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Review Article

Quality of Life in Heart Patients Receiving Telerehabilitation: An Overview with Meta-Analyses

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Abstract

Background: This overview is conducted to evaluate the effect of telerehabilitation on Health-Related Quality of Life (HRQOL) in patients with cardiovascular diseases (CVDs).

Methods: A comprehensive search was performed through the [MeSH] keywords (heart diseases, coronary disease, coronary artery disease, myocardial infarction, coronary artery bypass, heart failure, cardiac rehabilitation and telemedicine) until January 20, 2021 in databases of Science Direct, Medline/PubMed, Web of Science, Scopus, ProQuest, Google Scholar and Cochrane library. Finally, 20 reviews were entered into the analysis.

Results: The results of meta-analyses showed that receiving telerehabilitation program by telemedicine method has a positive effect on the physical dimension and changing the mental status of patients following this intervention depends on age so that the use of these technologies in heart patients with younger ages promotes mental status. On the other hand, increasing the duration of the intervention 18 months or more affects the physical dimension and 12 months or more affects promoting overall HRQOL. Among the various types of Telemedicine methods, telephone support has a greater effect on promoting the physical dimension.

Conclusion: The ability to use virtual technology is less at older ages, so age conditions of patients should be considered in choosing this type of intervention. The living place of the people and the level of access to advanced care, seem to play an important role in changing outcomes and choosing this type of intervention because the main purpose of telerehabilitation is to provide treatment care in areas with low access levels.

Keyword: Telerehabilitation; Telemedicine; Rehabilitations; Cardiovascular disease

Introduction

Cardiovascular disease (CVD) is the main cause of death worldwide that includes almost one-third of deaths (1). According to high mortality in CVD and especially heat failure (HF), there is a risk of decreasing in health-related quality of life (HRQOL) in these patients (2, 3). Cardiac rehabilitation (CR) and secondary prevention have 10 main cores including patient assessment, nutrition counseling, weight management, blood pressure management, lipid management, diabetes management, tobacco cessation, psychological

management, physical activity counseling, and exercise training (4).

Numerous studies have been conducted on the use of technology in CR programs, while the effect of these programs on HRQOL requires investigation (5, 6). Some studies compared the effect of telerehabilitation-based interventions on HRQOL in patients with CVDs, which showed conflicting results. The use of a smartphone-based interactive patient support tool after 6 months had no significant effect on HRQOL (7). Telerehabilitation had different effects on quality of life. HRQOL in chronic heart disease (CHD) patients increased slightly after 12 weeks in the telerehabilitation group compared to the control group. But after 24 weeks, it increased in the control group and decreased in the remote rehabilitation group (8). No significant increase has been occurred in a 90-day follow-up in HF patients using Mobile Web-Based Telemonitoring-MWBT (9). While HRQOL and all its dimensions have been significantly increased in HF patients using Mobile Phone-Based Telemonitoring-MPBT after 6 months (10).

In a meta-analysis, telemedicine had no effect on improving the physical and psychological dimensions of quality of life in patients with heart failure (HF) but increased the overall quality of life (6). In addition, the positive effects of telephone support and telemonitoring on the quality of life of heart failure patients were identified in six studies (5).

Although there were a significant number of systematic reviews examining the effect of telerehabilitation on various outcomes in cardiac patients, most of them do not have the same primary studies despite having similar inclusion criteria. Therefore, researchers decided to use an overview to analyze and meta-analyze studies to find the effect of telerehabilitation on HRQOL of patients with CVDs.

Materials and 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) by two reviewers until January 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 (11) and a comprehensive evidence map of an overview of systematic reviews (12, 13) to perform the present review.

Eligible criteria

All articles that were conducted on people over 18 years of age were selected. Studies implemented in non-CVDs were excluded; those combining cancer with non- CVDs diseases were excluded. Eligible interventions were virtual cardiac rehabilitation programs. Eligible cardiac rehabilitation program interventions had to have been offered via "telemedicine". Comparators were routine, standard, and non-virtual cardiac rehabilitation programs Outcomes included HRQOL. The studies as systematic review or meta-analysis were eligible.

Selection procedure

The search and screening process was performed by two reviewers. 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, 20 reviews that reported HRQOL entered the analysis (5, 6, 14-31) (Fig. 1).

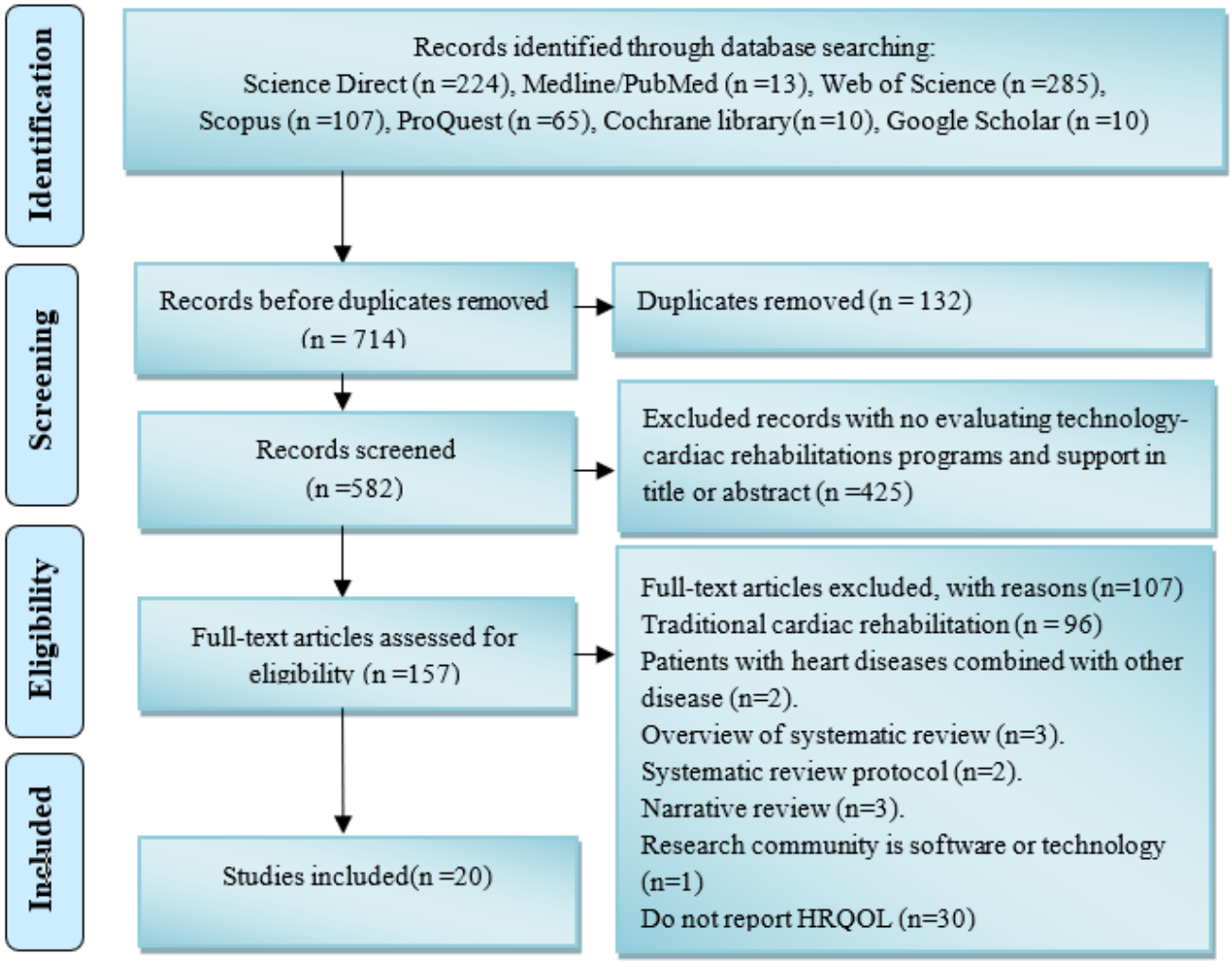

Fig. 1: PRISMA Flow Diagram

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 (32). 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.

