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Tele-Rehabilitation for Patients with Cardiovascular Disorders: A Systematic Review and Meta-analysis

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ABSTRACT

Background: Cardiovascular diseases (CVDs) remain the leading cause of global morbidity and mortality. Conventional cardiac rehabilitation, though effective, suffers from poor accessibility and adherence. Tele-rehabilitation (TR) has emerged as a potential alternative to center-based programs aiming to improve clinical outcomes through remote, technology-enabled interventions.

Objective: This study aimed to systematically assess the effectiveness of tele-rehabilitation on exercise capacity, health related quality of life, and physical activity among patients with cardiovascular diseases**.**

Methods: A systematic search of six electronic databases (PubMed, Web of Science, PEDro, Cochrane CENTRAL, Scopus, and Virtual Health Library) were conducted. Inclusion criteria comprised randomized controlled trials (RCTs) comparing TR to conventional cardiac rehabilitation or usual care in adult CVD patients. Data extraction, quality appraisal (Using the PEDro scale), and level of evidence assessment (Modified Sackett's scale) were conducted independently by two reviewers. Meta-analyses were performed using Comprehensive Meta-Analysis (CMA) software when homogeneity allowed, and sensitivity analyses were conducted to examine robustness. **Results:** Seven RCTs involving 1,567 patients were included and 4 studies were included in the meta-analysis. TR significantly improved exercise capacity (VO_2peak, 6MWD, METs) in most studies, with pooled VO_2peak SMD = 0.18 (95% CI: –0.01 to 0.37; p = 0.07) and pooled 6MWD SMD = 0.62 (95% CI: –0.31 to 1.56; p = 0.19). HRQoL showed heterogeneous effects: disease-specific measures (EQ-5D, MLHFQ) improved significantly in some studies, while physical function using (SF-36) showed no differences between groups.

Conclusions: Tele-rehabilitation demonstrated clinically meaningful improvements in exercise capacity and health related quality of life among patients with cardiovascular diseases. Meta-analysis supports the role of TR as a feasible and effective alternative to traditional cardiac rehabilitation.

Keywords: Cardiac tele-rehabilitation, Cardiovascular diseases, Exercise capacity, Quality of life, Systematic review.

INTRODUCTION

Cardiovascular diseases (CVDs) remain the foremost cause of morbidity and mortality globally, encompassing a broad spectrum of chronic conditions such as coronary artery disease, heart failure, and hypertension. These disorders collectively account for approximately 17.9 million deaths annually, representing 32% of all global deaths [(1)].

As populations age and non-communicable diseases become increasingly prevalent, the global burden of CVD is projected to rise further, placing substantial pressure on healthcare systems and highlighting the need for accessible, effective, and sustainable interventions [(2)].

Beyond their clinical toll, CVDs impose significant economic consequences through direct healthcare expenditures and indirect societal costs, including loss of productivity and long-term disability. The rising number of individuals living with CVD underscores an urgent demand for scalable and patient-centered models of care, particularly in the context of secondary prevention and rehabilitation. Traditional cardiac rehabilitation programs, though proven effective, are often underutilized due to logistical barriers such as transportation challenges, geographic isolation, limited availability of specialized centers, and poor patient adherence [(3)].

In recent years, tele-rehabilitation (TR) has emerged as a promising alternative to conventional center-based cardiac rehabilitation. By integrating communication technologies such as video conferencing, mobile applications, wearable sensors, and remote monitoring systems, TR allows patients to engage in structured, supervised rehabilitation from home. This model offers a range of benefits, including enhanced accessibility, flexible scheduling, and continuity of care—factors that may improve adherence and reduce dropout rates, particularly among elderly or mobility-limited populations [(4)].

The incorporation of wearable devices and telemonitoring further enhances the potential of TR. Real-time tracking of heart rate, step counts, and exertion levels enables dynamic and personalized feedback from healthcare providers, facilitating early intervention and individualized progression of exercise intensity [(5)].

This collaborative, data-driven model supports patient empowerment and encourages sustained self-management—essential elements in the long-term care of chronic cardiovascular conditions. Despite its advantages, TR faces certain limitations. Concerns persist regarding the reduced ability to provide direct supervision and ensure proper exercise technique, which may raise safety issues for certain high-risk

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populations [6]. Moreover, heterogeneity in TR modalities, program structures, and monitoring protocols presents challenges for standardization and outcome comparison across studies. There is thus a pressing need to evaluate the clinical effectiveness of TR and to establish best practices tailored to diverse patient populations and healthcare contexts.

Systematic reviews serve a pivotal role in synthesizing the growing body of evidence surrounding TR. By critically appraising and integrating findings from high-quality randomized controlled trials, systematic reviews can inform clinical decision-making, support guideline development, and guide resource allocation. The present review aimed to systematically assess the effectiveness of tele-rehabilitation in improving clinical and functional outcomes among patients with cardiovascular diseases. The purpose of the study was to evaluate the current evidence regarding the effectiveness of tele-rehabilitation for patients with cardiovascular diseases, focusing on outcomes such as exercise capacity, quality of life, symptom control, hospital readmissions, and program adherence.

MATERIALS AND METHODS

Study design and registration: This study was designed as a systematic review and meta-analysis, conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines [7].

