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Review Article

Reviews Evaluating Information Technology-Based Cardiac Rehabilitation Programs and Support: A Systematic Review

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Abstract

Background: Application of technology in virtual or remote cardiac rehabilitation programs can resolve the challenge of accessing healthcare services and reduce access level inequalities. This study aimed to evaluate the effect of technology on different clinical outcomes in cardiac rehabilitation programs used for cardiovascular (CVD) patients.

Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analyses and a comprehensive evidence map of overview was used. Two researchers searched electronic databases such as Science Direct, Medline / PubMed, Web of Science, Scopus, ProQuest, Google Scholar and Cochrane library at the time of publication until Mar 21, 2021.

Results: Of 51 reviews published, most of them have reported that the virtual or remote cardiac rehabilitation had a positive effect on most outcomes compared to usual care, and the difference in the type of comparison group and the high heterogeneity in reviews with inconsistent results are due to different technologies used in the interventions, follow-up duration, the type of heart disease, tools, and reporting methods, the quality of the reviews, and the quality of the primary studies included in the reviews.

Conclusion: Two important factors before choosing the remote cardiac rehabilitation technology include the complexity of technology and the level of satisfaction and acceptability of the interventions among participants. The simplicity of the interventions increases the acceptability level, and the more complex design and advanced monitoring level during the interventions and the need for specific equipment affect cost saving, so it is important to consider the above cases while choosing the type of technology.

Keywords: Cardiac rehabilitation; Information technology; Telemedicine; Telerehabilitation

Introduction

Cardiac rehabilitation (CR) is a secondary prevention program that aims to promote mental health status in patients with a history of cardiovascular diseases (CVDs) through education and interventions, initially carried out in hospitals (1). CR improves health status and quality of life and reduces hospital admissions. Mortality rates are reduced by

32% in CR recipients compared to non-CR recipients (2). We can predict a linear relationship between CVD incidence and poor socioeconomic status and patients with poor socioeconomic are affected more seriously by the deleterious outcomes of CVD. Most people with poorer socioeconomic status live in the suburbs and are far from large cities and equipped medical centers (3). It is difficult reverse these inequalities because people who live in larger cities and have access to well-equipped medical centers or have better socio-economic conditions, have better access to better care and treatment (4).

Tele-health can be effective in resolving the challenge of accessing healthcare services and reducing inequalities in access to healthcare. Since this technology monitors the patient's vital signs and physical status on a daily basis through a telemonitoring program, and any imbalance or abnormal condition can be diagnosed before it pose a risk to the patient and avoids emergency examinations and hospital referrals, which can also be costly (5). These virtual cardiac rehabilitation programs use cost-effective communication technologies such as telephones, the Internet, text messages and smartphones over a wide range of distances (6).

Numerous systematic reviews of the use of technology in health care have shown that the use of technology in virtual CR programs, despite their positive effect on various clinical outcomes, have shown contradictory results in some cases. Previous systematic reviews have reported numerous outcomes, but many have been studies with small sample size, with varying methodological quality, complicated the choice of the best technology to be applied in CR programs. Therefore, the present overview reviews high quality systematic articles and provides a summary of credible evidence on the effect of technology on the implementation of cardiac rehabilitation programs in the areas of training, implementation, standard support, increasing models of care and appropriate behavioral frameworks. Moreover, as a systematic review of systematic reviews aimed at evaluating the effect of technology used in cardiac rehabilitation programs on different clinical outcomes in CVD patients.

Methods

Search method

A comprehensive and regular search was performed through the [MeSH] keywords (heart diseases or coronary disease or coronary artery disease or myocardial infarction or coronary artery bypass or heart failure and cardiac rehabilitation and telemedicine). Two reviewers searched until Jan 20, 2021 without language restrictions in the Science Direct, Medline/PubMed, Web of Science, Scopus, ProQuest, Google Scholar, and Cochrane library. The reporting items were used for Preferred Reporting Items for Systematic Reviews and Meta-Analyses-PRISMA (7) and a comprehensive evidence map of an overview of systematic reviews (8, 9) to perform the present review.

