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Cardiovascular telerehabilitation improves functional capacity, cardiorespiratory fitness and quality of life in older adults: A systematic review and meta-analysis

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Abstract

Introduction: The aim was to identify whether cardiovascular telerehabilitation programs (CV-T-REHAB) can improve functional capacity, cardiorespiratory fitness and quality of life (QoL) to the same extent of presential rehabilitation (CV-P-REHAB) in older adults, by meta-analysis of previous studies.

Methods: Literature search was conducted in October 2020 in four databases to select controlled trials of CV-T-REHAB effects on functional capacity (six-minute walk test [6MWT]), cardiorespiratory fitness (maximal oxygen consumption [$\dot{V}O_{2max}$]), and QoL in older adults (> 50 years) and included new articles in April 2022.

Results: CV-T-REHAB improved 6MWT (11.14 m [CI95% = 8.03; 14.26], $p < 0.001$), $\dot{V}O_{2max}$ (1.18 ml/kg/min [CI95% = 0.70; 1.66], $p < 0.001$), and QoL (standardized mean difference [SMD] = 0.36 [CI95% = 0.05; 0.67], $p = 0.02$). CV-T-REHAB increased $\dot{V}O_{2max}$ to a greater extent than CV-P-REHAB (1.08 ml/kg/min [0.39; 1.76], $p = 0.002$). Although the 6MWT and $\dot{V}O_{2max}$ analyses proved consistent and homogeneous, the QoL analysis showed considerable inconsistency ($I^2 = 92.90\%$), suggesting the need for studies exploring the effect of CV-T-REHAB on QoL in this population. Part of the heterogeneity was explained by age differences, as CV-T-REHAB improved QoL in adults >65 years, but not in adults <64 years.

Conclusion: CV-T-REHAB improved cardiorespiratory fitness to a level equal to or higher than CV-P-REHAB and improved functional capacity and QoL; being mainly effective for QoL in older adults >65 years. Thus, CV-T-REHAB can be a good alternative, when not the best option and might be considered especially for individuals with limited access to participate in face-to-face programs.

Keywords

Telerehabilitation, cardiac rehabilitation, exercise therapy, physical and rehabilitation medicine, quality of life, physical fitness

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Introduction

Cardiovascular diseases have been the main cause of death in the world[1] and rehabilitation to treat patients previously hospitalized for cardiovascular events, such as coronary revascularization, percutaneous angioplasty, aortocoronary bypass, patients diagnosed with atherosclerosis, angina pectoris, myocardial infarction, and hypertension has been recommended by European and North American institutions.[2–6] In 1998, the first scientific article on telerehabilitation was published and in recent years, the number of articles on the subject has increased, primarily due to the emerging needs of patients and the development of new information and communication technologies.[7,8]

Cardiovascular rehabilitation is an essential component of secondary prevention, multifaceted interventions designed to

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improve physical and social functioning.[2] On the other hand, mobility restrictions and financial constraints for patients to move to a rehabilitation centre, have been the main limitations for maintaining CV-REHAB.[9] In addition, the obligation of social isolation caused by the recent Coronavirus pandemic, made some CV-REHAB programs impossible to be maintained and underscored the urgent need for virtual assistance.[10]

In this way, cardiovascular telerehabilitation (CV-T-REHAB) came up as an alternative to presential cardiovascular rehabilitation (CV-P-REHAB).[11] CV-T-REHAB allows contact between the health care professional, usually physical therapists, and patients from different places, connecting in real-time by electronic devices.[12] Despite some evidence of functional capacity and quality of life (QoL) improvements with CV-T-REHAB,[13–15] some studies failed to show progresses in some of the same outcomes.[16–18] The lack of consensus between studies may primarily be caused by comparison against non-rehabilitation or CV-P-REHAB groups since CV-T-REHAB certainly would be better than no intervention but doubly better than CV-P-REHAB.[19] Also, CV-T-REHAB could be more efficient for physical outcomes rather than psychological or social improvements that would be benefited by human interactions; however, this hypothesis remains unproved.[20] In fact, while a few studies have shown improvements from CV-T-REHAB in cardiorespiratory fitness even when compared to the CV-P-REHAB, some failed to show CV-T-REHAB benefits on QoL even when they were compared to non-rehabilitation control group. Differences in the characteristics of population, interventions and outcomes could determine heterogeneity between studies[18] and need to be properly tested by meta-analysis.

Thus, the present study aims to meta-analyse previous studies in the literature to identify the true effects of CV-T-REHAB when compared to CV-P-REHAB or control group (without rehabilitation) on cardiorespiratory fitness and QoL. The results of this study will be fundamental in designing future cardiovascular rehabilitation programs that will likely take place soon, allowing more patients to maintain their good health and QoL.