To enhance methodological transparency and reduce the risk of bias. The review protocol was prospectively registered in Faculty of Physical Therapy Cairo University.

Search strategy: A comprehensive literature search was performed across five major electronic databases: PubMed, Web of Science (WOS), Scopus, the Physiotherapy Evidence Database (PEDro), and the Cochrane Central Register of Controlled Trials (CENTRAL). The search included all records available from database inception until the final search date. A combination of medical subject headings (MeSH) and free-text terms was employed, including: “Tele-rehabilitation,” “traditional rehabilitation,” “cardiovascular disease patients,” “efficacy comparison,” “adherence rates,” “rehabilitation outcomes,” “remote rehabilitation,” “in-person rehabilitation,” “rehabilitation effectiveness,” “telehealth interventions,” and “patient-centered care.” Boolean operators (AND, OR) were used to enhance the specificity and sensitivity of the search. Filters were applied to limit results to studies published in English and conducted on human participants. Additionally, reference lists of all included articles were manually screened to identify potentially eligible studies missed during the database search.

Eligibility criteria: Study selection followed the PICO framework, focusing on adult patients with cardiovascular diseases such as coronary artery disease and heart failure. Included studies assessed the effects of tele-rehabilitation delivered via remote technologies—such as video calls, mobile applications, or wearable devices—either alone or alongside standard care. Comparators involved traditional in-person rehabilitation, no intervention, placebo, or alternative rehabilitation approaches. Primary outcomes evaluated were exercise capacity and health-related quality of life.

Exclusion criteria: Observational studies, reviews, case reports, non-English publications, or lacked full-text availability.

Study selection: Two reviewers independently screened the titles and abstracts of all identified records to determine their eligibility. Full-text articles of the shortlisted studies were then evaluated against the predefined inclusion and exclusion criteria. Any disagreements were resolved through consensus, and a third reviewer was consulted when needed. The entire selection process was illustrated using a PRISMA flow diagram.

Data extraction: Two reviewers independently extracted data using a standardized extraction form, collecting information on authorship, publication year, study design, sample size, participant demographics, type of cardiovascular diagnosis, intervention details (Mode, frequency and duration), use of virtual monitoring or wearable devices, comparator characteristics, outcome measures (Such as exercise capacity and quality of life), adherence rates, and key findings. Any discrepancies were resolved through discussion or by involving a third reviewer.

Methodological quality assessment and level of evidence: The methodological quality of each included study was evaluated using the physiotherapy evidence database (PEDro) scale, a validated 11-item tool in which 10 items contribute to a total score ranging from 0 to 10 [8]. The scale assesses key methodological criteria including randomization, allocation concealment, baseline comparability, blinding (Participants, therapists & assessors), follow-up adequacy, intention-to-treat analysis, between-group comparisons, and reporting of variability and effect sizes. Studies scoring 6 or higher were rated as “good,” scores of 4–5 as “fair,” and scores below 4 as “poor”. Risk of bias was assessed independently by two reviewers, with disagreements resolved by consensus. To evaluate the overall strength and applicability of the evidence, the Modified Sackett Scale was used to classify studies according to their methodological rigor[9].

Data synthesis and analysis

Where appropriate, a meta-analysis was performed using comprehensive meta-analysis (CMA) software (Biostat, Englewood, NJ, USA). Pooled effect estimates were calculated using standardized mean differences (SMDs) with corresponding 95% confidence intervals (CIs). A random-effects model was employed to account for expected inter-study variability. Statistical heterogeneity was assessed using the I^2 statistic, with thresholds of 25%, 50%, and 75% representing low, moderate, and high heterogeneity respectively. Meta-analyses were documented only when clinical and statistical homogeneity were sufficient across included studies. In cases of substantial heterogeneity, meta-analysis was not conducted, and findings were instead synthesized narratively. Sensitivity analyses were performed to assess the robustness of results, particularly when heterogeneity exceeded acceptable levels, by systematically excluding outlier studies or those with high risk of bias. Statistical significance was set at $p \leq 0.05$.

RESULTS

1. Literature search results:

A comprehensive literature search was performed across six major electronic databases—PubMed, Cochrane CENTRAL, Virtual Health Library, PEDro, Web of Science, and Scopus—using an optimized Boolean search strategy combining terms relevant to tele-rehabilitation and cardiovascular or pulmonary diseases. The search yielded a total of 2,913 records, including 1,524 from PubMed, 983 from Web of Science, 286 from PEDro, 91 from Cochrane CENTRAL, 25 from the Virtual Health Library, and 4 from Scopus. These results were imported into a reference management software for deduplication, which led to the removal of 413 duplicate entries. This left 2,500 unique records to be screened by title and abstract.

During the screening phase, 2,474 records were excluded due to not meeting the predefined eligibility criteria—these included irrelevant populations, inappropriate intervention types, or unsuitable study designs such as commentaries, conference abstracts, and protocols. A total of 26 full-text articles were then retrieved for further assessment. Ultimately, 7 randomized controlled trials (RCTs) met all inclusion criteria were included (10–16) in the final qualitative and quantitative synthesis. The study selection process adhered to the PRISMA 2020 guidelines and is illustrated in the PRISMA flow diagram.