Eligible criteria

Participants were adults (≥18 yr old) with CVDs. Studies implemented in non-CVDs were excluded; those combining cancer with non-CVDs diseases were excluded. Eligible interventions were virtual cardiac rehabilitation programs. Comparators were usual care, and non-virtual cardiac rehabilitation programs. Outcomes were not limitation. The studies as systematic review or meta-analysis were eligible.

Selection procedure

Two reviewers performed the search and screening process. In case of contradiction in the results of each screening stage, the views of the third person or discussion were used to achieve the result. Finally, after evaluating the quality, 51 reviews entered the analysis (Fig. 1).

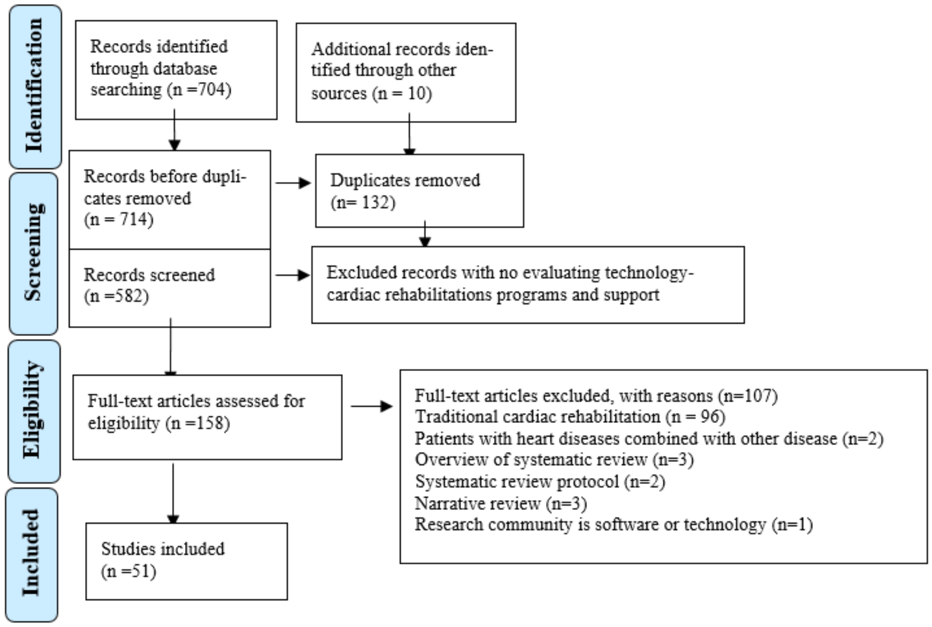

Fig. 1: PRISMA Flow Diagram

Quality of included reviews

To assess the risk of bias in systematic reviews, ROBIS-Risk of Bias in Systematic Reviews was reviewed. This tool examines the risk of bias in systematic reviews in four key areas: 1) criteria for qualifying study, 2) identifying and selecting studies, 3) evaluating and collecting data, 4) synthesis, and findings. For each question in each domain, information about possible systematic review constraints is provided, which leads to the judgments about concerns in that domain with criteria low, high, or indefinite. Evaluators in the final decision report the risk of bias in general, with signaling questions and supportive information on the low, high, or uncertain risk of bias (10). Two authors independently evaluated the quality of systematic reviews and agreed in case of the dispute through discussion Fig. 2. Review manager 5.3 was used to draw the risk of bias summary and risk of bias graph.

Fig. 2: Review authors' judgements about each risk of bias item presented as percentages across all included studies, a-Risk of bias summary, b-Risk of bias graph

Ethics approval

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee, and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Results

Overall, 51 reviews were published and 20 of them (20.2%) had Meta-analyzes. Based on systematic review reports, interventions were divided into 4 categories: e-health, m-health, tele-health, telemedicine, and 27 outcomes were extracted. Overall, 21, 23, 26, 12 outcomes were investigated in 5 e-health interventions, 11 m-health interventions, 28 tele-health interventions, and 7 telemedicine interventions, respectively. A summary of the outcomes of the reviews entered in the present overview is given in Table 1. Figure 3 demonstrates the result of network analysis, which schematically shows the outcomes of each intervention separately.

