third researcher.

Data Extraction and Statistical Analysis

The included studies were systematically reviewed, and key information was extracted into a structured table The extracted data included author(s), year of publication, country of study, and specific research content (Table 1). A thematic analysis was conducted to perform a qualitative synthesis of the included studies, systematically categorizing key barriers and facilitators influencing EBCR adherence. This process aimed to uncover the underlying mechanisms driving EBCR participation (Table 2). Subsequently, the BCW was employed to identify potential intervention functions. The APEASE criteria were applied, and a panel discussion was conducted within the research team to rigorously assess and refine the selected intervention functions, ensuring their scientific validity and practical applicability. Following the confirmation of intervention functions, the BCTs were systematically mapped to develop targeted intervention strategies,

Table 1 Study Characteristics

Number	First Author	Topic	Year	Study Location	Type of Study	Data Collection Methods	Type of Sport	Disease	Participants	Sample Size
1.	Li-Chao Ma[49]	Needs and Constraints for Cardiac Rehabilitation Among Patients with Coronary Heart Disease Within a Community-Based Setting: A Study Based on Focus Group Interviews	2024	China	Qualitative Study	Focus group	NA	CHD	Patients	11
2.	Ahmed M Almoghairi[50]	Barriers to Cardiac Rehabilitation Enrollment and Secondary Prevention Adherence in Patients with Coronary Heart Disease Following Percutaneous Coronary Intervention: A Cross-sectional Survey	2024	Saudi Arabia	Cross-sectional Study	Computer-assisted telephone interviews	NA	PCI	Patients	104
3.	Xiaoying Qiu[51]	Qualitative study on the obstacles of exercise rehabilitation in elderly coronary heart disease patients after percutaneous coronary intervention	2024	China	Qualitative Study	Semi-structured interview	NA	PCI	Patients	15
4.	Wen Guo[52]	Qualitative research on influencing factors of family cardiac rehabilitation exercise compliance in patients with coronary heart disease	2022	China	Qualitative Study	Semi-structured interview	NA	CHD	Patients	20
									Doctors	6
5.	Navin Kaushal[53]	How and Why Patients Adhere to a Prescribed Cardiac Rehabilitation Program: A Longitudinal Phenomenological Study of Patients with Acute Coronary Syndrome	2022	America	Qualitative Study	Semi-structured interview	NA	ACS	Patients	13

6.	Gareth Thompson[54]	Why would you not listen?It is like being given the winning lottery numbers and deciding not to take them":semi-structured interviews with post-acute myocardial infarction patients and their significant others exploring factors that influence participation in cardiac rehabilitation and long-term exercise training	2022	UK	Qualitative Study	Semi-structured interview	NA	AMI	Patients	10
									Supporters of cardiac rehabilitation)	10
7.	Lee, L. S.[55]	Capturing the perspectives of women with coronary artery disease regarding interval training or continuous exercise in cardiac rehabilitation	2022	Canada	Qualitative Study	Focus group	MICE	CAD	Patients	9
8.	Xie,X.[56]	Barriers to hospital-based Phase 2 cardiac rehabilitation among patients with coronary heart disease in China: a mixed-methods study	2022	China	Mixed	Questionnaire survey	Customized Personalized Exercise Programs	CHD	Patients	160
						Unstructured interview				17
9.	Rouleau, C. R.[57]	A qualitative study exploring factors that influence enrollment in outpatient cardiac rehabilitation	2018	Canada	Qualitative Study	Semi-structured interview	NA	ACS	Patients	14
10.	Amanda L Hannan[58]	Australian cardiac rehabilitation exercise parameter characteristics and perceptions of high-intensity interval training: a cross-sectional survey	2018	Australian	Cross-sectional Study	Questionnaire survey	HIIT	CAD	CR program coordinators (including nurses, physical therapists, exercise physiologists, other health care professionals involved in the CR program)	268
11.	Im,H.W.[59]	Barriers to Outpatient Hospital-Based Cardiac Rehabilitation in Korean Patients With Acute Coronary Syndrome	2018	Korea	Qualitative Study	Questionnaire survey	Customized Personalized Exercise Programs	ACS	Patients	552

(*Continued*)

https://doi.org/10.2147/JMDHS11196

Table 1 (Continued).

Number	First Author	Topic	Year	Study Location	Type of Study	Data Collection Methods	Type of Sport	Disease	Participants	Sample Size
12.	Bäck,M.[60]	Important aspects in relation to patients'attendance at exercise-based cardiac rehabilitation-facilitators, barriers and physiotherapist's role: a qualitative study	2017	Sweden	Qualitative Study	Semi-structured interview	Aerobic exercise	CAD	Patients	16
13.	Dunn,S.[61]	Identifying similar and different factors effecting long-term cardiac exercise rehabilitation behavior modification between New Zealand and the United Kingdom	2014	New Zealand UK	Qualitative Study	Focus group	Follow the guidelines' recommended exercise regimen	CAD	Patients	43
14.	Orna Reges[62]	Identifying barriers to participation in cardiac prevention and rehabilitation programmes via decision tree analysis: establishing targets for remedial interventions	2014	Palestine	Cross-sectional Study	Questionnaire survey	NA	ACS	Patients	420
15.	Grace, S. L.[63]	Barriers to cardiac rehabilitation: DOES AGE MAKE A DIFFERENCE?	2009	Canada	Cross-sectional Study	Questionnaire survey	NA	CAD	Patients	1273
16.	Leung, Y. W.[64]	A prospective examination of patterns and correlates of exercise maintenance in coronary artery disease patients	2007	Canada	Cohort study	Questionnaire survey	NA	CAD	Patients	465
17.	Mak, Y. M. W.[65]	Barriers to participation in a Phase II cardiac rehabilitation programme	2005	China	Prospective study	Medical records, follow-up calls and outpatient surveys	Customized Personalized Exercise Programs	CAD	Patients	193

Abbreviations: HIIT, High Intensity Interval Training; MICE, Moderate Intensity Continuous Training; PCI, percutaneous coronary intervention; CHD, Coronary Heart Disease; ACS, Acute Coronary Syndrome; CAD, Coronary Artery Disease; MI, Myocardial Infarction; AMI, Acute Myocardial Infarction.