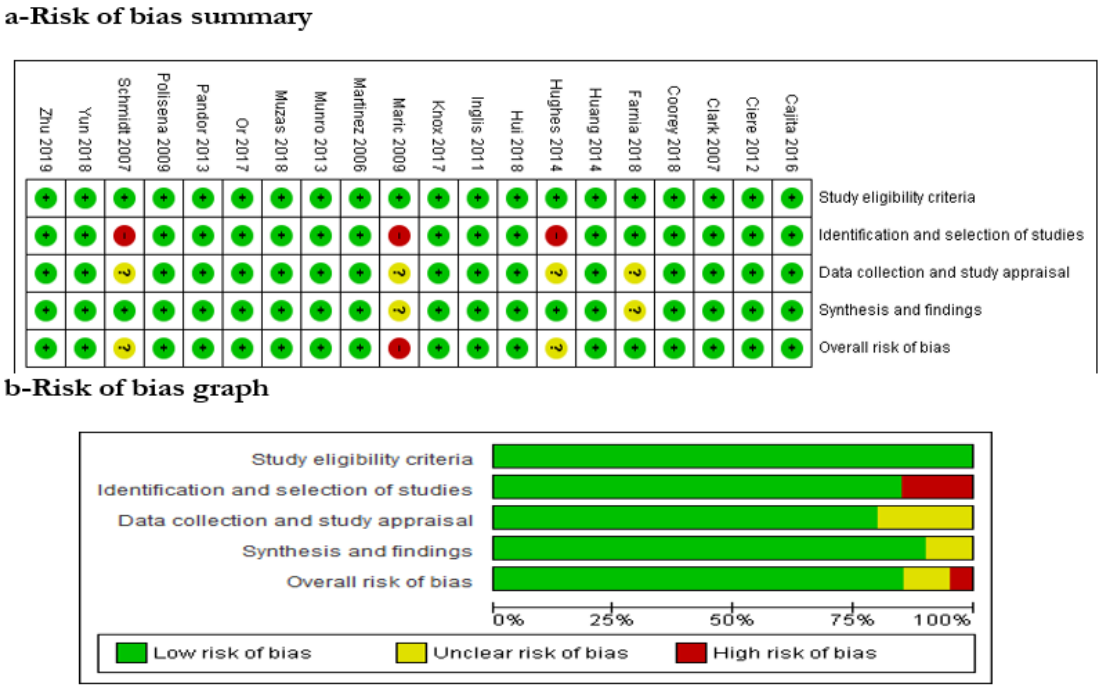

Fig. 2: Review authors' judgements about each risk of bias item presented as percentages across all included studies, a-Risk of bias summary, b-Risk of bias graph

Quality of included studies within reviews

The quality of the initial studies was investigated with the CONSORT checklist, which includes 25 items to evaluate six sections of title, abstract, introduction, cases and methods, results and discussion, and other information. Each of the articles gained number one in case of pointing to the items in the checklist, and number zero in case of non-pointing. The highest and lowest score that each article could gain was 37 to zero. Finally, 51 studies with appropriate quality were analyzed (33).

Analyses

Overall HRQOL is the sum of mental, and physical dimensions. If the results were reported in a study with two questionnaires, their results were used for comparison. If a study reported the average of the components of each dimension of a questionnaire separately, first the average of each dimension was determined and then the overall HRQOL was obtained by summing the dimensions of each questionnaire. The meta-analysis was performed separately for each dimension of HRQOL. The Q statistic, the I^2 index, and the standardized mean difference- SMD were used to evaluate the heterogeneity of the studies, and the heterogeneity was evaluated with the Q statistic (34). I^2 index was used due to its accuracy and the amount less than 50% indicates less variance between studies and a fixed-effect model was used. Otherwise, the I-V heterogeneity method was used (35). According to the different questionnaires, SMD effect size was used to aggregate using hedges g (36). Cohen's thresholds were used to interpret the effect size (37). Analyses were performed with review manager 5.3 and comprehensive meta-analysis software.

Results

Study Characteristics

Of 20 selected reviews published, 51 initial studies that measured HRQOL were selected. Details of the initial studies are listed in Table 1. A total of 12,449 people participated in 51 studies published between 2000 and 2021, of which 7,948 were men. The intervention consisted of 6,544

people with mean age 8.1±66.11 and control group consisted of 5905 people with average age 8.1±66.81. The men were 4,293 in the intervention group and 3,655 in the control group. Most of the studies 41.4% were conducted in the USA. In 41(74.5%) studies, participants had HF or CHF. In 51 studies, 58 tools were used. Most instruments that measured HRQOL were MLHFQ 22 (37.9%), SF-36 15 (25.9%), EQ-5D 8 (13.8%), SF-12 6 (10.3%), KCCQ2 (3.4%). Mac-new 2 (3.4%), GHQ1 (1.7%), QOL Heart disease1 (1.7%). QOL Darthmouth1 (1.7%).

Table 1: Basic characteristics of the included studies in the meta-analysis

First author, year	Country	Intervention	Control	follow up (mounts)	Intervention (n)	Control (n)	Disease	Type of study	Male Control (n)	Male Intervention	Question-naire
Ades,2000 (38)	USA	Home based monitoring	UC	3	83	50	CHD	No RCT	45	63	SF-36
Angermann,2012(39)	Germany	Heart net care-HNC	UC	6	352	363	HF	RCT	257	248	SF-36
Antonicelli,2008(40)	Italy	Home telemonitoring	Standard	12	28	29	CHF	RCT	19	16	SF-36
Arthur,2002(41)	Canada	Telephone monitoring	UC	6	120	122	CABG	RCT	96	101	SF-36
Artinian,2003(42)	USA	Web-based monitoring	UC	3	9	9	CHF	No RCT	-	-	MLHFQ
Barth,2001(43)	USA	Telephone calls	UC	2	17	17	CHF	RCT	6	10	MLHFQ
Benatar,2003(44)	USA	Nurse telemonitoring	UC	12	108	108	HF	RCT	41	39	MLHFQ
Blum,2014(45)	USA	Telemonitoring	UC	12	81	75	HF	RCT	54	57	MLHFQ-SF-36
Blum ,2006(46)	USA	Home telemonitoring	UC	12	64	51	HF	RCT	-	-	MLHFQ-SF-36
Boyne,2013(47)	Singapore	Telemonitoring	UC	3-6-12	197	185	HF	RCT	111	115	EQ-5D
Copeland,2010(48)	USA	Telephone support	UC	12	220	238	CHF	RCT	-	-	SF-36
Dalal,2007(49)	UK	Telephone support	UC	9	60	44	MI	RCT	35	49	Mac-new
Dar,2009(50)	UK	Telemonitoring	UC	6	91	91	HF	RCT	59	62	MLHFQ-SF-36
de Lusignan,2001(51)	UK	Home telemonitoring	UC	12	20	20	CHF	RCT			GHQ
Delaney,2013(52)	USA	Telemonitoring	UC	3	46	47	HF	RCT	14	14	MLHFQ
DeWalt,2006(53)	USA	Telephone support	UC	12	59	64	HF	RCT	26	34	MLHFQ
Dunagan, 2005 (54)	USA	Telephone support	UC	12	45	75	HF	RCT	35	31	MLHFQ-SF-12
Ferrante,2010(55)	Argentina	Telephone support	UC	36	760	758	HF	RCT	522	551	MLHFQ
Frederix,2015(56)	Belgium	Telerehabilitatio	UC	6	69	70	HF	RC	55	59	Heart