Methods

This systematic review was reported according to the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).

Protocol and registration

The systematic review was submitted to PROSPERO under registration CRD42021250513.

Eligibility criteria

The items of PICOS inclusion criteria were adults (>18 years old) of both sex with any cardiopathy; intervention with a cardiovascular telerehabilitation program; compared to in-person cardiovascular rehabilitation or compared to a no-intervention group; assessing as outcomes the functional capacity by the 6-min walking test (6MWT), the maximum oxygen consumption in a progressive effort test ($\dot{V}O_{2max}$), and QoL; within longitudinal controlled trials. No date of publication restriction was applied.

Exclusion criteria

Reviews, letters to the editor, case studies, and studies describing methodological protocols without results were excluded. Studies not written in the English language were excluded. Studies that did not have telerehabilitation and studies that did not measure the proposed outcomes, such as functional capacity, cardiorespiratory fitness and quality of life (QoL), were also excluded.

Information sources

The search was performed on MEDLINE/PubMed, Web of Science, Scopus and Cochrane, with the last update in October 2020 and new studies in April 2022.

Search

The combination of synonyms for telerehabilitation, cardiac rehabilitation, virtual rehabilitation, QoL, physical fitness, the targeted outcomes and control trial terms were combined as described in the Supplemental material.

Study selection

Two independent researchers screened the studies according to the protocol description, the conflicts were identified by an automated spreadsheet equation, and they were solved by a third reviewer.

Data collection process

Two independent reviewers extracted data from the studies and analysed the mean and standard deviation (SD) of 6MWT, $\dot{V}O_{2max}$ and QoL before and after the intervention and control period. The sample number (n) of both groups (intervention and control) were also used for the main meta-analyses. In addition to the main data, secondary data were collected to characterize the study and for further analysis. The characteristics of population (sex, age), intervention (type of training, duration of intervention, type of control group) and QoL outcomes (type of test) were grouped for further subgroup analysis.

Data items

We extracted the following categorical variables for subgroup analysis: sex (men or women), age (<64 years or >65 years), comorbidity (Arterial Hypertension, Coronary artery disease or Heart failure), type of control (CV-P-REHAB or no intervention), type of QoL questionnaires (Short Form 36 [SF-36]; EuroQol 5 Dimensions [EQ5D]; Minnesota Living With Heart Failure Questionnaire [MLHFQ]; Health Disease Health-Related Quality of Life Questionnaire [MacNew]; Health-Related Quality of Life Questionnaire [HRQol]; Dartmouth COOP Functional Health Assessment charts/ WONCA [Dartmouth QoL]) type of exercise (aerobic training [AT] or combined training [CT]), and duration of intervention (≤9wk, 12–24wk or ≥24wk).

Risk of bias in individual studies

The PEDro scale was used to identify the quality of primary studies, according to the description of methodological information and the results of each study.[21]

Statistical analysis

The three meta-analyses, testing the effects of cardiovascular telerehabilitation on (1) functional capacity (6MWT), (2) cardiorespiratory fitness ($\dot{V}$O2max) and (3) QoL in older adults (>50 years) were performed using the Comprehensive Meta-Analysis (CMA) software, version 3.3.070. The effect size was calculated based on the standard mean difference (SMD: the difference between changes