Table 1: Outcomes reported by the systematic reviews

Author (Reference No.)	*Systematic Review*	*Meta-analysis*	*All-cause mortality*	*All-cause hospitalizations*	*Hospitalizations*	*Adherence Medication*	*Cardiac mortality*	*Cost saving*	*Quality of life*	*Length of hospital stay*	*left ventricular ejection frac-*	*New York Heart Association*	*VO2*	*Acceptability*	*Emergency room visits*	*Feasibility*	*Patient satisfaction*	*Psychosocial*	*Self-management*	*Natriuretic Peptide*	*self-care*	*weight*	*BP*	*lipids*	*smoking*	*Physical activity*	*Diet*	*Blood glucose*	*HbA1c*	*Type of technology*
Aneni, 2014(11)	✓																					✓	✓	✓	✓	✓	✓	✓		e-health
Hughes,2014(12)	✓							✓	✓	✓				✓		✓			✓											e-health
Munro,2013(13)	✓								✓	✓												✓	✓			✓				e-health
Or,2017(14)	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓		✓			✓			✓	✓	✓		✓	✓	✓			e-health
Veen,2017(15)	✓					✓																				✓				e-health
Jerant, 2005(16)	✓			✓		✓	✓			✓		✓	✓								✓									Telemedicine
Knox,2017(17)		✓							✓																					Telemedicine
Kotb,2015(18)	✓	✓		✓	✓		✓																							Telemedicine
Kraai,2011(19)	✓																✓													Telemedicine
Lin,2017(20)	✓	✓	✓	✓	✓		✓			✓																				Telemedicine
Schmidt,2007(21)	✓								✓																					Telemedicine
Zhu, 2019(22)	✓	✓	✓	✓	✓		✓	✓	✓	✓																				Telemedicine
Cajita,2016(23)	✓	✓	✓		✓				✓	✓	✓	✓									✓	✓	✓							m-health
Carbo,2018(24)	✓	✓		✓	✓		✓	✓		✓	✓	✓																		m-health
Coorey,2018(25)	✓	✓				✓				✓								✓	✓			✓	✓	✓	✓	✓			✓	m-health
Gandapur,2016(26)	✓					✓																								m-health
Gandhi,2017(27)	✓	✓				✓	✓			✓			✓					✓				✓	✓	✓	✓	✓	✓			m-health
Hamilton,2018(28)	✓							✓								✓														m-health

Hui,2018(29)	✓					✓			✓								✓	✓							✓	✓				m-health
Muzas,2018(30)	✓								✓									✓												m-health
Park,2016(31)	✓																													m-health
Pfaeffli,2016(32)	✓					✓												✓							✓	✓	✓			m-health
Unal,2018(33)	✓					✓																✓	✓	✓	✓	✓	✓			m-health
Beatty,2013(1)	✓							✓	✓										✓			✓	✓	✓	✓	✓	✓	✓		Tele-health
Chaudhry,2007(34)	✓		✓	✓				✓																						Tele-health
Ciere,2012(35)	✓								✓												✓									Tele-health
Clark,2015(36)	✓																				✓					✓				Tele-health
Clark, 2007(37)	✓	✓	✓	✓				✓	✓	✓				✓	✓															Tele-health
Clarke,2011(38)	✓		✓	✓		✓		✓		✓					✓															Tele-health
Dang,2009(39)	✓		✓				✓			✓					✓															Tele-health
Farnia, 2018(40)	✓							✓									✓				✓									Tele-health
Giamouzis,2012(41)	✓		✓					✓		✓												✓	✓							Tele-health
Huang,2014(42)	✓	✓	✓			✓		✓	✓				✓					✓				✓	✓	✓	✓					Tele-health
Inglis,2011(43)	✓	✓	✓		✓			✓	✓	✓		✓								✓	✓									Tele-health
Jones,2016(44)	✓					✓								✓																Tele-health
Klersy,2009(45)		✓	✓	✓			✓																							Tele-health
Kotb,2014(46)	✓	✓	✓	✓														✓					✓	✓	✓					Tele-health
Louis,2003(47)	✓						✓	✓		✓				✓																Tele-health
Maric, 2009(48)	✓				✓			✓	✓						✓															Tele-health
Marin,2018(49)	✓					✓				✓				✓			✓									✓				Tele-health
Martinez,2006(50)	✓				✓		✓	✓	✓	✓		✓		✓		✓														Tele-health
Nakamura,2014(51)		✓				✓	✓																							Tele-health
Pandor,2013(52)	✓	✓	✓	✓	✓				✓	✓																				Tele-health
Pandor,2013(53)	✓		✓	✓	✓			✓	✓	✓				✓																Tele-health
Polisena,2009(54)	✓	✓			✓		✓		✓	✓					✓		✓				✓									Tele-health
Radhakrish-nan,2012(55)	✓												✓								✓	✓	✓	✓		✓		✓	✓	Tele-health
Rawstorn,2016(56)	✓	✓				✓	✓																✓	✓		✓		✓	✓	Tele-health
Seto,2008(57)	✓				✓			✓		✓																				Tele-health
Smith,2013(58)	✓			✓	✓																									Tele-health
Xiang,2013(59)	✓	✓	✓		✓					✓		✓																		Tele-health
Yun,2018(60)	✓	✓	✓		✓		✓		✓						✓							✓	✓							Tele-health