		n-SMS						T			QOL
Goldberg,2003(57)	USA	Telemonitoring	Standard	6	138	142	HF	RCT	93	96	MLHFQ-SF-12
Hagglund,2015(58)	Sweden	tablet	UC	3	32	40	HF	RCT	18	12	KCCQ
Gesica,2005(59)	Argentina	Telephone support	UC	20	760	758	HF	RCT	522	552	MLHFQ
Jerant,2003(60)	USA	Telecare	UC	2	13-12	12	HF	RCT	6	6-5	MLHFQ
Johnston,2016(7)	Sweden	Smartphone	UC	6	86	80	MI	RCT	63	71	EQ-5D
Kasper,2002(61)	USA	Telephone support	UC	6	102	98	HF	RCT	55	66	MLHFQ
Koehler,2011(62)	Germany	Telemonitoring	UC	1-3-6-9-12-24	345	356	HF	RCT	292	285	SF-36
Konstam,2011(2)	Island	Home monitoring	UC	1-3	44	44	HF	RCT	30	26	MLHFQ
Körtke,2005(63)		Telemonitoring	UC	6-12	100	70	SVD	RCT	67	90	SF-36
LaFramboise,2003(64)	Omaba	Telephone support	UC	2	26-21-20	23	HF	-	2	4-3-2	SF-36
Maddison,2019(8)	Newzeland	Telerehabilitation-remote	UC	3-6	82	80	HF	RCT	70	69	EQ-5D
Madigan,2013(65)	USA	Telemonitoring	UC	6	54	45	HF	RCT	18	24	KCCQ
Oerkild,2011(66)	Denmark	Telephone support	UC	12	36	39	CVD	RCT	26	19	SF-12
Piotrowicz,2010(67)	Poland	Home based telemonitoring	Standard	2	75	56	HF	RCT	53	64	SF-36
Piotrowicz,2015(68)	Poland	Telerehabilitation	Standard	2	75	56	HF	RCT	53	64	SF-36
Piotrowicz,2014(69)	Poland	Home based Telemonitoring	Standard	2	75	32	HF	RCT	31	64	SF-36
Ramachandran,2007(70)	India	Telephone support	UC		25	25	HF	RCT	19	20	SF-36
Reid,2012(71)	Canada	Internet based	UC	6	115	108	CVD	RCT	93	95	Macnew
Riegel,2006(3)	USA	Telephone case management	UC	1-3-6	69	65	HF	RCT	33	29	EQ-5D
Schwarz,2008(72)	USA	Telemonitoring	UC	3	51	51	HF	RCT	20	29	MLHFQ
Seto,2012(10)	USA	Mobile phone	Standard	6	50	50	HF	RCT	38	41	MLHFQ
Sisk,2006(73)	USA	Telephone support	UC	12	203	203	HF	RCT			MLHFQ-SF-12
Smith,2005(74)	USA	Telephone support	UC	1-6-12-18	356 354	359	HF	RCT	257	253 247	SF-36
Stromberg,2006(75)	Sweden	Monitoring CD Ram	Standard	6	82	72	HF	RCT	55	54	EQ-5D
Tomita,2008(76)	USA	Internet based	UC	6	16	24	HF		9	4	MLHFQ
Varnfield,2014(77)	Australia	Smartphone based	UC	6	53	41	MI	RCT	48	34	EQ-5D
Wade,2011(78)	USA	Telemonitoring	UC		164	152	HF	RCT	81	84	SF-12

Wakefield,2008(79)	USA	Telephone support	UC	3-6	45-52	49	HF	RCT	48	47-51	MLHFQ
Widmer,2015(80)	USA	Digital health intervention	UC	3	25	19	CVD		17	19	QOL Dartmouth
Woodend,2008(81)	Ontario	Telephone support	UC	1-3-12	62 62	59 66	CVD	RCT	41 52	46 48	MLHFQ
Wootton,2009 (82)	UK	Telephone support	UC	12	214	195	CHF	RCT	127	154	EQ-5D-SF-12
Zan,2015(9)	USA	Tele-Web based	UC	3	21	20	HF	-	14	15	MLHFQ

Overall QoL

Analysis of 47 studies without considering moderator analyses did not show a significant effect of telemedicine compared to normal care on overall HRQOL in CVD patients (SMD:0.02, 95% CI: -0.03, 0.06, *P*=0.42, I^2=49%) (Fig. 3).