1. Characteristics of included studies: The seven included studies—conducted between 2012 and 2022—were all randomized controlled trials evaluating tele-rehabilitation (TR) interventions in adults with cardiovascular diseases. These studies varied in terms of geographic location, sample size, patient populations, intervention duration, and telehealth modalities. Interventions encompassed digital platforms, mobile applications, wearable sensors, and hybrid models combining in-person initiation with home-based follow-up. The studies consistently compared TR to conventional center-based cardiac rehabilitation (CBCR) or usual care, with key outcomes including exercise capacity (VO_2peak or 6MWD), health-related quality of life (HRQoL), psychological well-being, functional capacity, metabolic markers, and hospital readmissions.

Dalli Peydró *et al.* [(11)] and **Blasco *et al.*** [(12)] conducted their studies in Spain using digital tools and remote monitoring for low-risk acute coronary syndrome and post-acute coronary syndrome populations respectively. **Maddison *et al.*** [(13)] from New Zealand utilized a smartphone app with real-time feedback in a coronary heart disease cohort, while **Batalik *et al.*** [(10)] in the Czech Republic implemented a heart rate monitor-guided home program. **Peng *et al.*** [(14)] in China used popular local communication apps to deliver exercise sessions for chronic heart failure patients. **Snoek *et al.*** [(16)] conducted a European multicenter trial targeting elderly patients who declined center-based rehabilitation. Finally, **Piotrowicz *et al.*** [(15)] carried out the largest trial with 850 heart failure patients in Poland using a sophisticated tele-monitoring infrastructure. All trials provided substantial insights into the feasibility, safety, and clinical effectiveness of TR in cardiac populations.

2. Methodological quality appraisal: The quality of the included RCTs was assessed using the PEDro scale, which evaluates internal validity and statistical reporting across 11 criteria, of which 10 are scored. All seven studies explicitly defined eligibility criteria and utilized random allocation, enhancing the transparency and generalizability of their findings. Concealed allocation was applied in six trials, with **Batalik *et al.*** [(10)] being the exception. Despite the inherent challenge of blinding in physical rehabilitation studies, assessor blinding was achieved in six studies, helping to minimize detection bias for outcome measurements.

Participant and therapist blinding was understandably absent across all studies due to the nature of home-based exercise interventions. However, five studies maintained high follow-up rates (> 85%) and applied intention-to-treat (ITT) analysis, thereby preserving the integrity of their randomization. Notably, **Peng *et al.*** [(14)] and **Batalik *et al.*** [(10)] fell short in these aspects, potentially introducing attrition and performance bias. All studies reported between-group comparisons along with appropriate measures of central tendency and variability. Based on their PEDro scores, six studies were classified as having “good” methodological quality (scores of 6–8), while one study (Batalik *et al.*) was rated as “fair” with a score of 5.

3. Risk of bias assessment: To assess the strength of the evidence, the Modified Sackett Scale was applied. This scale considers study design, sample size, methodological quality, and clinical relevance. Six of the included studies—**Dalli Peydró *et al.*** [11] , **Blasco *et al.*** [12], **Maddison *et al.*** [13], **Peng *et al.*** [14], **Piotrowicz *et al.*** [15] and **Snoek *et al.*** [16] were categorized as level I evidence, representing high-quality RCTs with robust methodology and sufficient sample sizes. These studies demonstrated adherence to core standards including randomization, concealed allocation, and blinding of assessors, thereby supporting a strong level of clinical inference.

In contrast, **Batalik *et al.*** [10] received a level II evidence rating due to a lower PEDro score and methodological limitations including lack of concealment, absence of ITT analysis, and suboptimal follow-up. While still contributing valuable data, this study's findings should be interpreted with caution. Overall, the evidence base generated from these trials is highly reliable, enabling confident conclusions about the clinical impact of tele-rehabilitation in CVD populations.

4. Level of evidence of outcomes: The table summarizing the level of evidence for each outcome highlights that exercise capacity—measured through VO_2peak, 6MWD, and METs—has the strongest support, with level I evidence derived from multiple high-quality RCTs (Five rated as "Good" and one as "Fair"). These studies consistently reported significant improvements or non-inferior outcomes favoring tele-rehabilitation (TR), with low to moderate heterogeneity, supporting the reliability of findings. Similarly, the feasibility and safety of TR interventions is also rated as level I, given the consistently high adherence, minimal adverse events, and successful implementation across diverse cardiac populations.

In contrast, health-related quality of life (HRQoL) and physical activity outcomes received level II evidence, reflecting some inconsistency in results despite the majority of studies being high quality. Psychological outcomes and cardiometabolic parameters were rated as level II–III, given their mixed findings and limited number of studies showing statistically significant between-group effects. Likewise, hospitalizations and mortality outcomes received level II–III evidence, as neither endpoint showed significant differences, though trends slightly favored TR. Overall, the table demonstrates that while TR showed clear benefits for exercise capacity and is safe and feasible, further high-powered trials are needed to clarify its effects on broader psychosocial and metabolic health indicators.

5. Narrative synthesis of results

- **Primary outcomes**

Exercise capacity (VO_2peak, 6MWD, METs): Improvements in exercise capacity were among the most consistent benefits of tele-rehabilitation (TR). **Dalli Peydró *et al.*** [11] reported a significant increase in VO_2max in the TR group compared to CBCR (p = .004), along with increased MET-min/week. **Peng *et al.*** [14] also found significant improvements in 6MWD ($p < .001$), indicating enhanced endurance.

