Effects of Exergaming in Patients with Cardiovascular Disease Compared to Conventional Cardiac Rehabilitation: A Systematic Review and Meta-Analysis

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Abstract (300 word limit)

Abstract: Background: Exercise-based cardiac rehabilitation (CR) programs are used for improving prognosis and quality of life in patients with cardiovascular disease (CVD). Nonetheless, adherence to these programs is low, and exercise-based CR programs based on virtual reality (i.e., exergaming) have been proposed as an alternative to conventional CR programs. However, whether exergaming programs are superior to conventional CR programs in patients with CVD is not known. Objective: This systematic review with meta-analysis was conducted to explore whether exergaming enhances exercise capacity, quality of life, mental health, motivation, and exercise adherence to a greater extent than conventional CR programs in patients with CVD. Method: Electronic searches were carried out in Pubmed, Embase, Web of Science, and Cumulative Index to Nursing and Allied Health Literature databases up to June 2021. Meta-analyses were performed using robust variance estimation with small-sample corrections. The effect sizes were calculated as the mean differences (MD) or standardized mean differences (SMD) as appropriate. The SMD magnitude was classified as trivial (<0.20), small (0.20-0.49), medium (0.50-0.79), or large (≥0.80). Heterogeneity was interpreted based on the I2 statistics as low (25%), moderate (50%), or high (75%). Results: Pooled analyses showed no differences between exergaming and conventional CR programs for enhancing exercise capacity (i.e., distance covered in the six-minute walk test) (MD = 14.07 meters [95% confidence interval (CI) −38.18 to 66.32 meters]; p = .426) and mental health (SMD = 0.17 [95% CI −0.36 to 0.70]; p = .358). The results showed a small, statisti-cally non-significant improvement in quality of life in favor of exergaming (SMD = 0.22 [95% CI = −0.37, 0.81]; p = .294). Moderate heterogeneity was found for exercise capacity (I2 = 53.7%), while no heterogeneity was found for quality of life (I2 = 3.3%) and mental health (I2 = 0.0%). Conclusions: Exergaming seems not to be superior to conventional CR programs for improving exercise capacity, quality of life, or mental health in patients with CVD.

Image

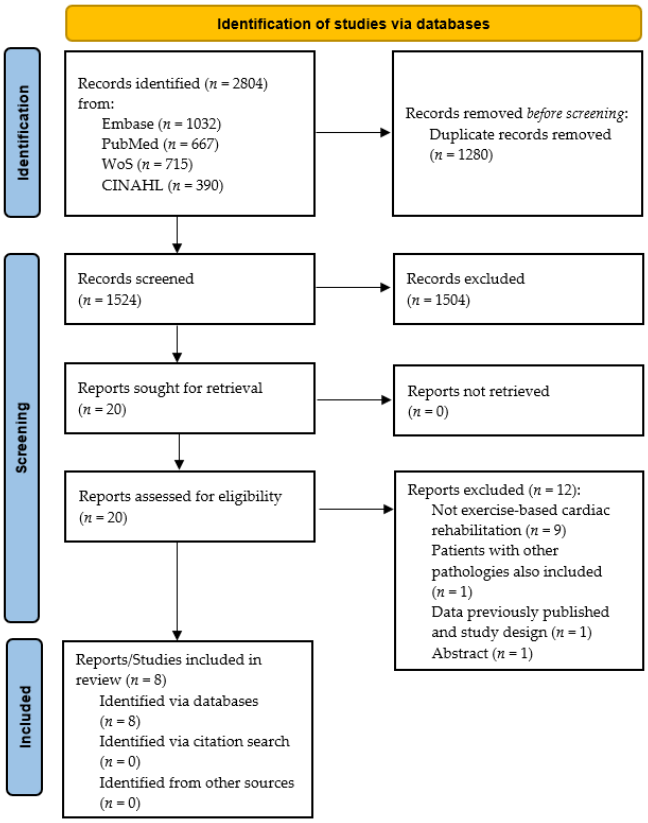


Figure 1. Flow chart of the systematic review process.

Table 1. Study and participant characteristics.