Table 2 Barriers and Facilitators of EBCR Adherence:A TDF and COM-B Framework Analysis

COM-B	TDF		Number
Psychological capability	Knowledge	A limited awareness of EBCR protocols, expected outcomes, and multidimensional health benefits	10
		Uncertainty regarding exercise intensity is another significant factor	7
		Lack a comprehensive understanding of the pathophysiology, disease progression, and long-term management strategies of CVDs	6
		Limited accessibility and quality of information further constrain knowledge acquisition and application	4
		Its exercise components, and associated health benefits	2
		Access to authoritative and accurate health information following diagnosis	2
	Memory and decision processes	Hesitation in decision-making	6
		Forgetting to follow an exercise plan	3
		Misalignment between EBCR's structured training format and personal exercise preferences	2
		Information overload	1
		External reminder mechanisms	1
	Behaviour refers	Dependence on external supervision	4
		External reinforcement strategies	4
		A tendency towards behavioural discontinuity	3
Physical capability	Skills	Exercise limitations due to chronic conditions(such as arthritis	9
		Proper mastery of exercise techniques	4
		A lack of prior exercise experience under professional supervision	4
		Difficulty in independently formulating exercise plans	1
Reflexive motive	Social/professional roles and identity	Experienced work-related scheduling conflicts with EBCR sessions	10
		Many patients faced challenges in balancing EBCR with caregiving responsibilities	9
		Some healthcare professionals did not incorporate EBCR into routine treatment recommendations	3
		Patients engaged in physically demanding occupations sometimes misconstrued their work activity as a substitute for EBCR	1
		Men associating exercise with social and cultural expectation	1
	Beliefs about capability	A lack of confidence in one's physical or mental capacity to complete EBCR	3
		Overconfidence in self-regulation	2
		Active engagement in EBCR was found to enhance self-efficacy and exercise confidence	2
	Optimism	A lack of interest in exercise	1
	Beliefs about consequences	A negative perception of EBCR	13
		Recognising the health benefits of EBCR	5
	Intention	Perceived physical frailty and fear of mortality	3
	Goals	The absence of clear exercise goals	9

(*Continued*)

Table 2 (Continued).

COM-B	TDF		Number
		Structured goal-setting	4
Automatic	Reinforcement	A lack of continuous reinforcement	2
		Perceived additional health benefits	2
	Emotion	Negative emotional states Perceptions of exercise-induced discomfort Emotional stability	12 3 3
Physical opportunity	Environmental context and resources	Limited accessibility to CR centres Financial burden Healthcare resource shortages Adverse weather conditions COVID-19 pandemic Inflexible hospital scheduling	9 8 4 4 2 1
		High-quality facilities and physical environments	3
		Favourable weather conditions	1
		Low-cost healthcare support	1
Social	Social environment	Strong social support networks	9
		Insufficient social support	8
		Recommendations,follow-ups, and encouragement from healthcare professionals	4
		Distrust towards healthcare professionals Cultural and traditional constraints	2 2
		Team-based interactions	2
		A lack of peer engagement in EBCR	1

Note: Table 2 presents the mapping of influencing factors to the TDF domains and COM-B components, categorising key barriers and facilitators of CR adherence. Facilitators are highlighted ingrey to enhance readability, while barriers remain unmarked for simplicity.

aligning them with the identified barriers and facilitators.[48] (Supplementary Material D provides the links between the TDF domains and the intervention functions, while Supplementary Material E presents the links between the BCTs and the intervention functions).

Quality Assessment

This study adhered strictly to the quality appraisal standards established by the Joanna Briggs Institute (JBI) for Evidence-Based Healthcare. A study-type-specific assessment tool was employed to conduct a systematic quality evaluation of the included studies (Table 3).

Results

Literature Screening results

A total of 1,688 studies were initially retrieved through database searches. After removing duplicates and conducting an initial screening based on titles and abstracts, 101 studies remained. A full-text review was then performed for further screening, ultimately resulting in the inclusion of 17 studies. The detailed literature selection process is illustrated in Figure 1.