Piotrowicz *et al.* [15] observed VO_2peak gains of 0.95 mL/kg/min ($p < .001$), and **Snoek *et al.*** [16] reported sustained VO_2peak improvements at 6 and 12 months. **Maddison *et al.*** [13] demonstrated that TR was non-inferior to center-based exercise, while **Batalik *et al.*** [10] noted long-term VO_2 improvements favoring TR at 15 months (p = 0.047).

Health-related quality of life (HRQoL): Findings for HRQoL were more heterogeneous. **Dalli Peydró *et al.*** [11] and **Peng *et al.*** [14] reported significant improvements in EQ-5D and MLHFQ scores respectively. **Piotrowicz *et al.*** [15] noted enhanced QoL after 9 weeks of TR (p = .008). **Batalik *et al.*** [10] showed within-group improvements in general health (p = .01). However, studies by **Blasco *et al.*** [12], **Maddison *et al.*** [13], and **Snoek *et al.*** [16] did not demonstrate significant between-group differences in HRQoL, suggesting TR maintains—but may not substantially enhance—quality of life.

Physical activity and functional effort:

TR generally led to increased physical activity and exertion levels. **Dalli Peydró *et al.*** [11] observed significantly greater physical activity levels (IPAQ scores and METs), while **Snoek *et al.*** [16] found higher self-reported activity in the TR group. **Blasco *et al.*** [12] **and Maddison *et al.*** [13] reported no significant differences. These mixed findings suggest that activity improvements may depend on intervention design and monitoring intensity.

- **Secondary outcomes**

Psychological Outcomes (Anxiety and Depression): Psychological outcomes varied. Only **Dalli Peydró *et al.*** [11] demonstrated significant reductions in HADS anxiety and depression scores in the TR group**. Peng *et al.*** [14] and **Blasco *et al.*** [12] found no significant changes in psychological status, indicating limited or variable influence of TR on mental health unless accompanied by targeted support.