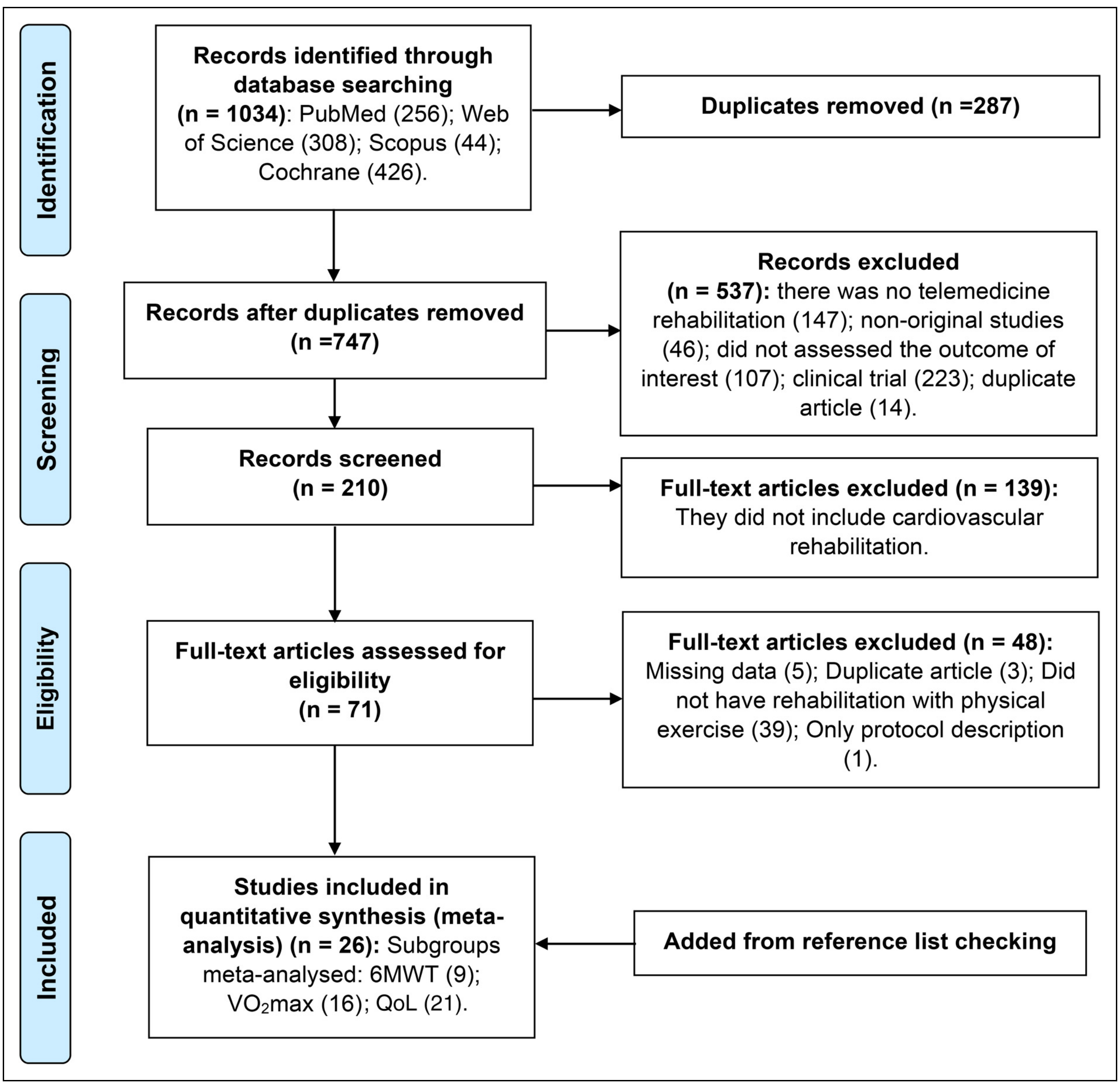

Figure 1. Study selection flowchart.

Table 1. Characteristics of the studies included.