Table 3 JBI Scoring Sheet

Title	Tool	
Needs and Constraints for Cardiac Rehabilitation Among Patients with Coronary Heart Disease in a Community-Based Setting	JBI Critical Appraisal Checklist for Qualitative Research	8/10
Barriers to Cardiac Rehabilitation Enrollment and Secondary Prevention Adherence in Patients with Coronary Heart Disease Following Percutaneous Coronary Intervention: A Cross-sectional Survey	JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	7/8
A qualitative study of factors impeding exercise rehabilitation in elderly patients after PCI for coronary artery disease	JBI Critical Appraisal Checklist for Qualitative Research	8/10
"Why would you not listen? It is like being given the winning lottery numbers and deciding not to take them": semi-structured interviews with post acute myocardial infarction patients and their significant others exploring factors that influence participation in cardiac rehabilitation and long term exercise training	JBI Critical Appraisal Checklist for Qualitative Research	10/10
Capturing the perspectives of women with coronary artery disease regarding interval training or continuous exercise in cardiac rehabilitation Study design: qualitative research	JBI Critical Appraisal Checklist for Qualitative Research	9/10
Barriers to hospital-based phase 2 cardiac rehabilitation among patients with coronary heart disease in China: a mixed-methods study Study design: mixed-methods study	JBI Critical Appraisal Checklist for Qualitative Research and JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	15/18
How and Why Patients Adhere to a Prescribed Cardiac Rehabilitation Program: A Longitudinal Phenomenological Study of Patients with Acute Coronary Syndrome	JBI Critical Appraisal Checklist for Qualitative Research	9/10
A qualitative study of the factors influencing adherence to home cardiac rehabilitation exercise in patients with coronary heart disease	JBI Critical Appraisal Checklist for Qualitative Research	8/10
Barriers to Outpatient Hospital-Based Cardiac Rehabilitation in Korean Patients With Acute Coronary Syndrome	JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	7/8
Australian cardiac rehabilitation exercise parameter characteristics and perceptions of high-intensity interval training: a cross-sectional survey	JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	6/8
A qualitative study exploring factors that influence enrollment in outpatient cardiac rehabilitation	JBI Critical Appraisal Checklist for Qualitative Research	7/10
Important aspects in relation to patients' attendance at exercise-based cardiac rehabilitation – facilitators, barriers and physiotherapist's role: a qualitative study	JBI Critical Appraisal Checklist for Qualitative Research	7/10
Identifying Similar and Different Factors Effecting Long-Term Cardiac Exercise Rehabilitation Behavior Modification Between New Zealand and the United Kingdom	JBI Critical Appraisal Checklist for Qualitative Research	8/10
Identifying barriers to participation in cardiac prevention and rehabilitation programmes via decision tree analysis: establishing targets for remedial interventions	JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	10/10
Barriers to Cardiac Rehabilitation: Does Age Make a Difference?	JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies	10/10
A prospective examination of patterns and correlates of exercise maintenance in coronary artery disease patients	JBI Critical Appraisal Checklist for Cohort Studies	8/11
Barriers to participation in a phase II cardiac rehabilitation programme Study design: Prospective study	JBI Critical Appraisal Checklist for Case Series	8/10

Characteristics of the Included Studies

Basic characteristics of the included literature: of the 17 studies included, the time span was from 2005 to 2024, with geographical coverage of Asia (n=8),[49–52,56,59,62,65] North America (n=5),[53,54,57,63,64] Europe (n=3)[54,60,61] and Oceania (n=2),[58,61] with one study being conducted in both the UK and New Zealand,[61] reflecting evidence from multicultural contexts Characteristics. The study designs were methodologically diverse, including qualitative studies (n=10),[49,51,52,54,55,57,59–61] cross-sectional studies (n=4),[50,58,62,63] cohort studies (n=1)[64], mixed methods studies (n=1)[56] and prospective studies (n=1)[65], with data collection methods based on interviews, focus groups and questionnaires. Questionnaires, with 3 studies integrating multi-stakeholder perspectives[52,54,58] and including clinicians, CR coordinators

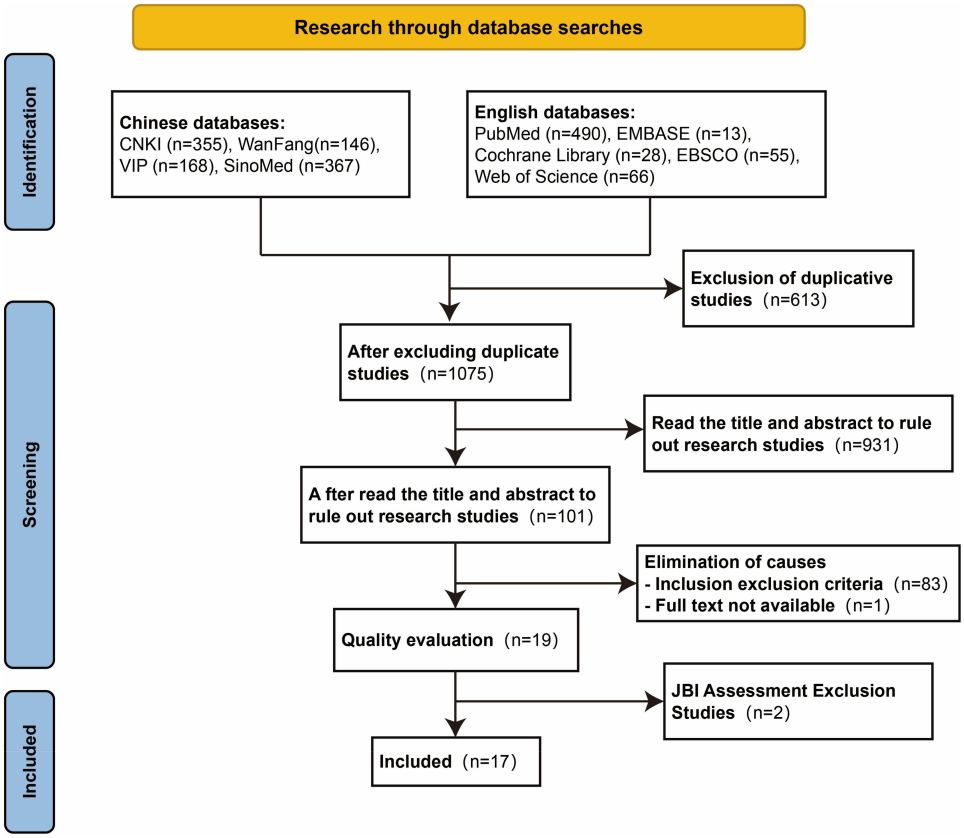

Figure 1 Study Screening Flowchart.