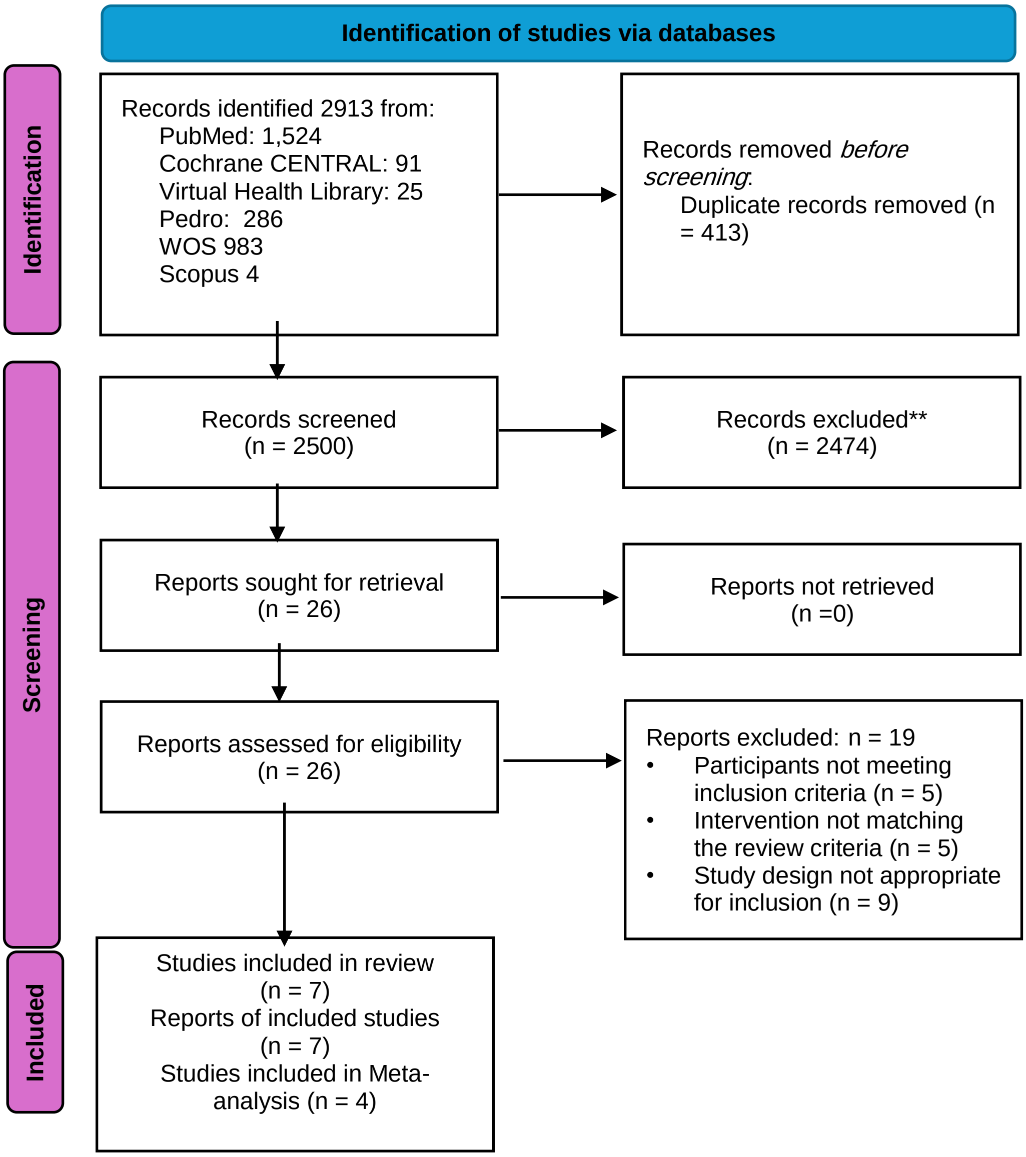

Figure (1): Prisma flow diagram

Cardiometabolic parameters (BP, BMI, Lipids, HbA1c): Blasco *et al.* [12] found TR significantly improved BP, HbA1c, LDL, and BMI in overweight individuals. However, **Dalli Peydró *et al.*** [11] reported non-significant changes in lipid profile or body weight. **Piotrowicz *et al.*** [15] and **Maddison *et al.*** [13] observed minor, non-significant changes. Overall, metabolic effects were present but not consistently robust across all studies.

Hospitalizations and mortality: Long-term outcomes such as hospitalizations and mortality were examined by **Piotrowicz *et al.*** [15] and **Batalik *et al.*** [10]. Neither study found statistically significant differences between TR and control groups, though the TR groups showed slightly fewer hospitalizations. These findings suggest potential benefits, warranting further investigation in larger trials.

Feasibility and safety: TR was generally well-tolerated, with high adherence (> 85%), low dropout rates, and minimal technical issues reported in all studies. No serious adverse events were linked to the interventions. This was true even for older populations, such as in **Snoek *et al.*** [16], confirming the feasibility of TR in diverse cardiac cohorts.

6. Meta-analytical findings

Effect of TR on exercise capacity using peak oxygen uptake (VO_2peak): Three studies (10,15,16) were included in this analysis. The pooled standardized mean difference (SMD) was 0.18 (95% CI: –0.01 to 0.37), indicating a small effect favoring TR, though it was not statistically significant ($p = 0.07$). Heterogeneity was low ($I^2 = 32\%$), suggesting a relatively consistent effect across trials (Figure 2).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Batalik et al., 2021	25.5	3.2	21	23.6	3.1	21	8.6%	0.59 [-0.03, 1.21]
Piotrowicz et al., 2019	17.9	6.2	422	16.7	5.9	422	62.4%	0.20 [0.06, 0.33]
Snoek et al., 2020	20.6	6	89	20.5	5.4	90	29.0%	0.02 [-0.28, 0.31]
Total (95% CI)			**532**			**533**	**100.0%**	**0.18 [-0.01, 0.37]**

Heterogeneity: Tau² = 0.01; Chi² = 2.95, df = 2 (P = 0.23); I² = 32%
Test for overall effect: Z = 1.84 (P = 0.07)

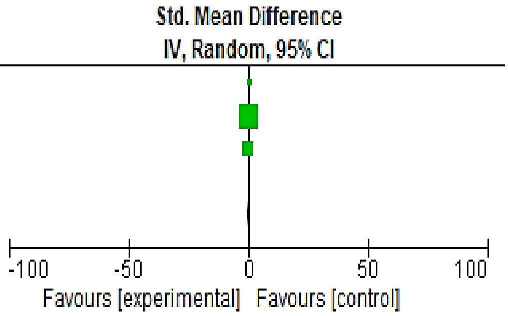

Figure (2): Effect of TR on peak oxygen uptake (VO_2peak).

Effect of TR on exercise capacity using 6-Minute walk distance (6MWD): This analysis included **Peng and Piotrowicz** [14,15]. **Peng *et al.*** [14] showed a large effect (SMD = 1.12), while **Piotrowicz *et al.*** [15] found a small benefit (SMD = 0.17). The pooled SMD was 0.62 (95% CI: –0.31 to 1.56; p = 0.19), with very high heterogeneity (I² = 94%), reflecting substantial variability between studies (Figure 3).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Peng et al., 2018	419.23	9.67	49	406.55	12.54	49	47.7%	1.12 [0.70, 1.55]
Piotrowicz et al., 2019	450	109.5	422	432	106.7	422	52.3%	0.17 [0.03, 0.30]
Total (95% CI)			**471**			**471**	**100.0%**	**0.62 [-0.31, 1.56]**

Heterogeneity: Tau² = 0.43; Chi² = 17.52, df = 1 (P < 0.0001); I² = 94%
Test for overall effect: Z = 1.30 (P = 0.19)

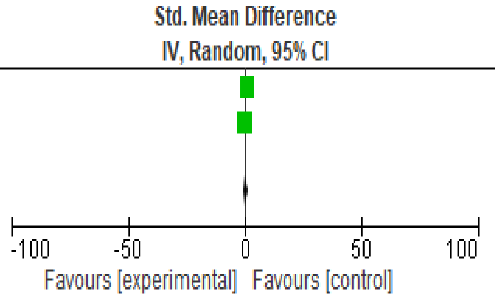

Figure (3): Effect of TR on 6MWD.