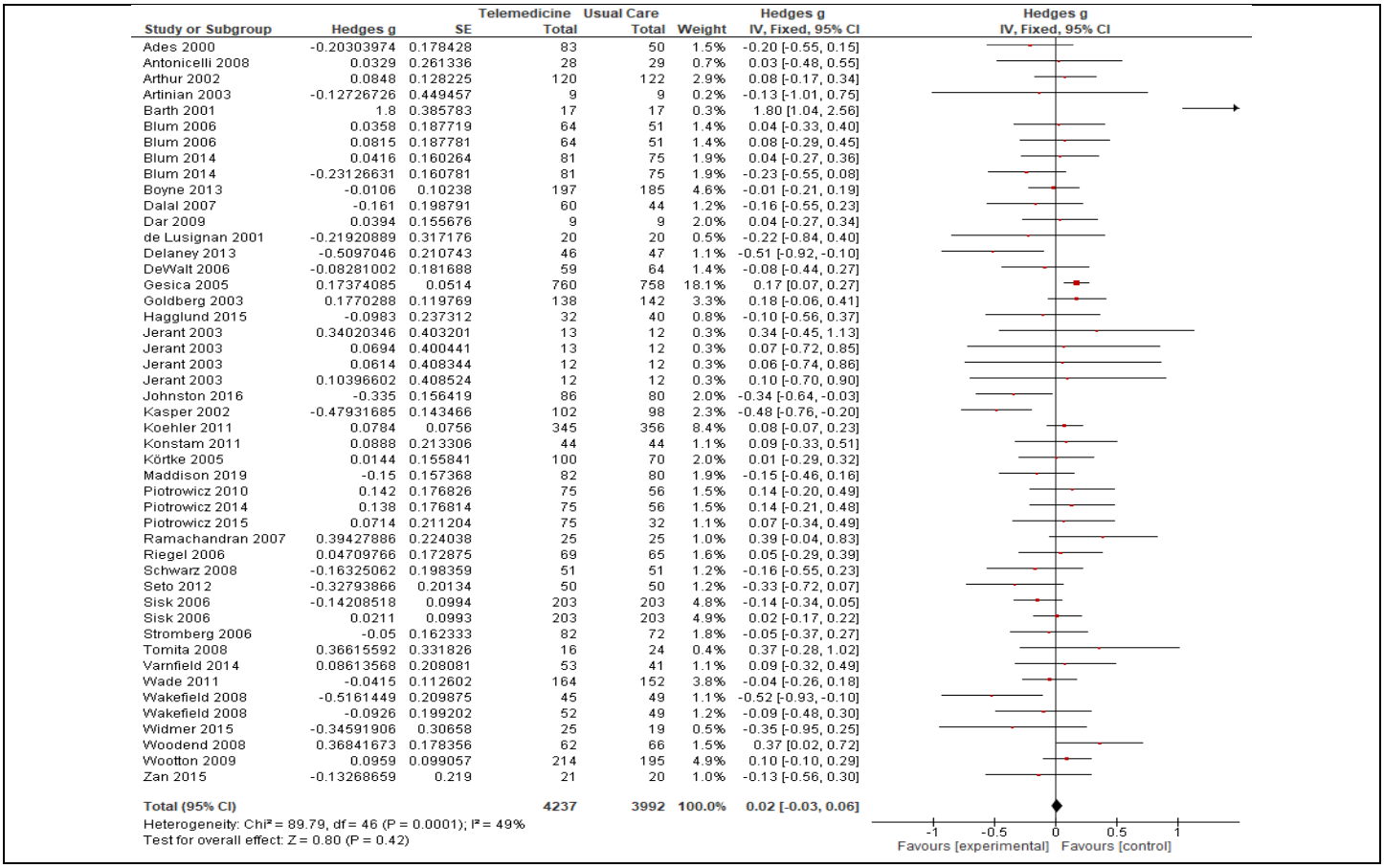

Fig. 3: Impact of telemedicine on overall HRQOL VS usual care

Mental QoL

Analysis of 35 studies without considering moderator analyses did not show a significant effect of telemedicine compared to usual care on overall mental in CVD patients (SMD: -0.05, 95% CI: -0.17,0.08, I^2=87%) (Figs. 4, 5). After the removal of two studies, Barth and Copeland (43, 48), heterogeneity decreased, but the effect of telemedicine overall mental was not significant compared to usual care (SMD: -0.05, 95% CI:-0.07,0.09, I^2=30.3%).