and CR supporters (eg, patients' family members and friends, etc) in addition to patient groups. The disease focus was on the CAD population, specifically coronary heart disease (CHD), acute coronary syndrome (ACS), post percutaneous arterial intervention (PCI), and acute myocardial infarction (AMI), and the sample sizes varied considerably, from a minimum of 9 individuals[55] to a maximum of 1273.[63] The types of campaigns were characterised by three features dynamic adjustments based on patients' baseline functional status;[56,59,65] second, aerobic exercise such as high-intensity interval training, which represents an emerging type of exercise,[55,58,60] and third, guideline-based exercise protocols.[61] It is noteworthy that nearly half of the studies did not explicitly record specific types of exercise, as detailed in Table 1.

Factors Influencing EBCR in CAD

After systematically reviewing and categorising the 17 included studies, an evaluation based on TDF identified multiple factors influencing patient participation in exercise-based CR. These factors encompassed 13 TDF domains, including knowledge, skills, social/professional role and identity, beliefs about capabilities, optimism, beliefs about consequences, reinforcement, goals, memory and decision processes, environmental context and resources, social influences, emotions, and behavioural regulation. These domains interact dynamically, collectively shaping patient engagement patterns in EBCR (as shown in Figure 2 and Table 2).

Knowledge, in this context, refers to an individual's understanding of CAD and EBCR. Many patients lack a comprehensive understanding of the pathophysiology, disease progression, and long-term management strategies of CVDs (n=6).[49,51,57,58,64,65] Furthermore, there is a limited awareness of EBCR protocols, expected outcomes, and multidimensional health benefits (n=10),[49–52,56,59–63] which affects their willingness to actively participate. Uncertainty regarding exercise intensity is another significant factor (n=7),[52,55–57,60,61,63] while limited accessibility and quality of information further constrain knowledge acquisition and application (n=4),[51,60,62,63] such as restricted health education channels and, in some cases, language barriers in specific sociocultural contexts. These factors may weaken patients'