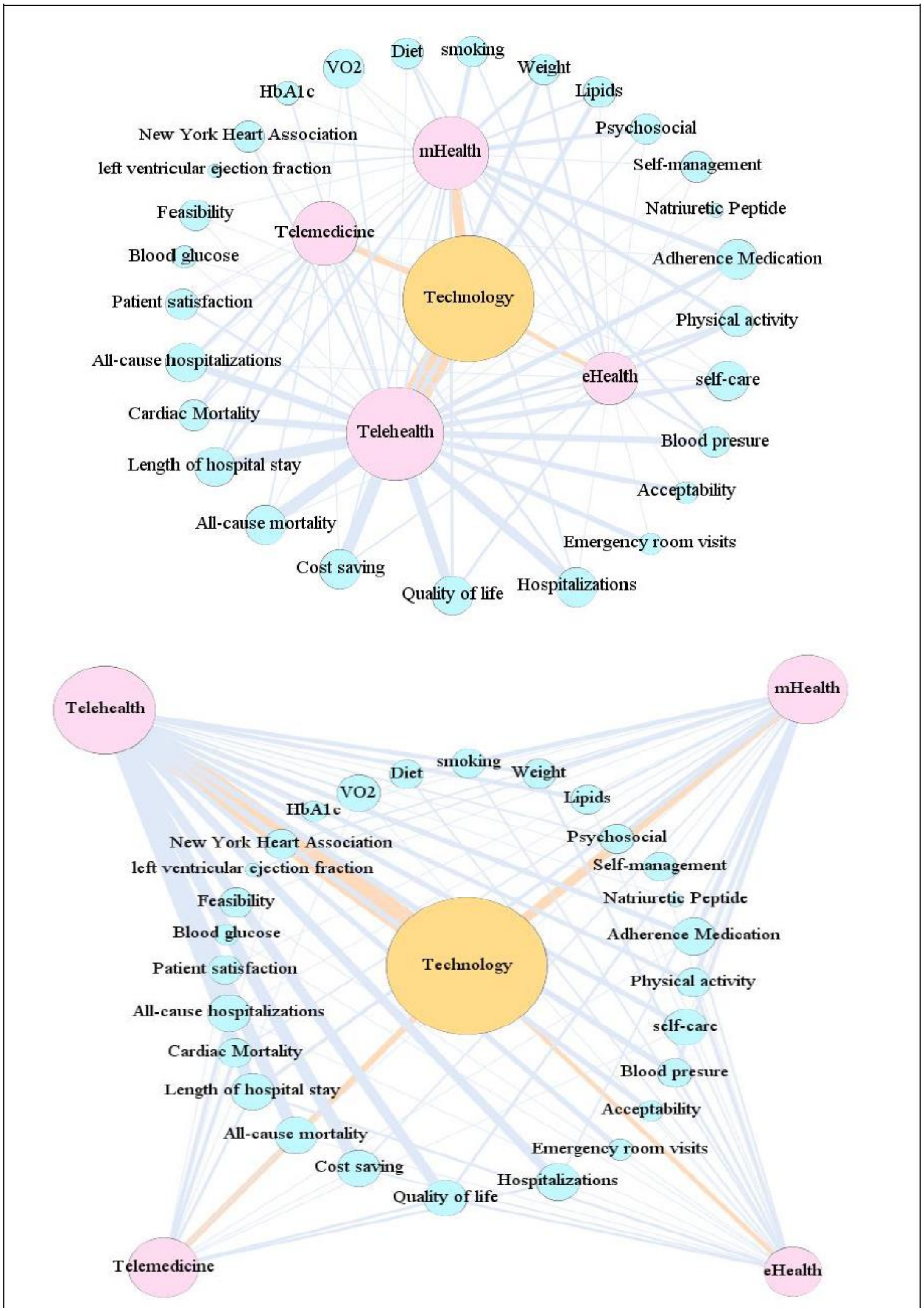

Fig. 3: Result of network analysis

Discussion

All-Cause Mortality and Mortality

Ten reviews showed a significant reduction in mortality rate (1, 16, 22, 23, 27, 39, 45, 49, 53, 54) but, two reviews did not report a significant reduction in mortality rate (24, 46). Zhu et al. referred to telemonitoring as an effective factor in reducing all-cause mortality (OR=0.75, 95% CI: 0.62-0.90) (22). Chaudhry et al. referred to telemonitoring as a factor reducing all-cause mortality by 40-56% (34). The type of technology, the type of heart disease of the participants and the quality of the reviews and the follow-up duration are among the factors affecting all-cause mortality and mortality. Giamouzis et al. reported a death rate of 29%, 27%, and 45% in telemonitoring, telephone support, and routine care groups after one year, respectively (41). Telemonitoring reduced the risk of all-cause mortality in heart failure (HF) patients by 34% (I^2=0%, RR=0.66, 95% CI:0.54-0.81) and such decrease was not statistically significant in structured telephone support group (I^2=0%, RR=0.88, 95% CI:0.76-1.01)(43). Telemonitoring reduces all-cause mortality and mortality by 23% in structured telephone support recipients, 24% in telemonitoring recipients during urinary hours and 51% in tele monitoring recipients on seven days of the week and 24 h a day (52).

All-cause Hospitalizations & Hospitalizations

Eight reviews have reported that technology leads to a significant decrease in all-cause hospitalizations as compared to routine care (14, 16, 22, 24, 34, 53, 54). One tele-health review (45) and seven telemedicine reviews reported a significant reduction in the risk of hospitalizations (16, 22, 37, 38, 41, 43, 47, 48, 54).