Effect of TR on mental health (SF-36 mental component): Analysis of mental health outcomes from **Batalik and Snoek** [10, 16] resulted in a pooled SMD of 0.11 (95% CI: –0.15 to 0.37; p = 0.41), indicating a very small and non-significant effect favoring TR. No heterogeneity was detected (I² = 0%), suggesting consistent findings across studies (Figure 4).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Batalik et al., 2021	61.6	19.7	21	62.5	22.8	23	19.7%	-0.04 [-0.63, 0.55]
Snoek et al., 2020	54	8.4	89	52.7	9.1	90	80.3%	0.15 [-0.15, 0.44]
Total (95% CI)			**110**			**113**	**100.0%**	**0.11 [-0.15, 0.37]**

Heterogeneity: Tau² = 0.00; Chi² = 0.32, df = 1 (P = 0.57); I² = 0%
Test for overall effect: Z = 0.82 (P = 0.41)

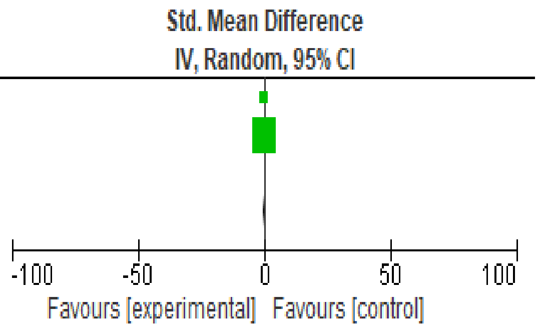

Figure (4): Impact of Tele-rehabilitation on mental health (SF-36 Physical Component).

Effect of TR on physical function (SF-36 physical component): Data from **Batalik and Snoek** [10, 16] yielded a pooled SMD of 0.07 (95% CI: –0.42 to 0.55; p = 0.78), indicating no significant difference between TR and control. Moderate heterogeneity (I² = 57%) suggests some inconsistency in effect size, possibly due to differences in baseline fitness or intervention intensity (Figure 5).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Batalik et al., 2021	53.6	14	21	59.2	26.5	23	36.8%	-0.26 [-0.85, 0.34]
Snoek et al., 2020	50.2	7.2	89	48.3	7.5	90	63.2%	0.26 [-0.04, 0.55]
Total (95% CI)			**110**			**113**	**100.0%**	**0.07 [-0.42, 0.55]**

Heterogeneity: Tau² = 0.07; Chi² = 2.30, df = 1 (P = 0.13); I² = 57%
Test for overall effect: Z = 0.28 (P = 0.78)

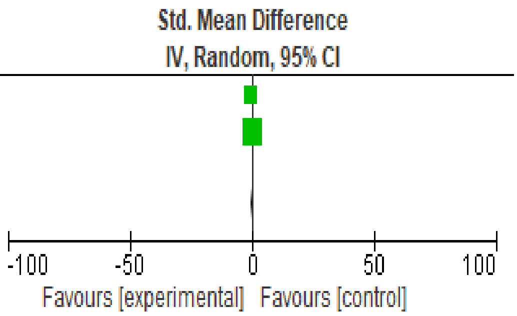

Figure (5): Impact of Tele-rehabilitation on Physical Function (SF-36 Physical Component)