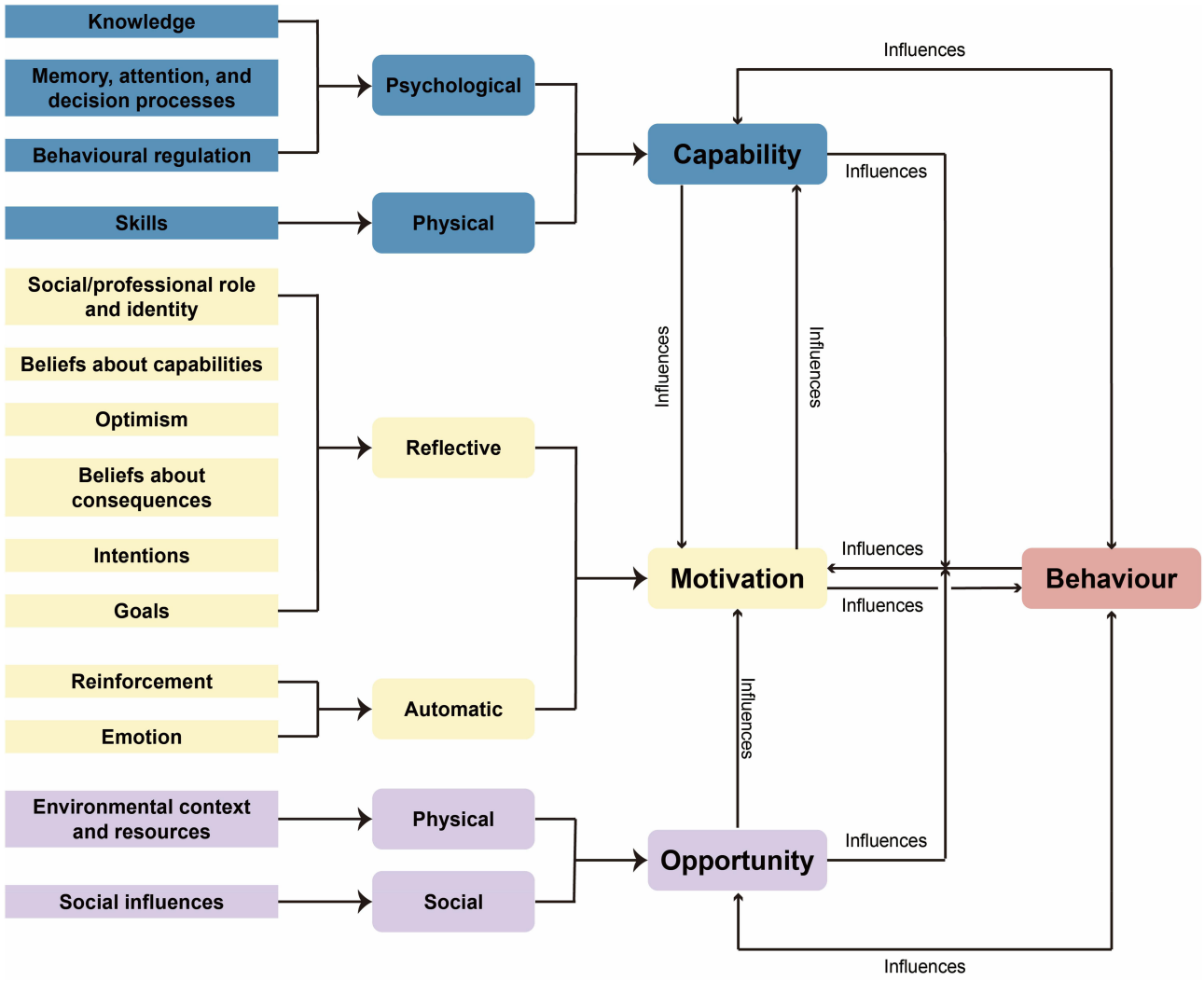

Figure 2 Integration of TDF domains in the COM-B model.

cognitive and executive abilities regarding EBCR. However, having a better understanding of EBCR, its exercise components, and associated health benefits (n=2)[54,64] can enhance patient awareness and acceptance of EBCR. Moreover, access to authoritative and accurate health information following diagnosis (n=2)[53,54] helps patients fully comprehend the value of EBCR, reduce uncertainty caused by information asymmetry, and make informed decisions, thereby supporting long-term adherence to rehabilitation programmes.

Skills refer to the abilities or proficiencies acquired through continuous practice and experience, encompassing both the mastery of exercise techniques and the ability to develop independent exercise plans. A lack of prior exercise experience under professional supervision (n=4)[50,56,57,62] emerged as a key barrier, with some patients lacking proper exercise techniques or engaging in inappropriate exercise patterns, increasing the risk of injury and consequently diminishing confidence and adherence to EBCR. Furthermore, exercise limitations due to chronic conditions (such as arthritis) (n=9)[49,51,55,58–60,63–65] represented a major obstacle. Additionally, difficulty in independently formulating exercise plans (n=1)[61] posed a significant challenge, as some patients displayed an over-reliance on medical professionals, struggling to autonomously plan and adjust adaptive training regimes, ultimately affecting the sustainability of EBCR. Conversely, proper mastery of exercise techniques (n=4)[53,60,61,64] was identified as a facilitating factor.

Social/professional roles and identity encompass the behaviours and personal attributes exhibited by individuals within their social or occupational environments. Family responsibilities, occupational demands, and cultural norms can

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all influence EBCR adherence. Many patients faced challenges in balancing EBCR with caregiving responsibilities (n=9)[51,52,55–57,59,61–63] or experienced work-related scheduling conflicts with EBCR sessions (n=10),[49,52,55,57,59,61–65] making it difficult to allocate time for rehabilitation. Additionally, some healthcare professionals did not incorporate EBCR into routine treatment recommendations (n=3),[50,57,65] while patients engaged in physically demanding occupations sometimes misconstrued their work activity as a substitute for EBCR (n=1),[60] reducing their motivation to participate. However, cultural factors may act as facilitators, as certain social groups hold positive perceptions of physical activity, such as men associating exercise with social and cultural expectations (n=1),[64] potentially increasing their acceptance of EBCR.

Beliefs about capability refer to an individual's perception of their ability to successfully engage in and benefit from EBCR. Two primary barriers were identified: firstly, a lack of confidence in one's physical or mental capacity to complete EBCR (n=3);[50,57,59] and secondly, overconfidence in self-regulation (n=2),[59,60] where some patients believed that unstructured physical activity could replace formal EBCR, leading to reduced adherence to structured rehabilitation programmes. On the other hand, active engagement in EBCR was found to enhance self-efficacy and exercise confidence (n=2),[53,54] promoting a positive behavioural cycle.

Optimism, defined as confidence in achieving positive outcomes, was another influential factor. A lack of interest in exercise among post-PCI patients (n=1)[60] acted as a barrier to EBCR adherence, with some patients perceiving EBCR sessions as monotonous and unengaging, leading to avoidance of participation. This negative experience may lower expectations of EBCR's benefits, making long-term adherence more challenging and ultimately affecting rehabilitation outcomes.

Beliefs about consequences refer to an individual's acceptance of the reality, validity, or effectiveness of an outcome associated with a specific behaviour. The most prominent barrier was a negative perception of EBCR (n=13),[49,50,52,55–58,60–65] with some patients expressing concerns about exercise-induced discomfort or questioning the clinical efficacy of EBCR, thereby reducing their willingness to participate. Additionally, perceived physical frailty and fear of mortality (n=3)[49,55,59] led some patients to avoid EBCR out of concern for potential complications or worsening health status. In contrast, recognising the health benefits of EBCR (n=5)[53,54,61,62,64] was a strong facilitator, as patients who understood EBCR's role in reducing cardiovascular event recurrence were more likely to increase their motivation for rehabilitation and maintain long-term adherence.

Reinforcement involves establishing dependencies or contingencies between responses and given stimuli to increase the likelihood of a behaviour occurring. A lack of continuous reinforcement (n=2)[50,57] was a barrier, as the absence of external feedback mechanisms led patients to struggle with sustaining motivation in the absence of immediate or long-term positive reinforcement. Conversely, perceived additional health benefits (n=2)[52,60] served as facilitators, with some patients recognising EBCR's secondary advantages, such as weight management and social engagement, thereby strengthening their motivation. This suggests that EBCR should not only be framed as a disease management tool but also as a means to improve overall health and quality of life.