First author, year	Condition	*N* and sex [CG]	Age (years) mean ± SD [CG]	Type of exercise	Weekly frequency	Duration of intervention	Type of control	Outcomes (assessments)
Piotrowicz et al., 2020	HF	417 B [416, B]	62.6 ± 10.8 [62.2 ± 10.2]	CT	5d	9wk	CV-P-REHAB	6MWT, $\dot{V}O_{2max}$
Batalik et al., 2020	CAD	25 M [26, M]	56.5 ± 6.9 [57.7 ± 7.6]	AT	3d	12wk	CV-P-REHAB	SF-36, $\dot{V}O_{2max}$
Claes et al., 2020	CAD	120 B [120, B]	61.7 ± 14.5 [59.6 ± 13.2]	AT	4-5d	24wk	CV-P-REHAB	SF-36, $\dot{V}O_{2max}$
Avila et al., 2020	CAD	26 B [29, B]	62.2 ± 7.1 [62.0 ± 7.4]	AT	3d	12wk	CV-P-REHAB	$\dot{V}O_{2max}$
Maddison et al., 2019	CAD	82 B [80, B]	61 ± 13.2 [61.5 ± 12.2]	AT	3d	12wk/24wk	CV-P-REHAB	EQ-5D, $\dot{V}O_{2max}$
Fang et al., 2019	CAD	33 B [34, B]	60.24 ± 9.351 [61.41 ± 10.169]	AT	3d	6wk	No intervention	6MWT
Avila et al., 2018	CAD	28 B [30, B]	58.6 ± 13 [61.9 ± 7.3]	AT	6-7d	12wk	CV-P-REHAB	SF-36, $\dot{V}O_{2max}$
Peng et al., 2018	CAD	98 B [98, B]	Overall: 66.3 ± 10.50	AT	3–5d	8wk	No intervention	MLHFQ, 6MWT
Bernocchi et al., 2018	HF	56 M [56, M]	71 ± 9 [42 ± 9.5]	CT	3–7d	16wk	No intervention	MLHFQ, 6MWT
Pinto et al., 2013	CAD	64 B [66, B]	62.9 ± 9.3 [64.3 ± 10.0]	AT	3d	48wk	No intervention	MacNew
Frederix et al., 2017	CAD	62 B [64, B]	61 ± 9 [61 ± 8]	AT	3d	24wk	CV-P-REHAB	HRQoL, $\dot{V}O_{2max}$
Bravo-Escobar et al., 2017	CAD	14 M [14, M]	56.50 ± 6.01 [55.64 ± 11,35]	AT	5–7d	8wk	CV-P-REHAB	SF-36
Skobel et al., 2017	CAD	19 B [42, B]	60 ± 50.65 [C: 58 ± 52.67]	CT	2-3d	24wk	No intervention	EQ-5D, $\dot{V}O_{2max}$
Kraal et al., 2017	CAD	45 B [45, B]	60.5 ± 8.8 [57.7 ± 8.7]	AT	2d	12wk	CV-P-REHAB	HRQoL, $\dot{V}O_{2max}$
Hwang et al., 2017	HF	24 B [29, B]	68 ± 14 [67 ± 11]	AT	3d	12wk	CV-P-REHAB	MLHFQ, 6MWT
Piotrowicz et al., 2015	HF	75 B [32, B]	54.4 ± 10.9 [62.1 ± 1.,5]	AT	5d	8wk	No intervention	SF-36, 6MWT
Piotrowicz et al., 2015	HF	75 B [56, B]	56.4 ± 10.9 [60.5 ± 8.8]	AT	3d	12wk	CV-P-REHAB	SF-36
Kraal et al., 2014	HF	25 B [25, B]	60.6 ± 7.5 [56.1 ± 8.7]	AT	2d	12wk	CV-P-REHAB	HRQoL, $\dot{V}O_{2max}$
Barberan-Garcia et al., 2014	HF	60 B [94, B]	64.6 ± 6 [66 ± 9]	AT	3d	48wk	CV-P-REHAB	6MWT
Scalvini et al., 2013	CAD	100 B [100, B]	63 ± 12 [63 ± 11]	CT	7d	4wk	CV-P-REHAB	6MWT
Piotrowicz et al., 2010	HF	75 B [56, B]	56.4 ± 10.9 [60.5 ± 8.8]	CT	3d	8wk	CV-P-REHAB	SF-36, 6MWT
Ades et al., 2000	CAD	50 B [83, B]	58 ± 12 [56 ± 9]	AT	4–6d	12wk	CV-P-REHAB	$\dot{V}O_{2max}$
Snoek et al., 2021	CAD	61 B [61, B]	60.0 ± 8.4 [59.0 ± 10.7]	AT	5d	24wk	No intervention	HRQoL, $\dot{V}O_{2max}$
Grace et al., 2016	CAD	55 W [55, W]	63.1 ± 10.9 [66.2 ± 10.2]	AT	2-3d	24wk	CV-P-REHAB	$\dot{V}O_{2max}$
Lunde et al., 2020	CAD	48 B [54, B]	59.5 ± 9.1 [58.4 ± 8.2]	AT	1–3d	24wk	CV-P-REHAB	HRQoL, $\dot{V}O_{2max}$
Widmer et al., 2017	CAD	37 B [34, B]	62.5 ± 10.7 [63.6 ± 10.9]	AT	3d	12wk	CV-P-REHAB	Dartmouth QoL

Note: AT: aerobic training; B: both sexes; CAD: coronary artery disease; CG: group control; CT: combined training; d: days; Dartmouth: Dartmouth COOP Functional Health Assessment charts/WONCA; EQ5D: EuroQol 5 Dimensions; HF: heart failure; HRQol: Health-Related Quality of Life Questionnaire; HTA: arterial hypertension; M: men; MacNew: Health Disease Health-Related Quality of Life Questionnaire; MLHFQ: Minnesota Living With Heart Failure Questionnaire; SD: standard deviation; SF12: Short Form 12; SF36: Short Form 36; $\dot{V}O_{2max}$: maximal oxygen consumption; W: women; 6MWT: 6-min walk test.

within the training and control groups). Since there was no heterogeneity, fixed-axis models were selected for all analyses. Conservative pre-post correlations of 0.05 were assumed.[22] The subgroup analysis considered the effects of characteristics of the study population, training protocols and duration of the intervention on the main effects. The mixed effects were applied among the subgroup analyses when there was significant heterogeneity between the studies within one of the compared subgroups. In contrast, the fixed effects were applied when there was no heterogeneity between the studies within both subgroups. For all analyses, the value of $p < 0.05$ was considered significant. The Egger test was used to test the publication bias considering the value of $p < 0.05$.