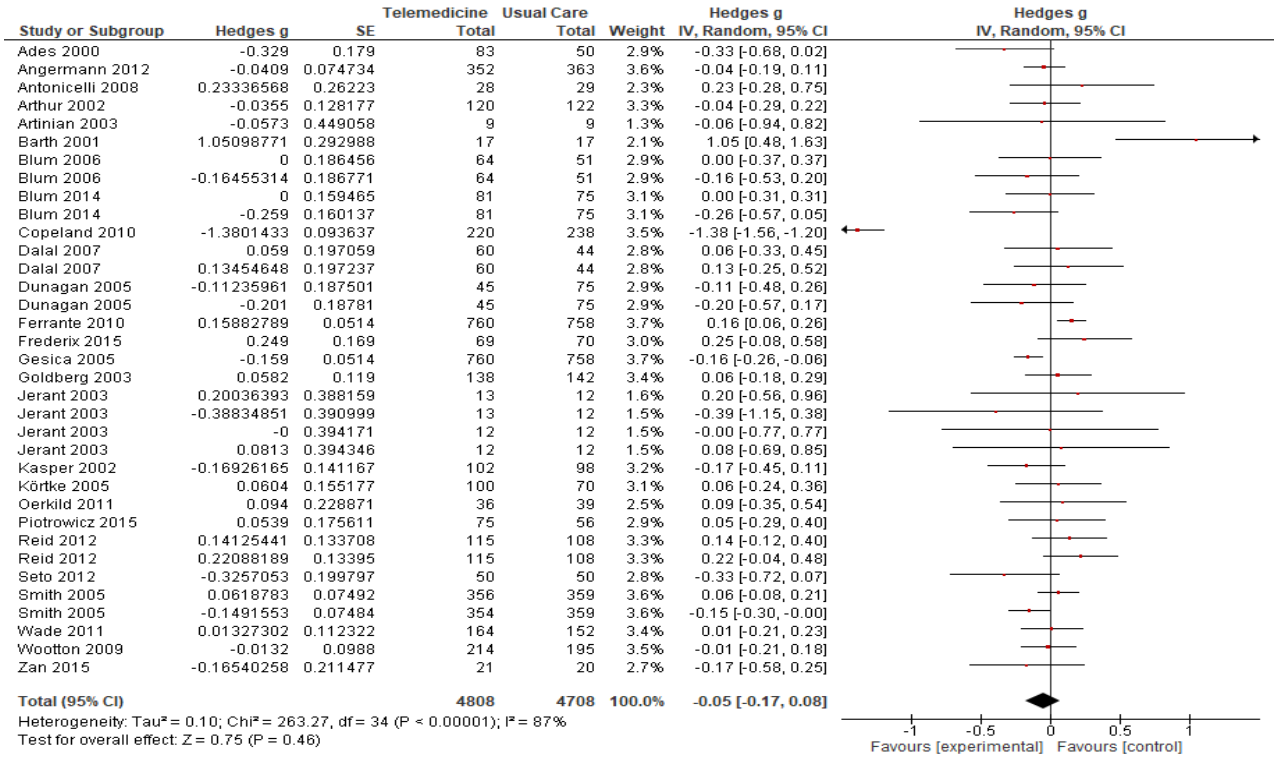

Fig. 4: Impact of telemedicine on overall mental vs usual care

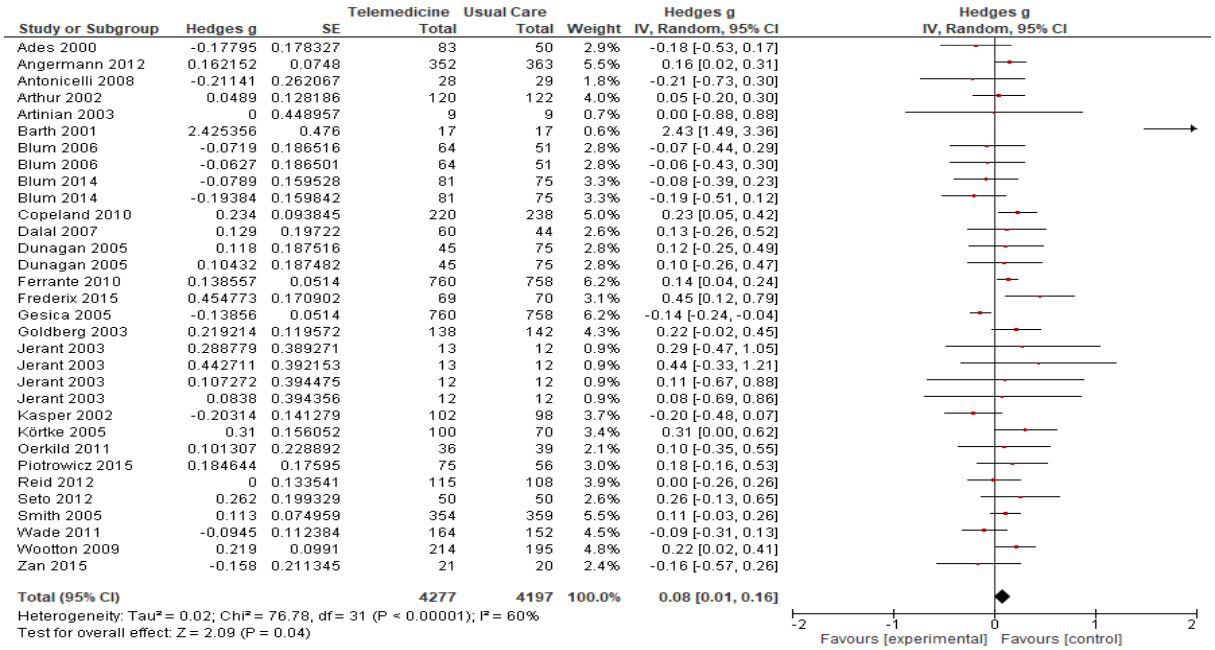

Fig. 5: Impact of telemedicine on overall physical vs usual care

Physical QoL

Analysis of 32 studies without considering moderator analyses showed a significant effect of telemedicine compared to usual care on overall physical in CVD patients (SMD: 0.08, 95% CI: 0.01, 0.16, I^2=60 %) (Fig. 4). Analysis of overall physical by separating the type of questionnaire showed that telemedicine showed a significant effect only on the aggregation of 4 studies that used the SF-12 questionnaire (SMD: 0.19, 95% CI:0.06, 0.33, I^2=0%).

Moderator analyses

The results of moderator analyses show that there was a significant positive effect on overall HRQOL compared to usual care in 14 studies with follow up 12 months or more (SMD: 0.045, df=13 *P*=0.02). Analysis of the type of intervention showed that m-health had a negative and significant effect on overall HRQOL compared to usual care (SMD: -0.33, df=1, *P*=0.01). Moderator analyses showed that telemedicine with follow up (18 months or more) had a significant positive effect on overall physical compared to usual care (SMD: 0.13, df=1, *P*=0.002) while with follow up less than 18, (SMD: 0.08, df=29, *P*=0.08), this effect was not significant. Overall physical analysis based on telemedicine type showed that telephone support has a significant positive effect on overall physical compared to usual care (SMD: 0.16, df=12, *P*=0.04) while in Net care interventions (SMD: 0.09, df=3, *P*=0.11), telemonitoring (SMD: 0.041, df=13, *P*=0.22), it was not significant compared to usual care.

Meta-regression results

Effects of mean age on the effect size of telemedicine on overall mental includes 34 studies (ß= -0.09, *P* =0.007). Therefore, it can be concluded that by increasing one unit of the average age of participants, the effect size of overall mental reduces in 34 studies (Fig. 6).

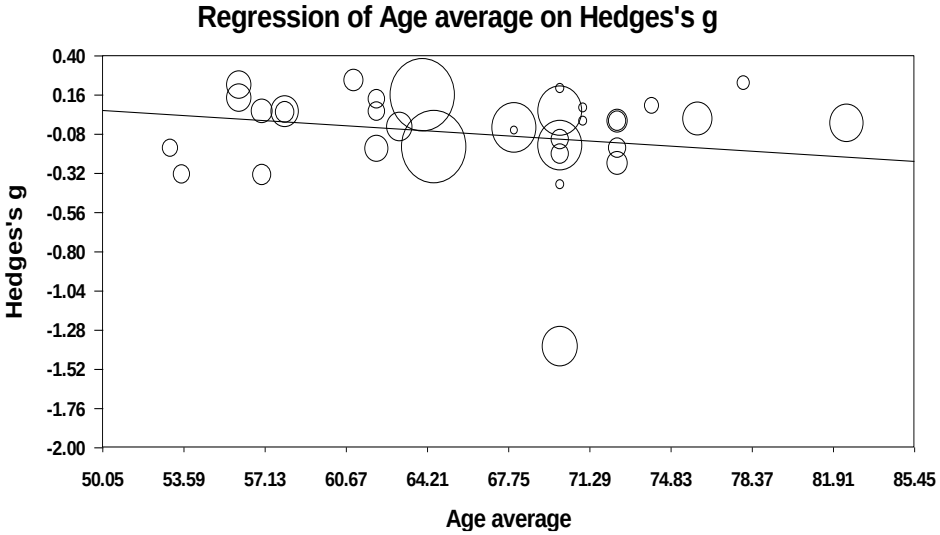

Fig. 6: Meta-regression bubble plot for the effect of age on mental

Publication bias assessment

Publication bias was examined with Egger test (overall HRQOL *P*=0.24, overall mental *P*=0.72, overall physical *P*=0.25). Moreover, graphical funnel plots were symmetrical in most zones and did not show bias (Fig. 7).

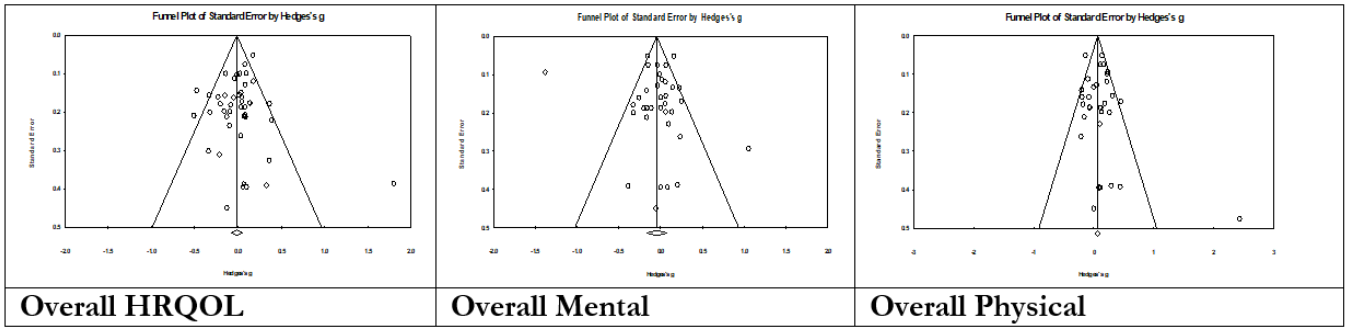

Fig. 7: Funnel plot for the estimation of publication bias. Physical and mental and overall HRQOL

Discussion

The findings revealed that telemedicine has a positive and significant effect compared to usual care in promoting physical dimension, while it does not have a significant effect on promoting overall HRQOL and mental. The previous 20 reviews reported HRQOL, of which 14 reviews reported that the effect of technology, including telemedicine, was significantly effective and positive compared to usual care on HRQOL (5, 6, 14, 16, 21, 23, 27, 28, 30, 31, 83, 84).

In this study, telemedicine had a positive effect on the physical dimension; on the other hand, increasing the duration of intervention and telephone support has increased the effect of the intervention on the physical dimension. A systematic review also showed that telephone support structure had a positive and significant effect on physical dimension and HRQOL overall (84). Telehome monitoring significantly reduced the number of hospital readmissions for patients with angina and improved quality of life and physical functioning in patients with heart failure or angina (81). It seems that the effect of telephone support on the physical dimension may be due to the continuous support provided in it, which allows early detection of complications or progress of the disease.