Hamilton et al. did not show a significant difference between virtual and non-virtual heart rehabilitation programs in HF failure patients (28). Although there are differences in the type of telehealth- interventions, there was no significant difference in odds ratio of hospitalization admissions (18). In a review of five studies, Gandhi et al. did not report a significant difference in hospital readmissions (OR=0.93, 95% CI=0.06-14.72) (27).

Emergency Room Visits

Few reviews have reported emergency room visits where the telemonitoring technology has been used. Tele monitoring did not significantly decrease all-cause emergency admission as compared to routine care (38). An RCT showed an increase in emergency room visits after home telemonitoring intervention. While another RCT reported contradictory results and, an observational study also showed no difference between different technology approaches in terms of the frequency of emergency room visits (54).

Length of Stay

Seven reviews reported a decrease in the length of stay (LOS) when technology was used as compared to routine care (14, 20, 22, 43, 47, 49, 52). Zhu et al. stated difference between intervention and control groups in terms of LOS between telemonitoring and control groups (SMD = -1.71, 95% CI = -4.83 to -1.42) and between telephone support and control groups (SMD= -3.41, 95% CI=- 5.01 to -1.82) (22). Lin et al. demonstrated in a review study that LOS of patients with heart failure was 0.67-95 d in the telemedicine group and 3-150 d in the control group (20).