Goals represent the mental representation of an outcome or state that an individual seeks to achieve, playing a pivotal role in the sustained execution of health behaviours. The absence of clear exercise goals (n=9)[50,52,56,60–65] was a major barrier, as patients without specific rehabilitation targets often lacked the motivation to persist, leading to poor training adherence. In contrast, structured goal-setting (n=4)[53,57,60,64] was a key facilitator, as developing personalised EBCR plans helped reinforce behavioural consistency, making it easier for patients to sustain engagement in rehabilitation exercises.

An individual's cognitive processing and executive function significantly influence EBCR adherence during health-related decision-making. Hesitation in decision-making (n=6)[52,60,61,63–65] was a primary barrier, as patients prioritised work, family responsibilities, or other non-EBCR, thereby reducing the perceived importance of EBCR participation. Additionally, forgetting to follow an exercise plan (n=3)[50,55,62] was another key challenge, particularly for patients experiencing high cognitive load in daily life, which negatively impacted adherence. Misalignment between EBCR's structured training format and personal exercise preferences (n=2)[56,59] also contributed to reduced participation rates. Furthermore, information overload (n=1)[60] was identified as a potential barrier, as some patients struggled to filter and process key information, affecting their understanding and execution of EBCR. However, external reminder mechanisms

(n=1)[53] were recognised as a facilitating factor, with tools such as digital notifications or healthcare professional follow-ups helping to enhance patients' focus on rehabilitation tasks, reduce forgetfulness, and improve EBCR adherence.

Environmental context and resources refer to personal or environmental conditions that hinder or facilitate the development of skills, capabilities, independence, social competence, and adaptive behaviours. Limited accessibility to EBCR centres (n=9)[50,51,56,57,59,60,62,63,65] and financial burden (n=8)[51,56–59,61,62,65] were identified as major barriers, with factors such as long geographical distances, inconvenient transportation, high EBCR costs, and inadequate insurance coverage restricting patients' ability to engage in regular rehabilitation. Healthcare resource shortages (n=4)[49–51,58], including a lack of trained professionals and limited EBCR service availability, were also reported as potential obstacles, affecting both rehabilitation opportunities and service quality. Furthermore, adverse weather conditions (n=4)[52,59,61,64] imposed restrictions on outdoor physical activity, further disrupting rehabilitation plans. The COVID-19 pandemic (n=2)[52,56] posed unique challenges by increasing the complexity of rehabilitation processes and patients' psychological burden, reducing their willingness to participate. Additionally, inflexible hospital scheduling (n=1)[60] was identified as a potential barrier, as limited outpatient hours and appointment difficulties made it challenging for patients to consistently attend EBCR sessions. On the other hand, facilitating environmental factors included high-quality facilities and physical environments (n=3)[53,61,64], favourable weather conditions (n=1)[54], and low-cost healthcare support (n=1)[61], all of which enhanced EBCR accessibility and ensured greater continuity of rehabilitation services.

The social environment plays a critical role in shaping patients' thoughts, emotions, and behaviours, significantly influencing EBCR decision-making and execution. Insufficient social support (n=8)[51,52,56,57,60,65] was identified as a key barrier, as a lack of encouragement from family, friends, or healthcare professionals reduced patients' motivation for long-term adherence. Distrust towards healthcare professionals (n=2)[56,58] also emerged as an obstacle, with some patients questioning their expertise or the scientific validity of EBCR recommendations, thereby diminishing their willingness to follow medical advice. Additionally, cultural and traditional constraints (n=2)[50,62] posed challenges in certain contexts; for example, in Saudi Arabia, social norms limited female patients' participation in EBCR[50]. Furthermore, a lack of peer engagement in EBCR (n=1)[59] meant that some patients lacked role models, which in turn weakened their motivation. In contrast, strong social support networks (n=9)[52–55,57,60,61,63,64] were considered key facilitators, as positive reinforcement from family members or EBCR teams helped strengthen motivation. Additionally, team-based interactions (n=2)[54,61] enhanced patients' sense of belonging within EBCR, further promoting long-term adherence. Moreover, recommendations, follow-ups, and encouragement from healthcare professionals (n=4)[54,61–63] were important facilitators of EBCR engagement.

Emotion is a complex response involving experiences, behaviours, and physiological changes. Negative emotional states (n=12)[49–52,55–57,60–65] were identified as primary barriers to EBCR adherence, with anxiety, fear, and pessimism leading to avoidance of rehabilitation training and reduced participation rates. Additionally, perceptions of exercise-induced discomfort (n=3)[50,52,59] caused some patients to associate exercise with pain or fatigue, further decreasing their willingness to adhere to EBCR. By contrast, emotional stability (n=3)[53–55] was identified as a facilitator, as patients with better emotional regulation were more likely to sustain long-term EBCR engagement.

Behaviour refers to any observable or measurable action aimed at managing or modifying a condition. Dependence on external supervision (n=4)[60–63] was found to be a barrier, as some patients lacked self-discipline and required continuous external reinforcement to maintain their EBCR routines. Additionally, a tendency towards behavioural discontinuity (n=3)[50,57,65] was observed, with patients failing to sustain EBCR due to the absence of effective self-monitoring mechanisms, leading to early dropout. Conversely, external reinforcement strategies (n=4)[52,53,55,64] were key facilitators, as methods such as data tracking and incentive-based systems helped boost motivation and improve long-term adherence to EBCR.

Intervention Functions and BCTs

This study employed BCW to identify potential intervention functions, aligned with the key influencing factors of EBCR adherence. A structured panel discussion was conducted following the APEASE criteria to systematically evaluate and refine the initially selected intervention functions. After rigorous assessment, six intervention functions were finalised:

education, persuasion, training, enablement, modelling, and environmental restructuring. To develop targeted intervention strategies, 20 commonly used BCTs were selected and applied within the intervention framework.