Moderator analyses showed that increasing duration of implementation 12 months or more, the positive effect of telemedicine on overall HRQOL is determined. By increasing the duration of implementation 18 months and more than 18 months, the positive effect of telemedicine on the physical dimension is determined. A systematic review showed that telemedicine did not have a significant effect on physical and mental health, but it significantly affects overall HRQOL. Telemedicine interventions after 52 weeks of follow-up had a greater effect on HRQOL. This effect over a long period of time could be related to more support that has created (6). While it was found that telerehabilitation did not have a significant effect on HRQOL patients 24 weeks after the intervention (8). Additional education through a computer-based program for 6 months had no significant effect on the promotion of psychological problems, but it had a positive and significant effect on overall HRQOL and the physical dimension. According to their study, factors such as gender and age of patients and cardiac condition of patients are among the factors affecting the results of the study (75). The difference in the accuracy of the tools could be a factor in the lack of effect of telemedicine on quality of life dimensions (29). It seems that the HRQOL study tool to be influential in the results of the study. The effects of home telemonitoring on SF-36 vitality subscale was significant (one month after intervention P=0.022, three months later P=0.017, and one year later P=0.009) (81). However, in Wakefield's study, this effect was not significant throughout the study (79).

In this study, meta-regression results showed that there was a significant and very strong negative relationship between overall mental and people's age. One of the most important hypotheses in this regard is technophobia in elderly patients. Older people may have used the internet or tech-

nology or a smartphone for fewer years, and this issue leads to fear and distrust of telemedicine. Therefore, the trust of older patients in online and remote counseling to improve and enhance mental conditions is not acceptable and does not implement (85). In another hypothesis, it seems that isolation and less expression of emotions are more in the aging process and this issue prevents older people to receive appropriate counseling to promote their mental dimension. On the other hand, teaching people how to use technology at older ages is less and they do not implement what they are asked to do alone and without dependence (31).

Conclusion

Among the types of telemedicine methods, telephone support has a greater effect on promoting the physical dimension. Telemedicine can provide close monitoring on the status of cardiac patients. It is effective in improving physiological conditions, but better planning is important based on the age of the patients to improve the mental status of patients. One of the limitations of the study was that in the initial studies, the living place of the people in terms of geography, rural and urban and the level of access to advanced care was not specified. This mediator seems to play an important role in changing outcomes because the main purpose of telerehabilitation is to provide treatment care in areas with low access levels. Therefore, it is recommended that initial studies report these cases when recording data.

Data Availability

The data used to support the findings of this study are included within the study and supplementary file.

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.

Acknowledgements

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Abbreviation words and full phrases	
CVD	Cardio Vascular Disease
CR	Cardiac Rehabilitation
CHD	Coronary Heart Disease
HF	Heart Failure
CABG	Coronary Artery Bypass Surgery
MI	Myocardial Infarction
CHF	Congestive Heart Failure
HRQL	Health-Related Quality of Life
MLHFQ	Minnesota Living with Heart Failure Questionnaire
SF-36	36-Item Short Form Health Survey
SF-12	12-Item Short Form Survey
EQ-5D	Euro Quality of Life Five-Dimensional
KCCQ	Kansas City Cardiomyopathy Questionnaire
GHQ	General Health Questionnaire
AMSTAR	Measurement Tool to Assess Reviews
ROBIS	Risk of Bias in Systematic Reviews
RCT	Randomized Clinical Trial
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
MeSH	Medical Subject Headings
CONSORT	Consolidated Standards of Reporting Trials
PICO	Population, Intervention, Comparison, and Outcome
SMD	Standardized Mean Difference
ES	Effect Size
CIs	Confidence Intervals
CMA	Comprehensive Meta-Analysis Software
Mhealth	Mobile health
MWBT	Mobile Web-Based Telemonitoring
MPBT	Mobile Phone-Based Telemonitoring

References

1. Joseph P, Leong D, Mckee M, et al (2017). Reducing the global burden of cardiovascular disease, part 1: the epidemiology and risk factors. *Circ Res,* 121(6):677-694.
2. Konstam V, Gregory D, Chen J, et al (2011). Health-related quality of life in a multicenter randomized controlled comparison of telephonic disease management and automated home monitoring in patients recently hospitalized with heart failure: SPAN-CHF II trial. *J Card Fail,* 17:151-7.
3. Riegel B, Carlson B, Glaser D, Romero T (2006). Randomized controlled trial of telephone case management in Hispanics of Mexican origin with heart failure. *J Card Fail,* 12(3):211-219.
4. Beatty AL, Fukuoka Y, Whooley MA (2013). Using mobile technology for cardiac rehabilitation: a review and framework for development and evaluation. *J Am Heart Assoc,* 2(6):e000568-e000568.
5. Inglis SC, Clark RA, McAlister FA, Stewart S, Cleland JG (2011). Which components of heart failure programmes are effective? A systematic review and meta-analysis of the outcomes of structured telephone support or telemonitoring as the primary component of chronic heart failure management in 8323 patients: abridged Cochrane Review. *Eur J Heart Fail,* 13(9):1028-1040.
6. Knox L, Rahman RJ, Beedie C (2017). Quality of life in patients receiving telemedicine enhanced chronic heart failure disease management: A meta-analysis. *J Telemed Telecare,* 23(7):639-649.
7. Johnston N, Bodegard J, Jerstrom S, et al (2016). Effects of interactive patient smartphone support app on drug adherence and lifestyle changes in myocardial infarction patients: A randomized study. *Am Heart J,* 178:85-94.
8. Maddison R, Rawstorn JC, Stewart RAH, et al (2019). Effects and costs of real-time cardiac telerehabilitation: randomised controlled non-inferiority trial. *Heart,* 105(2):122-129.
9. Zan S, Agboola S, Moore SA, Parks KA, Kvedar JC, Jethwani K (2015). Patient Engagement With a Mobile Web-Based Telemonitoring System for Heart Failure Self-Management: A Pilot Study. *JMIR Mhealth Uhealth,* 3(2):e33.
10. Seto E (2008). Cost comparison between telemonitoring and usual care of heart failure: a systematic review. *Telemed J E Health,* 14(7):679-686.
11. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med,* 6(7):e1000097.
12. Lunny C, Brennan SE, McDonald S, McKenzie