Cost Saving

Ten reviews reported that technology use significantly reduced cost saving as compared to routine care (1, 16, 28, 36, 39, 40, 43, 47, 49, 57). Four reviews have reported technology was not effective in reducing cost saving as compared to routine care (12, 22, 38, 48). The type of technology, the degree of complexity, and level of monitoring used in the interventions affect the cost-saving results (34). Telemonitoring led to a significant decrease in hospitalization cost compared to routine care (843±1733 vs. 1298±2322, 35% reduction, P<0.01). Another study included in the above review has shown telemonitoring led to a 12% decrease in hospitalization costs and only one study showed that the telemonitoring intervention led to an increase in the hospitalization costs as compared to routine care (1382±3384 vs. 747±2137, $P<0.16$) (41).

Acceptability & Feasibility

Patients had optimal acceptability towards technology use, but participants did not regard the telemonitoring program with the video link as useful in one study (37). Patients had optimal acceptability towards telemonitoring and structured telephone support interventions in 76%-100% of cases (43). Good acceptability (80%-90%) of telemonitoring programs was reported among participants (47). In a review study, the majority of studies carried out telemonitoring interventions and most participants had heart failure and reported the least acceptability. Three reviews compared m-health interventions with routine care and reported that m-health interventions had a positive effect on feasibility (28, 30, 31).

Quality of Life & Psychosocial Conditions

There were nineteen reviews on quality of life, of which 14 have reported a positive and significant effect of technology on the quality of life in CVD patients compared to routine care (17, 22, 23, 29, 37, 43, 47, 50, 52-54, 60). Seven reviews reported technology had a positive effect on the psychosocial conditions of CVD patients compared to routine care (13-15, 25, 27, 46). Two reviews reported that technology had no significant positive effects on quality of life (61) of CVD patients as compared to routine care (21, 30). Three reviews referred to the different tools, duration and type of interventions as factors leading to different QoL evaluation results (12, 25, 42).

Patient Satisfaction

Three reviews reported the positive effects of technology-based interventions on patient satisfaction compared to routine care (12, 19, 29), and one review reported that tele-health intervention led to inconsistent results due to a variety of assessment tools used. Seven studies reported no significant differences in patient satisfaction but five studies reported a significant increase in patient satisfaction in tele-health interventions (54).

Management & Self-care

Hughes et al. study was the only review compared tele-health with routine care in terms of their effect on self-management and reported that tele-health had a positive and significant effect (12). Tele-health had a positive and significant effect on self-care(35). Telemedicine had a positive and significant effect on self-care(16). Radhakrishnan et al. reported the positive and significant effect of tele-health on self-care outcomes in nine studies, but eight studies with a smaller sample size (n=23 to 214) did not report the positive effect of tele-health on self-care (55).

Smoking Cessation

E-health and tele-health were effective on smoking cessation (11, 46). M-health and tele-health interventions were reported to have no effect on smoking cessation in three reviews (27, 29, 32) and one review (42), respectively. M-health had an effect on smoking cessation but it was not statistically significant (25).

Physical Activity

Eight reviews reported the effect of technology on the physical activity of CVD patients in comparison with routine care (11, 13, 15, 27, 29, 32, 43, 56), while three studies did not report effective results according to the diversity of studies and type of evaluation (11, 25, 49).

Medication Adherence

Tele-health and m-health interventions were reported to have a positive effect on medication adherence in two reviews (51, 54) and five reviews (25-27, 29, 33) compared to routine care, respectively. In addition, one review did not report the positive effect of tele-health on medication adherence (38).

Diet

m-health had a positive effect on dietary adherence compared to routine care (27). One review reported that m-health intervention did not have a positive effect on dietary adherence compared to the routine care (32) and e-health was not effective on dietary adherence as compared to routine care in a review of five studies, and it was reported to be effective in four studies (11).

Weight

Four reviews referred to the positive effect of technology on weight loss compared to routine care (11, 25, 41, 55). This weight loss was reported to be up to 75% after the intervention (41, 55). A review study, showed no statistically significant BMI changes in two studies, but one study showed a positive and significant effect on BMI changes (P<0.001). Two reviews did not report weight changes following the tele-health intervention (14, 42). In a review, Huang et al., did not report significant weight and BMI changes in short-term and long-term follow-ups (42).

New York Heart Association

Three reviews reported that technology had a positive effect in New York Heart Association compared to routine care (23, 24, 43). There were II-IV patients when NYHA interventions began, but there were III-IV patients after interventions (16).