Discussion

Exploring the Behavioural Mechanisms of EBCR Through the COM-B

The occurrence of behaviour relies on an individual's capability, opportunity, and motivation, which do not function as independent variables but rather interact through complex feedback mechanisms, influencing the sustainability of behaviour. Since the 2011 version of the COM-B model lacked clarity in describing the interrelationships between capability, opportunity, motivation, and behaviour,[33,34] this study adopts the 2020 redefined COM-B.[66] This updated framework allows for a more precise analysis of the dynamic interactions among these factors and provides deeper insights into their impact on exercise adherence in CR (Figure 2). Limited capability, insufficient opportunity, and weak motivation may collectively hinder behavioural maintenance. More critically, these factors do not exert linear effects but instead form a dynamic behavioural system.

Opportunity is a key external determinant of EBCR adherence, encompassing physical and social opportunities.[34] It not only determines whether a patient can access EBCR but also shapes their capability and motivation, indirectly influencing behaviour. Firstly, the accessibility of external resources directly influences a patient's capability level.[67] Limited availability of EBCR facilities reduces opportunities for professional rehabilitation guidance,[67] thereby hindering the development of exercise skills. Furthermore, some healthcare professionals do not routinely recommend EBCR, depriving patients of authoritative information sources, which in turn restricts their knowledge levels and diminishes their confidence in EBCR.[68] Secondly, opportunity affects motivation. Financial burden is one of the most critical barriers to EBCR adherence, with studies showing that low-income patients are more likely to discontinue EBCR due to cost-related concerns.[69,70] Additionally, a lack of social support deprives patients of external reinforcement, leading to declining motivation for long-term adherence.[71]

Capability consists of psychological and physical capabilities, determining not only whether a patient can execute EBCR but also how effectively they utilise opportunities and sustain motivation.[66] Firstly, patients' knowledge and skill levels influence their confidence in performing EBCR.[72] A lack of systematic understanding of EBCR leads patients to underestimate its benefits, thereby reducing their motivation for participation. Additionally, insufficient exercise skills may result in negative experiences during training, lowering self-efficacy and further weakening their willingness to persist.[73–75] Secondly, capability influences the utilisation of available opportunities. Even if external resources are accessible, patients lacking essential knowledge may fail to actively seek EBCR-related support. Moreover, decision-making hesitancy and information overload can cause uncertainty in executing rehabilitation plans, ultimately limiting the effective use of external resources.[76]

Motivation consists of automatic and reflective motivation, determining whether a patient is willing to engage in EBCR.[66] Firstly, negative emotions and cognitive beliefs may impact EBCR adherence.[77] Some patients perceive exercise as painful, leading them to avoid EBCR training. Additionally, a lack of clear exercise goals may result in a sense of directionlessness, thereby reducing the motivation to persist. Secondly, motivation affects both capability development and opportunity utilisation. Patients with low motivation levels may be less inclined to learn about EBCR, limiting their ability to engage effectively. Furthermore, a negative attitude towards EBCR training may cause patients to avoid rehabilitation programmes despite the availability of resources, further diminishing their rehabilitation opportunities.[78]

EBCR adherence is shaped by the dynamic feedback loop between opportunity, capability, and motivation, ultimately determining its sustainability. In a positive feedback cycle, social support and healthcare resources provide exercise guidance, enhancing patients' skills and confidence,[79] which in turn encourages active participation in EBCR, creating a virtuous cycle. Conversely, in a negative feedback loop, limited knowledge and negative emotions weaken patients' awareness and beliefs about EBCR, causing them to avoid rehabilitation training. This avoidance further hinders the development of exercise capability, resulting in declining adherence and the formation of a vicious cycle.[77,78] Optimising

EBCR intervention strategies requires precise regulation of opportunity, capability, and motivation, breaking negative cycles and facilitating long-term behavioural change.

Intervention Strategies for Enhancing Adherence to EBCR

The implementation of EBCR for CAD varies across different environments and patient groups, each facing distinct challenges and needs. To improve adherence and long-term rehabilitation outcomes, tailored strategies should be developed for hospital-based, home-based, and remote rehabilitation settings, as well as for older adults, working professionals, and rural patients.

In the hospital rehabilitation phase, healthcare professionals should assist patients in setting clear and specific rehabilitation goals to enhance their motivation and self-efficacy.[80] For instance, nurses could establish a short-term goal of 30 minutes of daily walking before discharge and provide basic exercise skill training during hospitalisation, ensuring that patients can safely and correctly perform EBCR. Additionally, a detailed rehabilitation schedule outlining exercise timing, location, and intensity can improve the structure and feasibility of rehabilitation training. Live demonstrations by nurses or video recordings can also be provided, allowing patients to retain correct exercise techniques after discharge.

During the home CR phase, adherence is often influenced by family support and self-management ability. To minimise the risk of forgetting exercises, patients could log their exercise plans in a calendar or use mobile reminders, helping establish rehabilitation as a daily habit. For older adults, family members could assist in maintaining rehabilitation logs or providing companionship, such as participating in training sessions at least twice a week, to enhance safety and motivation. Family involvement not only improves adherence but also reduces the likelihood of discontinuation due to feelings of isolation or lack of motivation. Additionally, framing rehabilitation goals in terms of long-term health benefits, such as "reducing blood pressure by 10 mmHg within six months" or "lowering cardiovascular event risk by two episodes per year", can further strengthen patient confidence and commitment to EBCR.