JE (2017). Toward a comprehensive evidence map of overview of systematic review methods: paper 1—purpose, eligibility, search and data extraction. *Systematic Reviews,* 6:231.
13. Lunny C, Brennan SE, McDonald S, McKenzie JE (2018). Toward a comprehensive evidence map of overview of systematic review methods: paper 2—risk of bias assessment; synthesis, presentation and summary of the findings; and assessment of the certainty of the evidence. *Syst Rev,* 7:159.
14. Cajita MI, Gleason KT, Han HR (2016). A Systematic Review of mHealth-Based Heart Failure Interventions. *J Cardiovasc Nurs,* 31(3):E10-22.
15. Ciere Y, Cartwright M, Newman SP (2012). A systematic review of the mediating role of knowledge, self-efficacy and self-care behaviour in telehealth patients with heart failure. *J Telemed Telecare,* 18(7):384-391.
16. Clark RA, Inglis SC, McAlister FA, Cleland JGF, Stewart S (2007). Telemonitoring or structured telephone support programmes for patients with chronic heart failure: systematic review and meta-analysis. *BMJ,* 334(7600):942.
17. Coorey GM, Neubeck L, Mulley J, Redfern J (2018). Effectiveness, acceptability and usefulness of mobile applications for cardiovascular disease self-management: Systematic review with meta-synthesis of quantitative and qualitative data. *Eur J Prev Cardiol,* 25:505-521.
18. Farnia T, Jaulent MC, Steichen O (2018). Evaluation Criteria of Noninvasive Telemonitoring for Patients With Heart Failure: Systematic Review. *J Med Internet Res,* 20(1):e16.
19. Huang K, Liu W, He D, et al (2015). Telehealth interventions versus center-based cardiac rehabilitation of coronary artery disease: A systematic review and meta-analysis. *Eur J Prev Cardiol,* 22(8):959-971.
20. Hughes HA, Granger BB (2014). Racial disparities and the use of technology for self-management in blacks with heart failure: a literature review. *Curr Heart Fail Rep,* 11(3):281-289.
21. Hui L, Xiao X, Chun-Mei L, et al (2018). A systematic review of the effect of mobile health on cardiac rehabilitation among coronary heart disease patients. *Fronti Nursi* , 5:217-226.
22. Maric B, Kaan A, Ignaszewski A, Lear SA (2009). A systematic review of telemonitoring technologies in heart failure. *Eur J Heart Fail,* 11(5):506-17.
23. Martinez A, Everss E, Rojo-Alvarez JL, et al (2006). A systematic review of the literature on home monitoring for patients with heart failure. *J Telemed Telecare,* 12(5):234-41.
24. Munro J, Angus N, Leslie SJ (2013). Patient focused internet-based approaches to cardiovascular rehabilitation–a systematic review. *J Telemed Telecare,* 19(6):347-353.
25. Muzas Fernández A, Soto González M (2018). Utilización de smartphone en los programas de rehabilitación cardíaca. Una revisión sistemática. *Rehabil,* 52:238-245.
26. Or CK, Tao D, Wang H (2017). The effectiveness of the use of consumer health information technology in patients with heart failure: a meta-analysis and narrative review of randomized controlled trials. *J Telemed Telecare,* 23:155-166.
27. Pandor A, Gomersall T, Stevens JW, et al (2013). Remote monitoring after recent hospital discharge in patients with heart failure: a systematic review and network meta-analysis. *Heart,* 99(23):1717-26.
28. Polisena J, Tran K, Cimon K, et al (2010). Home telemonitoring for congestive heart failure: a systematic review and meta-analysis. *J Telemed Telecare,* 16(2):68-76.
29. Schmidt S (2007). Telemedizin und Lebensqualität. *DMW,* 132:442-447.
30. Yun JE, Park JE, Park HY, Lee HY, Park DA (2018). Comparative effectiveness of telemonitoring versus usual care for heart failure: a systematic review and meta-analysis. *J Card Fail,* 24(1):19-28.
31. Zhu Y, Gu X, Xu C (2020). Effectiveness of telemedicine systems for adults with heart failure: a meta-analysis of randomized controlled trials. *Heart Fail Rev*, 25(2):231-243.
32. Whiting P, Savović J, Higgins JP, et al (2016). ROBIS: a new tool to assess risk of bias in systematic reviews was developed. *J Clin Epidemiol,* 69:225-234.
33. Moher D, Schulz KF, Altman D, Group C (2005). The CONSORT Statement: revised recommendations for improving the quality

of reports of parallel-group randomized trials 2001. *Explore (NY)* ,1(1):40-45.
34. Cochran WG (1954). The combination of estimates from different experiments. *Biometrics,* 10:101-129.
35. Higgins JP, Thompson SG (2002). Quantifying heterogeneity in a meta-analysis. *Stat Med,* 21(11):1539-1558.
36. Hedges L, Olkins I (1985) *Statistical methods for meta-analysis*. 1st ed. Orlando, Elsevier Science.
37. Cohen J (2013). *Statistical power analysis for the behavioral sciences*. Routledge.
38. Ades PA, Pashkow FJ, Fletcher G, Pina IL, Zohman LR, Nestor JR (2000). A controlled trial of cardiac rehabilitation in the home setting using electrocardiographic and voice transtelephonic monitoring. *Am Heart J,* 139(3):543-8.
39. Angermann CE, Stork S, Gelbrich G, et al (2012). Mode of action and effects of standardized collaborative disease management on mortality and morbidity in patients with systolic heart failure: the Interdisciplinary Network for Heart Failure (INH) study. *Circ Heart Fail,* 5:25-35.
40. Antonicelli R, Testarmata P, Spazzafumo L, et al (2008). Impact of telemonitoring at home on the management of elderly patients with congestive heart failure. *J Telemed Telecare,* 14(6):300-305.
41. Arthur HM, Smith KM, Kodis J, McKelvie R (2002). A controlled trial of hospital versus home-based exercise in cardiac patients. *Med Sci Sports Exerc,* 34(10):1544-50.
42. Artinian NT, Harden JK, Kronenberg MW, et al (2003). Pilot study of a Web-based compliance monitoring device for patients with congestive heart failure. *Heart Lung,* 32(4):226-33.
43. Barth V (2001). A nurse-managed discharge program for congestive heart failure patients: outcomes and costs. *Home Health Care Manag Pract,* 13:436-443.
44. Benatar D, Bondmass M, Ghitelman J, Avitall B (2003). Outcomes of chronic heart failure. *Arch Intern Med,* 163(3):347-52.
45. Blum K, Gottlieb SS (2014). The effect of a randomized trial of home telemonitoring on medical costs, 30-day readmissions, mortality, and health-related quality of life in a cohort of community-dwelling heart failure patients. *J Card Fail,* 20(7):513-21.
46. Blum K, Janowick F, Gottlieb S (2006). One year changes in quality of life for heart failure patients in a home telemonitoring program (abstract). *J Cardiac Fail*,12:S122.
47. Boyne JJ, Van Asselt AD, Gorgels AP, et al (2013). Cost-effectiveness analysis of telemonitoring versus usual care in patients with heart failure: the TEHAF-study. *J Telemed Telecare,* 19(5):242-8.
48. Copeland LA, Berg GD, Johnson DM, Bauer RL (2010). An intervention for VA patients with congestive heart failure. *Am J Manag Care,* 16(3):158-65.
49. Dalal HM, Evans PH, Campbell JL,et al (2007). Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms--Cornwall Heart Attack Rehabilitation Management Study (CHARMS). *Int J Cardiol,* 119:202-11.
50. Dar O, Riley J, Chapman C, Dubrey SW, et al (2009). A randomized trial of home telemonitoring in a typical elderly heart failure population in North West London: results of the Home-HF study. *Eur J Heart Fail,* 11(3):319-25.
51. de Lusignan S, Wells S, Johnson P, Meredith K, Leatham E (2001). Compliance and effectiveness of 1 year's home telemonitoring. The report of a pilot study of patients with chronic heart failure. *Eur J Heart Fail,* 3(6):723-730.
52. Delaney C, Apostolidis B, Bartos S, Morrison H, Smith L, Fortinsky R (2013). A Randomized Trial of Telemonitoring and Self-Care Education in Heart Failure Patients Following Home Care Discharge. *Home Health Care Manag Pract,* 25:187-195.
53. DeWalt DA, Malone RM, Bryant ME, et al (2006). A heart failure self-management program for patients of all literacy levels: a randomized, controlled trial [ISRCTN11535170]. *BMC Health Serv Res,* 6:30.
54. Dunagan WC, Littenberg B, Ewald GA, et al (2005). Randomized trial of a nurse-administered, telephone-based disease management program for patients with heart failure. *J Card Fail,* 11(5):358-65.
55. Ferrante D, Varini S, Macchia A, et al (2010).