Natriuretic Peptide

Two reviews have reported the positive effect of technology on natriuretic peptide as compared to routine care (24, 43). Brain natriuretic peptide decreased by 30%-57% in intervention groups(24).

Left Ventricular Ejection Fraction (LVEF)

Cajita et al. showed an average LVEF development in his review study and two studies reported that m-health and routine care interventions led to no significant change in LVEF development (23). Overall, 3 out of 4 studies reported a positive effect of m-health on LVEF, and its development ranged between 14% and 17% in the m-health group (24) .

VO2

A review study reported not difference in peak VO2 uptake following m-health intervention only in one study (-0.2 mL/kg/min, P=0.65) (27).

Blood Pressure

Six reviews have reported that technology had a positive significant effect in reducing blood pressure (BP) as compared to the routine care (14, 25, 27, 33, 41, 46). The rate of compliance with blood pressure monitoring was higher in the tele-health group (14). Tele-health interventions led to no significant reduction in CP changes in the short term (12 wk to 12 months), but SBP and DBP reduced significantly in the long term (24 months)(42).

Lipids

Coorey et al. reviewed 30 studies and reported a significant reduction in cholesterol levels in the m-health group (-46.9±38.3mg / dl, P<0.0001) LDL-C (-36.7±35.7 mg/dl P=0.0004) and triglyceride (-39.3±69.1 mg/dl P=0.03) compared to the baseline. There was also a decrease in LDL-C level in the control group (25). A review of six studies found no change in blood lipid concentration in two studies with good methodological quality in a two-year follow-up. A 6-month follow-up study showed no change in HDL-c level but showed a significant reduction in triglyceride level. Another 7-month follow-up study showed a decrease in mean cholesterol and triglyceride levels, but reported an increase in HDL.C level. Another 2-year follow-up study showed that e-health intervention led to a significant reduction in HDL-C level as compared to routine care intervention (P=0.033) (11). Huang et al. found no difference between tele-health and routine care intervention in terms of total cholesterol, HDL-C, and LDL-C in short-term follow-up (12 wk to 12 months) as well as in total cholesterol and HDL-C in the long-term follow-up (24 months) (42).

HbA1c

Two reviews reported a significant decrease in HbA1c levels (11, 25). Coorey et al. reported a decrease in HbA1c levels in 54.2% of m-health recipients (25). Rawstorn et al. also reported no significant differences between tele-health and centered-based care interventions in terms of HbA1c levels (56).

Blood Sugar

Rawstorn et al. showed no significant difference between tele-health and center-based care groups in terms of blood sugar in one study(56). A high-quality study found that e-health reduced fasting blood sugar (FBS) by an average (12 mg/dl or 0.67 mmol.l) over 12 and 24 months. Between the two low-quality studies, FBS was reduced significantly after 6 months, while another study showed a significant increase in FBS level after 2 years (11).

Limitations

In this overview, network analysis was used because the aim of the present overview was to identify the diversity of technologies used in virtual CR programs and to evaluate of outcomes in previous reviews. Considering the diversity of interventions, the diversity of technologies used, diversity of participants in terms of CVD type, different follow-up durations in studies and diversity of comparison groups and most importantly the diversity of consequences and diversity of data collection methods such as the use of different tools and questionnaires lead to very high heterogeneity. Therefore, instead of performing a meta-analysis on the meta-analyzes, the results of previous meta-analyzes were used for comparison purposes.

Conclusion

Most reviews report the positive effect of using virtual or remote cardiac rehabilitation compared to usual care on most outcomes. The contradictory results obtained in some reviews were due to differences in the type of comparison and high heterogeneity group, the type of technologies used in the interventions, the duration of follow up, the type of heart disease, the type of tools and data reporting methods, the quality of reviews and the quality of the pilot studies entered into the reviews. Among the outcomes reviewed, two important factors before choosing the remote cardiac rehabilitation technology include the complexity of technology and the level of satisfaction and acceptability of the interventions among participants. The simplicity of the interventions increases the acceptability level, and the more complex design and advanced monitoring level during the interventions and the need for specific equipment affect cost saving, so it is important to consider the above cases while choosing the type of technology.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare no conflicts of interest.

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