Table (1): Characteristics of included studies

Study ID (Author, Year)	Study Design	Country	Sample Size	Participant Characteristics	Technology Used	Intervention Details	Comparator / Control	Duration of Intervention & Follow-up	Outcomes Measured	Results
Dalli Peydró *et al.*, 2022 (11)	RCT	Spain	59 (CTR: 31, CBCR: 28)	Mean ~56 yrs; Male: 87–96%; Low-risk ACS with LVEF ≥50%	Web platform + app (Cardioplan) + Monitoring tools (Polar H7)	TR: 2 weeks hospital + 10-month home program via app; TM for adherence, vitals, education	CBCR: 8-week supervised rehab	CTR: 10 months; CBCR: 8 weeks; Follow-up: 10 months	QOL (EQ-5D), Endurance (VO2max, METs, IPAQ), HADS, Lipids, Diet adherence	↑ QOL,↑ IPAQ & VO2max (p=.004), ↓ HADS, ↑ diet adherence (70% vs 32%, p=.001), ↓ ApoB/ApoA-I
Batalik *et al.*, 2021(10)	RCT	Czech Republic	56 (HBCT: 28, CBCR: 28)	Mean age ~57 yrs; Male: ~80%; CAD post-PCI/CABG; LVEF >45%	Polar M430 HR monitor + GPS + PolarFlow web account + phone check-ins	TR: 12-week home program, 3x/week, 60 min, 70–80% HR + weekly coaching; TM: HR & GPS tracking	CBCR: same duration & intensity, hospital-based	12 weeks; Follow-up at 15 months	QOL (SF-36), VO2peak, BMI, waist, hospitalizations, mortality	↑ VO2peak in TR (p=.047); ↑ HRQL in both; no BMI/waist change; CBCR: 5 hospitalizations vs TR: 3
Snoek *et al.*, 2020 (16)	RCT	Multi-center (Europe)	179 (MCR: 89, Control: 90)	Median age 72 yrs; 81% male; CAD or valvular surgery; declined center-based rehab	Smartphone + HR belt + app + phone coaching	TR: 6-month home exercise (30 min, 5x/week) + remote coaching; TM via HR feedback	No CR; standard local care only	6-month intervention; 12-month total follow-up	QOL (MCS/PCS), VO2peak, PA, BP, HbA1c, BMI, Anxiety, Depression	Stable QOL/BP/BMI;↑VO2peak, PA, ↓ HbA1c; no added adverse events
Maddison *et al.*, 2019 (13)	RCT (Non-Inferiority)	New Zealand	162 (REMOTE-CR: 82, CBexCR: 80)	Mean age ~61 yrs; Male: ~86%; Post-CHD; many with MI, angina, angioplasty; ~25% CABG	App + BioHarness 3 sensor + web dashboard + live audio coaching	TR: 12-week app-guided, monitored exercise 3x/week; goal setting; no TM after 12 weeks	CBexCR: 12-week supervised in-center sessions	12-week intervention; Follow-up at 12 & 24 weeks	QOL (EQ-5D), VO2max, BP, BMI, lipids, glucose, PA, motivation	TR non-inferior on VO2max (p=.48), ↓ sedentary time (p=.03), CBexCR ↓ waist/hip (p=.04), TR cheaper
Piotrowicz *et al.*, 2019 (15)	RCT	Poland	850 (TR: 425, UC: 425)	Mean age ~62 yrs; Male ~89%; HF (NYHA I–III), LVEF ≤40%, post-hospitalization	Tele-ECG (EHO mini), BP monitor, weight scale, mobile phone, CIED	TR: 1-week inpatient + 8-week home-based (5x/week), aerobic/resistance/respiratory training + education + remote monitoring	UC: Usual care (medical management, lifestyle advice); ~12%	TR: 9 weeks; Follow-up: 14–26 months	QoL, , peak VO_2 ,6MWT, % Days alive/out of hospital, NYHA, mortality,	↑ QoL post-9 weeks; ↑ VO_2 (+0.95 mL/kg/min) , ↑ 6MWT (+30m), no difference in % days alive or mortality

				(≤6 months)	monitoring		received any rehab		hospitalization	
Peng *et al.*, 2018 (14)	RCT	China	98 (TR: 49, CG: 49)	Mean age 66.3 yrs; 59.2% male; NYHA I–III; chronic HF >3 months; LVEF ~34%; Ischemic HF: 60%	QQ & WeChat + HR monitor + instant messaging	TR: 8-week home program (32 sessions aerobic + resistance); TM via weekly messages & intensity adjustment	Usual care: discharge education only	8 weeks interventio n + 4 months follow-up	QOL (MLHFQ), Endurance (6MWD), Resting HR, NYHA, LVEF, HADS	↑ QOL & 6MWD (p<.005), ↓ HR (p<.05), no change in NYHA/LVEF/anxiety/depress ion; no adverse events
Blasco *et al.*, 2012 (12)	RCT	Spain	203 (TMG: 102, CG: 101)	Age ~61 yrs; Male: ~80%; Post-ACS; Smokers or with HTN, LDL-c >100, or diabetes	web platform + SMS + home BP/lipid/glu cose monitors	TM: weekly vitals + monthly lab reports + SMS feedback for 12 months	Usual care + lifestyle advice	12 months	QOL (SF-36), BP, BMI, LDL-c, HbA1c, smoking, CV risk profile	↑ CV risk control (69.6% vs 50.5%, p=.01), ↑ BP & HbA1c control, ↓ BMI in overweight, ↑ SF-36 physical score

RCT: Randomized controlled trial, **CTR:** Center-based telerehabilitation, **CBCR:** Center-based cardiac rehabilitation, **ACS:** Acute coronary syndrome, **LVEF:** Left ventricular ejection fraction, **App:** Application, **TM:** Telemonitoring, **QOL:** Quality of life, **EQ-5D:** EuroQol 5-Dimension questionnaire, **VO2max:** Maximal oxygen consumption, **METs:** Metabolic equivalents, **IPAQ:** International Physical Activity Questionnaire, **HADS:** Hospital Anxiety and Depression Scale, **ApoB/ApoA-I:** Apolipoprotein B to apolipoprotein A-I ratio, **TMG:** Telemonitoring group, **CG:** control group, **BP:** Blood pressure, **LDL-c:** Low-density lipoprotein cholesterol, **HbA1c:** Hemoglobin A1c, **CHD:** Coronary heart disease, **CABG:** Coronary artery bypass grafting, **PA:** Physical activity, **CBexCR:** Center-based exercise cardiac rehabilitation, **HR:** Heart rate, **GPS:** Global positioning system, **CAD:** Coronary artery disease, **PCI:** Percutaneous coronary intervention, **NYHA:** New York Heart Association, **HF:** Heart failure, **6MWD:** Six-minute walk distance, **MLHFQ:** Minnesota Living with Heart Failure Questionnaire, **ECG:** Electrocardiogram, **MCR:** Mobile cardiac rehabilitation, **MCS/PCS:** Mental/physical component summary.