Results

The flow diagram for the studies selection is detailed in Figure 1. Among the 26 studies included, 21 subgroups within studies assessed QoL, 9 assessed 6MWT and 16 assessed $\dot{V}O_{2max}$ as outcomes. [13–18,23–43]

Characteristics of the studies

The characteristics of the studies included are described in Table 1. Twenty-three studies included both men and women, while three included only men and one included only women. Even though we did not exclude studies with individuals below 50 years old, the lower mean age of the studies included was 54.4 ± 10.9 [33] and the studies were clustered according to the mean age of participants for further analysis (<64 years vs ≥65 years). The telerehabilitation programs included AT or CT, lasting from 4 to 48 weeks; their frequency varied from three to seven times per week.

Quality of the studies

The quality of the studies ranged from 6 to 8 on the Pedro scale, and the details of their classification can be seen in Table 2.

Evidence synthesis

Egger tests confirmed the absence of publication bias within the three main meta-analyses (6MWT, $t = 1.00$ and $p = 0.34$; $\dot{V}O_{2max}$, $t = 1.00$ and $p = 0.33$; QoL,

Table 2. PEDro scale score for the studies included.

First author, year	1	2	3	4	5	6	7	8	9	Overall
Piotrowicz et al., 2020	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Batalik et al., 2020	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7
Claes et al., 2020	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7
Avila et al., 2020	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7
Maddison et al., 2019	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7
Fang et al., 2019	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Avila et al., 2018	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Peng et al., 2018	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7
Bernocchi et al., 2018	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Pinto et al., 2013	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Frederix et al., 2017	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	8
Bravo-Escobar et al., 2017	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Skobel et al., 2017	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	8
Kraal et al., 2017	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Hwang et al., 2017	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Piotrowicz et al., 2015	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Piotrowicz et al., 2015	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Kraal et al., 2014	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Barberan-Garcia et al., 2014	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	8
Scalvini et al., 2013	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Piotrowicz et al., 2010	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Ades et al., 2000	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Snoek et al., 2021	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Grace et al., 2016	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Lunde et al., 2020	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7
Widmer et al., 2017	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	7

Note: 1: eligibility criteria specified; 2: random allocation of participants; 3: allocation concealed; 4: groups similar at baseline; 5: assessors blinded; 6: outcome measures assessed in 85% of participants; 7: intention to treat analysis; 8: reporting of between group statistical comparisons; 9: point measures and measures of variability reported for main effects.