Patients undergoing remote rehabilitation rely heavily on digital health technologies,[81] making technological support essential to ensure smooth rehabilitation implementation. Wearable devices and mobile applications can automatically track exercise data and provide real-time feedback, such as "Congratulations! You have completed 30 minutes of walking today—keep up the great work!", reinforcing positive motivation. Additionally, doctors can send personalised encouragement via SMS or online platforms, such as "Your blood pressure has dropped by 5 mmHg compared to last month—keep going!", helping patients visualise their progress and maintain long-term adherence. For patients unfamiliar with technology, family members could assist in monitoring exercise data or using paper-based logs, reducing the impact of technological barriers on EBCR compliance.

Older patients often face physical limitations and unfamiliarity with new technologies, which may hinder their ability to adhere to EBCR.[82] A low-intensity exercise programme, such as Baduanjin (a traditional Chinese health exercise), could be recommended, while encouraging family members to participate to reduce physical constraints on rehabilitation execution. Instead of relying on complex smart devices, older patients may benefit from paper-based rehabilitation logs or simple pedometers to track progress. Additionally, face-to-face guidance from healthcare professionals, complemented by government or medical association-endorsed rehabilitation guidelines, could improve trust in EBCR, reduce misconceptions about exercise risks, and enhance willingness and adherence.

For working professionals, time constraints often pose a challenge to EBCR adherence. Optimising time management is crucial to ensure exercise feasibility. Patients could be advised to perform 10-minute stretching exercises during lunch breaks and allocate 20 minutes for running in the evening, integrating workplace-friendly exercise routines to improve adherence. Smart devices could be used for automatic step tracking, reducing the burden of manual recording while improving convenience in monitoring progress. Peer-support mechanisms, such as a workplace "rehabilitation challenge" group, where employees share their daily exercise achievements, could enhance mutual accountability and motivation, making CR training more engaging and sustainable.

Rural patients often engage in labour-intensive daily activities, making integrating EBCR into routine work a key strategy for improving adherence. Encouraging patients to incorporate daily activities such as walking or carrying water into their rehabilitation plan can make exercise more aligned with daily habits, reducing resistance to behavioural change. Establishing a "village walking club", where patients engage in group-based exercise, could foster a supportive

rehabilitation environment, boosting both motivation and long-term adherence. Given limited healthcare resources in rural areas, telehealth follow-ups by healthcare professionals could provide personalised guidance, ensuring smooth implementation of rehabilitation plans while enhancing patient confidence and commitment to EBCR.

Limitations

This study primarily investigates the factors influencing adherence to EBCR. However, several limitations should be acknowledged. Firstly, this study included both Chinese and English publications, resulting in a higher proportion of studies from China, which may affect the generalisability of the findings. Additionally, healthcare systems, cultural backgrounds, and rehabilitation management models vary across different countries and regions, potentially influencing EBCR adherence in distinct ways. Future research should consider broadening the scope of literature sources to ensure greater applicability of the conclusions. Secondly, this study did not explicitly differentiate between overall CR adherence and exercise-specific adherence. While patients with high overall CR adherence typically demonstrate greater commitment to exercise, the two constructs remain distinct. For instance, adherence in EBCR is significantly influenced by physical capability, confidence in exercise performance, and environmental support, whereas overall CR adherence involves a broader range of behavioural regulations, health perceptions, and medical compliance. Therefore, future studies should further explore the interaction between the two to develop more precise intervention strategies. In addition, most of the included literature did not provide detailed descriptions of specific exercise modalities, such as the differences between Baduanjin, aerobic exercise, and resistance training. This may result in certain exercise modalities not being adequately considered in adherence analyses, affecting the understanding of adaptations to different exercise types. Finally, the included studies encompassed both PCI-treated and non-PCI-treated CAD patients. Although pathophysiological differences may exist between these groups, no systematic discrepancies in EBCR adherence factors were observed during data extraction. Consequently, this study aggregated common influencing factors rather than conducting separate analyses. However, we acknowledge that this approach may introduce a degree of heterogeneity. Future research could further stratify patient populations based on clinical characteristics to explore more refined determinants of exercise adherence.

Conclusion

This study systematically identified the key factors influencing EBCR adherence among patients with CAD using TDF and mapped them onto the COM-B. The interactions between capability, opportunity, and motivation and their underlying mechanisms in EBCR adherence were thoroughly explored. The findings indicate that limited knowledge, restricted exercise skills, and inadequate behavioural regulation may weaken patients' ability to engage in rehabilitation, while low healthcare accessibility, financial burden, and insufficient social support may restrict their rehabilitation opportunities. Additionally, negative emotions, low self-efficacy, and weak health beliefs were identified as key factors that could further undermine rehabilitation motivation. Building on these findings, BCW was applied to select and refine intervention functions based on the identified influencing factors. Six intervention functions were finalised: education, persuasion, training, enablement, modelling, and environmental restructuring, alongside the implementation of 20 BCTs to develop targeted intervention strategies. Overall, this study not only provides theoretical insights into EBCR adherence but also offers practical guidance for designing personalised and actionable EBCR interventions. Future research could further validate the effectiveness of the proposed intervention strategies through longitudinal studies or intervention trials, optimising their implementation to maximise long-term behavioural change and health benefits.

Data Sharing Statement

All data relevant to the study are included in the article or uploaded as online supplemental information.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no conflicts of interest to declare for this work.

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