Table (2): PEDRO scale for the included studies

Study ID	*Eligibility criteria specified*	*Random allocation*	*Concealed allocation*	*Baseline comparability*	*Blinding of subjects*	*Blinding of therapistsz*	*Blinding of assessors*	*>85% follow-up*	*Intention-to-treat analysis*	*Between-group comparison*	*Point measures and variability reported*	*Total PEDro Score (out of 10)*	*Quality of the study*
Dalli Peydró et al., 2022	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	Good
Batalik et al., 2021	Y	Y	N	Y	N	N	N	N	N	Y	Y	5	Fair
Snoek et al., 2020	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	Good
Maddison et al., 2019	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	Good
Piotrowicz et al., 2019	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	Good
Peng et al., 2018	Y	Y	Y	Y	N	N	Y	N	N	Y	Y	6	Good
Blasco et al., 2012	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	Good

DISCUSSION

This systematic review synthesized evidence from seven randomized controlled trials evaluating the efficacy of tele-rehabilitation (TR) in cardiovascular patients, guided by PRISMA 2020 methodology. Most trials were of high methodological quality (six with PEDro scores ≥6), and meta-analyses were conducted for core outcomes including VO_2peak, six-minute walk distance (6MWD), and SF-36 physical and mental components. Overall, the narrative synthesis demonstrated consistent improvements in exercise capacity, variable changes in quality of life, modest psychological benefits, and strong feasibility and safety. However, meta-analytic estimates showed small to moderate effects for VO_2peak (SMD = 0.18, p = 0.07) and 6MWD (SMD = 0.62, p = 0.19), both of which failed to reach statistical significance, possibly due to high inter-study heterogeneity and limited statistical power. Tele-rehabilitation effectively enhanced cardiorespiratory fitness across diverse models and patient populations. Gains in VO_2peak and 6MWD were observed in trials using structured and sensor-guided home programs [11, 15] with effects comparable to center-based cardiac rehabilitation [13]. These findings are consistent with prior reviews reporting non-inferior outcomes from remote rehabilitation interventions [17, 18]. High adherence and real-time monitoring likely contributed to these improvements [19], though variability in baseline fitness and exercise intensity may have influenced responsiveness. Larger, well-monitored trials demonstrated superior gains relative to smaller studies with less robust supervision.

The effect of TR on quality of life (QoL) varied depending on the measurement tool. Disease-specific instruments (e.g., MLHFQ, EQ-5D) were more sensitive to intervention effects, capturing significant improvements in perceived health and functional well-being [11, 14]. This aligns with meta-analyses showing that telehealth CR can match or exceed center-based programs in improving disease-related QoL domains [20,21]. In contrast, generic measures like the SF-36 yielded negligible differences between groups [13, 16], likely due to ceiling effects or reduced sensitivity in detecting small changes post-rehabilitation [22, 23]. Future trials should incorporate both disease-specific and general QoL instruments to comprehensively evaluate psychosocial outcomes.

Psychological outcomes such as anxiety and depression showed variable response to TR. Significant reductions in HADS scores were observed in trials that included structured psychosocial components [11], supporting the utility of integrating behavioral support into rehabilitation frameworks [24, 25]. Trials relying solely on physical training showed minimal mental health gains [14], underscoring the importance of multimodal intervention design. Evidence from broader literature suggests that pairing exercise with cognitive-behavioural therapy or relaxation strategies amplifies improvements in mood and emotional well-being [26, 27].

Behavioural and clinical metrics such as physical activity levels and cardiometabolic indicators also benefited from TR. Studies incorporating real-time tracking, feedback, and tailored prompts reported significant increases in weekly activity and self-reported exertion [11, 16] are consistent with behavioural theory emphasizing self-monitoring and goal setting [28, 29]. In contrast, trials lacking continuous engagement tools observed minimal activity changes [12, 13]. Cardiometabolic markers such as blood pressure, lipid profiles, and HbA1c improved in programs that integrated structured risk factor management [11, 12]. But, not in those lacking multidisciplinary oversight [15, 16]. These findings align with prior meta-analyses showing that TR can achieve comparable risk control to in-person care [30, 31]. Although two large trials [10, 15] showed no differences in mortality or rehospitalization, the high adherence rates (> 85%) and minimal adverse events across studies that affirmed the feasibility and safety of TR in cardiovascular populations, including older adults. This is consistent with findings from prior systematic reviews [32, 33]. However, lack of blinding, incomplete follow-up, and protocol variability across studies limited the robustness of pooled estimates. Moving forward, standardized protocols, objective activity measures (e.g., accelerometers), and longer-term follow-up will be essential to better evaluate the sustained clinical benefits of TR and its impact on healthcare utilization.

Given the ongoing burden of cardiovascular disease and barriers to traditional rehabilitation participation, TR provides a scalable, patient-centred solution. Future research should aim to standardize intervention protocols, incorporate objective outcome assessments, and evaluate long-term effects on mortality, hospital readmission, and cost-effectiveness to strengthen the evidence base and inform policy and clinical guidelines.

CONCLUSION

This systematic review confirmed that tele-rehabilitation is an effective and feasible intervention for patients with cardiovascular diseases, particularly in enhancing exercise capacity and health related quality of life. These results suggest that tele-rehabilitation offered a promising, accessible alternative to traditional cardiac rehabilitation, especially when tailored with personalized feedback and structured monitoring.

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