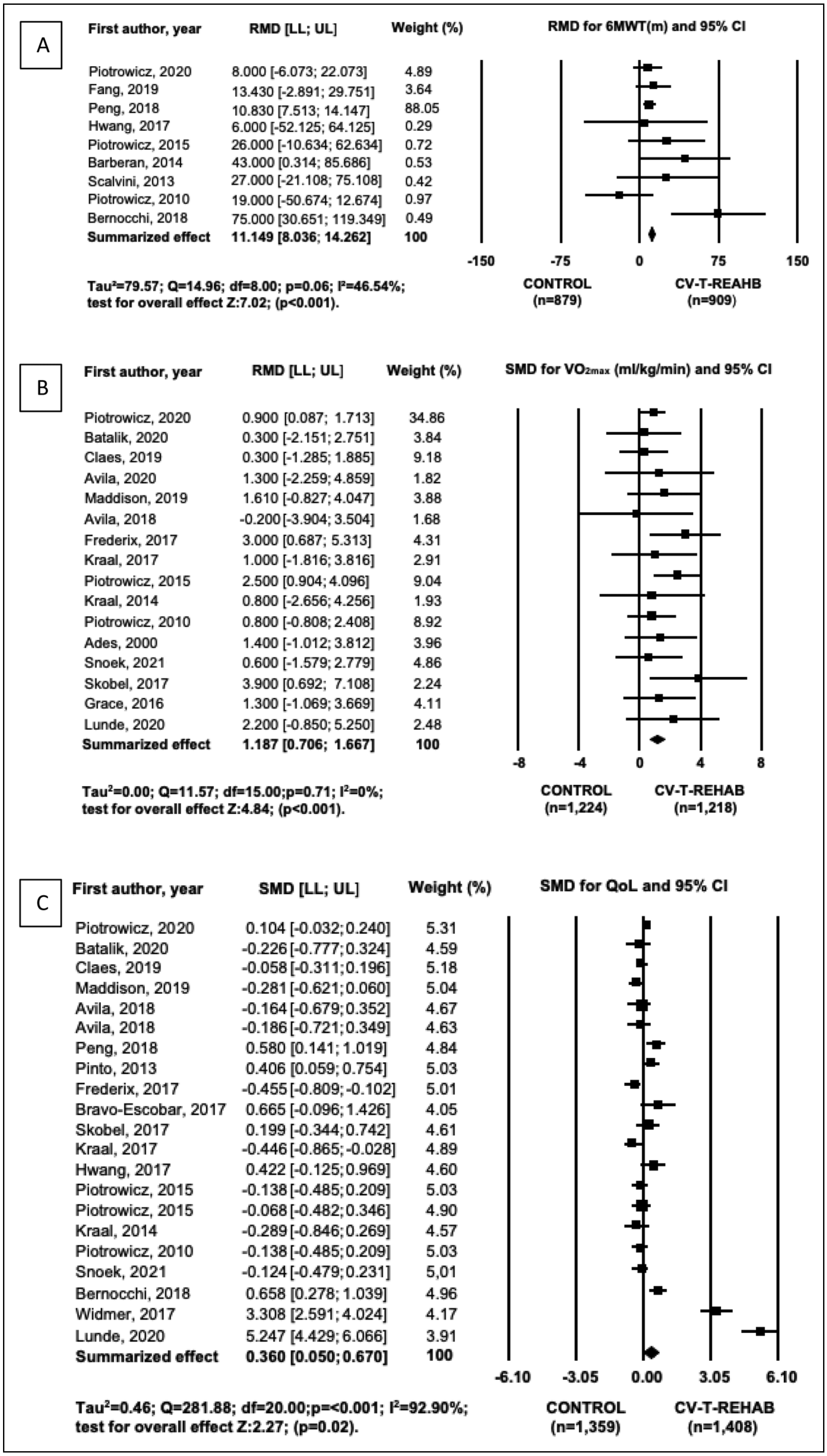

Figure 2. Forest of the effect of telerehabilitation on 6MWT (A), $\dot{V}O_{2max}$ (B) and QoL (C).
RMD: raw mean difference; SMD: standardized mean difference; LL: lower limit; UL: upper limit; CI: confidence interval.

$t = 1.60$ and $p = 0.12$). Cardiac telerehabilitation significantly increased functional capacity (Figure 2(a)). Although the meta-analysis of 6MWT was considerably consistent ($I^2 = 46.54\%$, $p = 0.06$) we did subgroup analyses to explore any remaining heterogeneity (Table 3). The age of individuals and intervention duration did not affect the results. On the other hand, cardiovascular telerehabilitation increased 6MWT only when compared to no intervention, while its improvement was not different from in presential cardiovascular rehabilitation (CV-P-REHAB). Furthermore, comparing the types of exercise, only AT significantly increased 6MWT while CT did not.

The effect of CV-T-REHAB on improving cardiorespiratory fitness was also significant (Figure 2(b)) and consistent across studies ($I^2 = 0\%$). Furthermore, CV-T-REHAB led to significant increments in comparison to no intervention and, in comparison, within CV-P-REHAB (Table 4). Both AT and CT were effective to improve the $\dot{V}O_{2max}$. The duration of the intervention did not affect $\dot{V}O_{2max}$ improvement.

Figure 2(c) shows a significant effect of CV-T-REHAB on QoL; however, the analysis was significant heterogeneous and had high inconsistency across studies ($I^2 = 92.90\%$). Subgroup analysis (Table 5) showed a significant increase for some QoL assessments such as MLHFQ, MacNew and Dartmouth; and for the subgroup of older adults above 65 years (including all types of QoL instruments). Interestingly, CV-T-REHAB did not improve QoL when compared to CV-P-REAHB. Duration of intervention did not influence QoL outcomes.

Discussion

The main findings of the present study were the efficacy of CV-T-REHAB improving functional capacity (6MWT) and QoL, and improving $\dot{V}O_{2max}$ even to a higher extent than presential cardiovascular rehabilitation (CV-P-REHAB).

Regarding functional capacity, CV-T-REHAB improved 6MWT to the same extent as CV-P-REHAB and significantly higher than the control with no interventions. This effect was observed for both aging groups (<64 years and >65 years), and the different duration of interventions (9 weeks and >12 weeks), although only for AT rather than CT.