Study (author, year)	Group	Study characteristics	Participant characteristics	
		Country; study design; journal	Sample size; men percentage; age	CVD diagnosis; risk factors or comorbidities
Cacau et al. (2013)	EG	Brazil; RCT; Rev Bras Cir Cardiovasc	30; 43.0%; 49.2 ± 2.6 years	CAD; NR
	CG		30; 53.0%; 52.0 ± 2.4 years	
Chuang et al. (2006)	EG	Taiwan; RCT; Phys Ther	10; 100%; 65.7 ± 14.5 years	CAD; AHT, DM2, DLP, SM
	CG		10; 100%; 63.7 ± 10.3 years	
Garcia-Bravo et al. (2020)	EG	Spain; RCT; Int J Environ Res Public Health	10; 70.0%; 48.7 ± 6.7 years	CAD; NR
	CG		10; 100%; 53.7 ± 10.3 years	
Gulick et al. (2021)	EG	USA; RCT; J Med Internet Res;	41; 72.0%*; 61 ± 9.9 years*	MS; COPD
	CG		31; 72.0%*; 61 ± 9.9 years*	
Jaarsma et al. (2021)	EG	Sweden, Italy, Israel, Netherlands, Germany, USA; RCT; Eur J Heart Fail	234; 72.0%'; 66 ± 12.0 years'	CHF; AHT, AF, CVA, COPD, DM2, MI
	CG		230; 70.0%'; 67 ± 11.0 years'	
Klompstra et al. (2014)	EG	Sweden; Single Intervention; BMC Geriatrics	32; 68.8%; 63.0 ± 14.0 years	CHF; SM
Ruivo et al. (2017)	EG	Ireland; RCT; J Cardiopulm Rehabil Prev	16; 87.5%; 59.4 ± 11.8 years	MS; AHT, DLP; DM2, OB, SM
	CG		16; 75.0%; 60.4 ± 8.5 years	
Vieira et al. (2018)	EG	Portugal; RCT; Disabil Rehabil: Assist Technol	11; 100%; 55.0 ± 9.0 years	CAD; AHT, DLP; DM2, OB, SM
	CG1		11; 100%; 59.0 ± 11.3 years	
	CG2		11; 100%; 59.0 ± 5.8 years	

Table 2. Intervention characteristics and main findings.