Long-term results after a telephone intervention in chronic heart failure: DIAL (Randomized Trial of Phone Intervention in Chronic Heart Failure) follow-up. *J Am Coll Cardiol,* 56(5):372-8.

56. Frederix I, Hansen D, Coninx K, et al (2015). Medium-Term Effectiveness of a Comprehensive Internet-Based and Patient-Specific Telerehabilitation Program With Text Messaging Support for Cardiac Patients: Randomized Controlled Trial. *J Med Internet Res,* 17(7):e185.
57. Goldberg LR, Piette JD, Walsh MN, et al (2003). Randomized trial of a daily electronic home monitoring system in patients with advanced heart failure: the Weight Monitoring in Heart Failure (WHARF) trial. *Am Heart J,* 146:705-12.
58. Hagglund E, Lynga P, Frie F, Ullman B, Persson H, Melin M, Hagerman I (2015). Patient-centred home-based management of heart failure. Findings from a randomised clinical trial evaluating a tablet computer for self-care, quality of life and effects on knowledge. *Scand Cardiovasc J,* 49(4):193-9.
59. Investigators G (2005). Randomised trial of telephone intervention in chronic heart failure: DIAL trial. *BMJ,* 331(7514):425.
60. Jerant AF, Azari R, Martinez C, Nesbitt TS (2003). A randomized trial of telenursing to reduce hospitalization for heart failure: patient-centered outcomes and nursing indicators. *Home Health Care Serv Q,* 22(1):1-20.
61. Kasper EK, Gerstenblith G, Hefter G, et al (2002). A randomized trial of the efficacy of multidisciplinary care in heart failure outpatients at high risk of hospital readmission. *J Am Coll Cardiol,* 39(3):471-80.
62. Koehler F, Winkler S, Schieber M, et al (2011). Impact of remote telemedical management on mortality and hospitalizations in ambulatory patients with chronic heart failure: the telemedical interventional monitoring in heart failure study. *Circulation,* 123:1873-80.
63. Körtke H, Zittermann A, El-Arousy M, Zimmermann E, Wienecke E, Körfer R (2005). Neues Ostwestfälisches Postoperatives Therapiekonzept (NOPT). *Med Klin,* 100:383-389.
64. LaFramboise LM, Todero CM, Zimmerman L, Agrawal S (2003). Comparison of Health Buddy with traditional approaches to heart failure management. *Fam Community Health,* 26(4):275-88.
65. Madigan E, Schmotzer BJ, Struk CJ, et al (2013). Home health care with telemonitoring improves health status for older adults with heart failure. *Home Health Care Serv Q,* 32(1):57-74.
66. Oerkild B, Frederiksen M, Hansen JF, Simonsen L, Skovgaard LT, Prescott E (2011). Home-based cardiac rehabilitation is as effective as centre-based cardiac rehabilitation among elderly with coronary heart disease: results from a randomised clinical trial. *Age Ageing,* 40(1):78-85.
67. Piotrowicz E, Baranowski R, Bilinska M, et al (2010). A new model of home-based telemonitored cardiac rehabilitation in patients with heart failure: effectiveness, quality of life, and adherence. *Eur J Heart Fail,* 12(2):164-71.
68. Piotrowicz E, Stepnowska M, Leszczynska-Iwanicka K,et al (2015). Quality of life in heart failure patients undergoing home-based telerehabilitation versus outpatient rehabilitation--a randomized controlled study. *Eur J Cardiovasc Nurs,* 14(3):256-63.
69. Piotrowicz E, Zieliński T, Bodalski R, et al (2015). Home-based telemonitored Nordic walking training is well accepted, safe, effective and has high adherence among heart failure patients, including those with cardiovascular implantable electronic devices: a randomised controlled study. *Eur J Prev Cardiol,* 22(11):1368-1377.
70. Ramachandran K, Husain N, Maikhuri R, et al (2007). Impact of a comprehensive telephone-based disease management programme on quality-of-life in patients with heart failure. *Natl Med J India,* 20(2):67-73.
71. Reid RD, Morrin LI, Beaton LJ, et al (2012). Randomized trial of an internet-based computer-tailored expert system for physical activity in patients with heart disease. *Eur J Prev Cardiol,* 19(6):1357-64.
72. Schwarz KA, Mion LC, Hudock D, Litman G (2008). Telemonitoring of heart failure patients and their caregivers: a pilot randomized controlled trial. *Prog Cardiovasc Nurs,* 23(1):18-26.

73. Sisk JE, Hebert PL, Horowitz CR, McLaughlin MA, Wang JJ, Chassin MR (2006). Effects of nurse management on the quality of heart failure care in minority communities: a randomized trial. *Ann Intern Med,* 145(4):273-83.
74. Smith AC (2013). Effect of telemonitoring on re-admission in patients with congestive heart failure. *Medsurg Nurs,* 22(1):39-44.
75. Stromberg A, Dahlstrom U, Fridlund B (2006). Computer-based education for patients with chronic heart failure. A randomised, controlled, multicentre trial of the effects on knowledge, compliance and quality of life. *Patient Educ Couns,* 64(1-3):128-35.
76. Tomita MR, Tsai B-M, Fisher NM, et al (2008). Effects of multidisciplinary Internet-based program on management of heart failure.*J Multidiscip Healthc,* 2009(2):13-21.
77. Varnfield M, Karunanithi M, Lee C-K, et al (2014). Smartphone-based home care model improved use of cardiac rehabilitation in postmyocardial infarction patients: results from a randomised controlled trial. *Heart,* 100(22):1770-1779.
78. Wade V, Stocks N (2017). The Use of Telehealth to Reduce Inequalities in Cardiovascular Outcomes in Australia and New Zealand: A Critical Review. *Heart Lung Circ,* 26(4):331-337.
79. Wakefield BJ, Ward MM, Holman JE, et al (2008). Evaluation of home telehealth following hospitalization for heart failure: a randomized trial. *Telemed J E Health,* 14(8):753-761.
80. Widmer RJ, Allison TG, Lerman LO, Lerman A (2015). Digital Health Intervention as an Adjunct to Cardiac Rehabilitation Reduces Cardiovascular Risk Factors and Rehospitalizations. *J Cardiovasc Transl Res,* 8(5):283-92.
81. Woodend AK, Sherrard H, Fraser M, et al (2008). Telehome monitoring in patients with cardiac disease who are at high risk of readmission. *Heart Lung,* 37(1):36-45.
82. Wootton R, Gramotnev H, Hailey D (2009). A randomized controlled trial of telephone-supported care coordination in patients with congestive heart failure. *J Telemed Telecare,* 15(4):182-6.
83. Marin TS, Kourbelis C, Foote J, et al (2019). Examining adherence to activity monitoring devices to improve physical activity in adults with cardiovascular disease: A systematic review. *Eur J Prev Cardiol*, 26(4):382-97.
84. Pandor A, Thokala P, Gomersall T, et al (2013). Home telemonitoring or structured telephone support programmes after recent discharge in patients with heart failure: systematic review and economic evaluation. *Health Technol Assess,* 17(32):1-207.
85. Nimrod G (2018). Technophobia among older Internet users. *Educ Gerontol,* 44:148-162.