Whether the studies that used only 6MWT included the most diseased patients that were not able to perform a $\dot{V}O_{2max}$ test is not clear. Nevertheless, it seems plausible that more diseased patients would face more challenges to accomplishing the CT by telerehabilitation at home than only AT. In fact, the 6MWT is not a maximum test and has been indicated by the American Thoracic Society for patients with chronic obstructive pulmonary disease and heart failure[44] different of $\dot{V}O_{2max}$ test, that can detect maximal performance even in athletes. Since the combination of resistance training with AT (CT) is the basis of cardiac rehabilitation programs due to the need for functional capacity and cardiorespiratory fitness improvements, understanding why we did not confirm the efficiency of CT CV-T-REHAB on functional capacity is fundamental.

Although an increase in maximal cardiorespiratory fitness ($\dot{V}O_{2max}$) is expected to happen following an exercise intervention in older adults with cardiovascular disease,[45] CV-T-REHAB was also higher than CV-P-REHAB. We speculate it could be due to higher adherence to training in the CV-T-REHAB compared to CV-P-REHAB. Indeed, a recent literature review, confirmed the higher adherence to cardiac telerehabilitation compared to centre-based cardiac rehabilitation among seven studies.[46] Like what we observed for 6MWT results, the length of intervention did not affect the $\dot{V}O_{2max}$ results. On the other hand, both AT and CT (CV-T-REHABs) efficiently increased $\dot{V}O_{2max}$ compared to control groups and the usual higher magnitude of improvement for AT (seeing in cardiovascular patients)[45]

Table 3. Subgroup analysis of CV-T-REHAB effects on 6MWT.

Subgroup	K	References	RMD	LL	UL	p within	p difference
Age							
<64 years	5	13,23,32,36,37	9.37	−0.17	18.92	0.05	0.2
>65 years	4	14,15,18,35	31.51	−0.48	63.51	0.05	
Control							
CV-P-REHAB	3	18,36,37	−3.19	−27.27	20.89	0.80	0.24
No intervention	6	13–15,23,32,35	16.95	6.05	27.85	<0.001	
Type of exercise							
AT	4	13,14,32,37	11.23	8.00	14.46	<0.001	0.71
CT	5	15,18,23,36,37	16.45	−10.78	43.68	0.24	
Intervention duration							
9wk	6	13,14,23,32,36,37	10.67	7.54	13.81	<0.001	0.01
>12wk	3	15,18,35	46.93	19.75	74.11	<0.001	

Note: AT: aerobic training; CT: combined training; CV-P-REHAB: presential cardiovascular rehabilitation; CV-T-REHAB: cardiovascular telerehabilitation; K: number of randomized controlled trials; LL: lower limit; RMD: raw mean difference, UL: upper limit; 6MWT: 6-min walking test.

Table 4. Subgroup analysis of CV-T-REHAB effects on $\dot{V}O_{2max}$.

Subgroup	K	References	RMD	LL	UL	p within	p difference
Control							
CV-P-REHAB	13	16,17,24–26,28,30,31,34,37,39,41,43	1.08	0.39	1.76	0.002	0.67
No intervention	4	31,33,34,40	1.28	0.61	1.95	<0.001	
Type of exercise							
AT	13	16,17,24,26,28,31,33,34,38,39,41,43	1.32	0.66	1.97	<0.001	0.54
CT	3	23,30,37	1.02	0.31	1.73	0.004	
Intervention duration							
≤9wk	2	23,38	1.65	0.52	2.78	0.004	0.40
12–24wk	7	16,23,24,27,32,35,39	0.87	0.20	1.54	0.011	
≥24wk	7	17,25,29,31,40,41,43	1.42	0.56	2.29	0.001	

Note: AT: aerobic training; CT: combined training; CV-P-REHAB: presential cardiovascular rehabilitation; CV-T-REHAB: cardiovascular telerehabilitation; K: number of randomized controlled trials; LL: lower limit; RMD: raw mean difference; UL: upper limit; $\dot{V}O_{2max}$: maximal oxygen consumption.

Table 5. Subgroup analysis of CV-T-REHAB effects on QoL.

Subgroup	K	References	SMD	LL	UL	p within	p difference
Type of test							
EQ-5D	2	25,30	−0.14	−0.43	0.14	0.32	<0.001
MacNew	1	27	0.40	0.05	0.75	0.02	
MLHFQ	3	14,15,18	0.58	0.32	0.83	<0.001	
HRQoL	5	28,31,34,39,41	0.73	−0.57	2.05	0.27	
Dartmouth	1	42	3.30	2.59	4.02	<0.001	
SF-36	7	16,17,26,29,32,33,37	0.01	−0.08	0.10	0.82	
Age							
<64 years	16	16,17,23,25,26–32,34,37,39,41,42	0.33	−0.01	0.67	0.06	0.25
>65 years	3	14,15,18	0.58	0.32	0.83	<0.001	
Type of exercise							
AT	16	14,16–18,24,25,27–29,31,32,34,37,39,41,42	0.38	−0.01	0.79	0.05	0.75
CT	3	15,23,30	0.30	−0.07	0.67	0.11	
Control							
CV-P-REHAB	13	16–18,25,26,28,29,31,32,34,37,41,42	0.51	−0.04	1.07	0.07	0.29
No intervention	7	14,15,23,27,30,33,39	0.19	−0.002	0.40	0.05	
Intervention duration							
≤9wk	5	14,30,33,34,38	0.20	−0.20	0.60	0.32	0.62
12–24wk	8	15,16,18,23,27,32,34,43	0.26	−0.15	0.67	0.21	
≥24wk	7	17,25,27,29,31,40,41	0.62	−0.13	1.38	0.10	

Note: AT: aerobic training; CT: combined training; CV-P-REHAB: presential cardiovascular rehabilitation. CV-T-REHAB: cardiovascular telerehabilitation; Dartmouth QoL: Dartmouth COOP Functional Health Assessment charts/WONCA for quality of life; EQ5D: EuroQol 5 dimensions; HRQol: Health-Related Quality of Life Questionnaire; K: number of randomized controlled trials; LL: lower limit; MacNew: Health Disease Health-Related Quality of Life Questionnaire; MLHFQ: Minnesota Living With Heart Failure Questionnaire; SF-36: Short Form 36; SMD: standardized mean difference; UL: upper limit.

was not seen here. A six-year follow-up study showed the difference between the patients with cardiovascular diseases that survived or died was only 1 MET (metabolic equivalent), equivalent to 3.5 ml/kg/min.[47] In this way, the short-term interventions CV-T-REHAB were enough to lead to a mean of one-third reduction of the risk (1.18 ml/kg/min [0.70; 1.66]) and an even higher reduction comparing the CV-T-REHAB with no intervention (1.28 ml/kg/min [0.61; 1.95]).

The CV-T-REHAB was also enough to improve QoL, however the effect of CV-T-REHAB on QoL was inconsistent across studies. The improvement in QoL was seem in some questionnaires but not all. We attribute these differences to the different questionnaire scales that may remain difficult to compare even though we applied standardized analysis (SMD effects).

The increase in QoL with CV-T-REHAB was higher for patients above 65 years old than the younger ones. We suggest that whether this is true, CV-T-REHAB could be an even better alternative to older patients with physical and health limitations (e.g.: sarcopenia, pain, osteoarthritis, urinary incontinence, uncontrolled blood pressure) and need to overcome more barriers to be at rehabilitation centres. However, it is noteworthy that not all older adults have the required skills or access to handle certain technological devices,[46] and thus, telerehabilitation should be used to complement the existing services rather than replace them.[41,48]

Study limitation

The main limitation of our meta-analyses was the significant heterogeneity, suggesting confounding factors' influence on the benefits of CV-T-REHAB on QoL. Even for the meta-analyses with non-significant heterogeneity, subgroup analyses were performed to identify any source of confounding factors. Although we raised some candidates to explain heterogeneity between studies, there were still a few heterogeneous subgroups remaining, in which future confounding factors need to be identified.

Unfortunately, some subgroup analyses were not possible due to the original heterogeneity within studies such as the inclusion of participants from different sexes, lack of information regarding the exercise protocols and adherence to each intervention.

Conclusion

The cardiovascular telerehabilitation programs were not just efficient in improving functional capacity by 6MWT and QoL but also better than in-person programs to improve cardiorespiratory fitness, assessed by $\dot{V}O_{2max}$. The reason for the higher $\dot{V}O_{2max}$ increase in CV-T-REHAB compared to CV-P-REHAB is still to be debated. However, we suggest it could be associated with higher adherence to the rehabilitation program. Thus, CV-T-REHAB can be a good alternative, when not the best option and might be considered especially for individuals with limited access to face-to-face programs.

Because cardiovascular telerehabilitation with CT did not improve functional capacity, there is still a need to improve the telerehabilitation protocols to make it enough for all the benefits the CV patients demand. The longest interventions herein tested one year of rehabilitation. Still, not many studies tested these long-lasting effects, so future studies must continuous to explore how long the benefits can be maintained and develop strategies to keep the patients engaged in their rehabilitation. At last, since the telerehabilitation effectiveness for patients with CV disease is now confirmed, future studies need to compare types of protocols that will increase its effectiveness and ensure long-lasting benefits.

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Supplemental material

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