Study	Intervention characteristics	Intervention and technology description	Main findings
Cacau et al.	Supervised training; phase I; intervention length (NR); 2 sessions a day until hospital discharge; intensity (NR)	EG: Physiotherapeutic protocols: breathing exercises, airways clearance techniques, metabolic exercise, and motor exercise using VR CG (active): Physiotherapeutic protocols: breathing exercises, airways clearance techniques, metabolic exercise, and motor exercise	The EG had lower hospitalization length (EG: 9.5 ± 0.5 days; CG: 12.2 ± 0.9 days), as well as higher exercise capacity (6MWT) at post-intervention The EG had higher functional independence, better energy levels, and less pain, while no between-group differences were found in emotional reactions, physical ability, and social interaction (measured with the Nottingham Health Profile)
Chuang et al.	Supervised training; phase II; 12 weeks; 2 sessions a week; <30 min or >30 min depending on the subject's condition; 3 min of low intensity with progressive increase until they reach a score of 16 in Borg scale or target HR or $V0_2$	EG: Treadmill with speed alteration and incline adjustments using Microsoft Direct 3D-constructed "virtual runner" model with "wraparound" screens CG (active): Treadmill with speed alteration and incline adjustments	The number of sessions needed to reach the target of 85% heart rate max and the target of 75% VO_2 peak was lower in the EG than in the CG. Moreover, the maximum work rate achieved in the endurance training sessions was higher in the EG
Garcia-Bravo et al.	Supervised training; phase II; 8 weeks; 2 sessions a week; 60 min a session; intensity adapted according to the limits of HR and sensation of effort	EG: warm-up (10 min), VR-based training (20 min), resistance exercise (endless belt) for 10 min and limb strength exercises with weight of 0.5-3.0 kg (10 min) and cool-down (10 min) CG (active): warm-up (10 min), aerobic exercise (treadmill for 30 min) and limb strength 0.5-3.0 kg (10 min) and cool-down (10 min)	No between-group differences in exercise capacity (metabolic equivalent of task and 6MWT), functional independence measure, recovery of heart rate after 6MWT, quality of life (Short Form Health Survey-36 Questionnaire), depression (Beck-II Depression Inventory), and satisfaction (Client Satisfaction Questionnaire). Moreover, no differences were found in adherence and adverse events during the intervention
Gulick et al.	Supervised training; phase II; intervention length (NR); training frequency (NR); intensity (NR)	EG: Standard of care CR: 4 types of exercise equipment, including bionautica trail system (VR), stationary bikes, ellipticals, and hand rowing machines CG (active): Standard of care CR: 4 types of exercise equipment, including treadmills, stationary bikes, ellipticals, and hand rowing machines	Patient attendance was lower in the EG (58%) than in the CG (81%), with no correlation between the group and reasons for ending No between-group differences in education (5-question test), satisfaction (6-question examination), engagement (3-question test), and exercise capacity (6MWT)
Jaarsma et al.	Home based; phase III; 48 weeks; 5 sessions a week; 30 min per session; intensity (NR)	EG: Standard practice at their referring center (usual care) and Nintendo Wii Sports with baseball, bowling, boxing, golf, and tennis CG (passive): Standard practice at their referring center (usual care): protocol-based physical activity advice from a heart failure team member	No between-group differences in exercise capacity (6MWT) at 3, 6, and 12 months, as well as in exercise motivation (15-question exercise motivation index), exercise self-efficacy (6-question exercise self-efficacy questionnaire), and self-reported physical activity (single item question)
Klompstra et al.	Home based; phase III; 12 weeks; 7 sessions a week; 20 minutes per session; intensity (NR)	EG: Nintendo Wii sports. Advice 20 min everyday: bowling, tennis, baseball, golf, and boxing games	Exercise capacity (6MWT) increased from 501 ± 95 meters to 521 ± 101 meters. Fifty-three percent of the patients increased the distance more than 30 meters, which was considered clinically relevant Lower New York Heart Association scale and shorter time since diagnosis (less than one year) were related to the increase in exercise capacity
Ruivo et al.	Supervised training; phase II; 6 weeks; 2 sessions a week; 60 min per session; intensity monitored with individual target HR zones	EG: Aerobic, resistance, and flexibility training using 9 circuit stations Nintendo Wii sports (boxing and canoeing) CG (active): Aerobic, resistance, and flexibility training using 9 circuit stations and music video	Lower tendency for dropping out in the EG (6%) than in the CG (19%). Higher improvement in energy expenditure in the EG compared to the CG No between-group differences in the median individual attendance and the number of patients experiencing adverse events during the intervention. Moreover, no differences in changes in exercise capacity (metabolic equivalent of task), affect toward exercise (Positive and Negative Affect Scale),

			anxiety and depression (Hospital Anxiety and Depression Scale), and quality of life (MacNew)
Vieira et al.	Mixed; phase III; 24 weeks; 3 sessions a week; 60 min per session aprox; two progressive levels of intensity: level 1 (65% of HR reserve) and after three months, level 2 (70% of HR reserve); intensity monitored with the Borg scale	EG: Education on cardiovascular risk factors and 10 exercises: a warm-up exercise, 7 exercises of conditioning workout aimed at enhancing muscular endurance and/or strength, and 2 exercises to increase limb flexibility using a computer and Kinect-rehab play CG1 (active): Education on cardiovascular risk factors and 10 exercises: a warm-up exercise, 7 exercises of conditioning workout aimed at enhancing muscular endurance and/or strength, and 2 exercises to increase limb flexibility using a paper booklet CG2 (passive): Usual care: Education on cardiovascular risk factors and daily walks encouraged	The EG showed an enhanced selective attention and conflict resolution ability (Stroop Test) in comparison with the two CGs In contrast, no between-group differences were found in the quality of life (MacNew), depression, anxiety, and stress (Depression, Anxiety, and Stress Scale 21)

Biography (150 word limit)

Junior researcher Blasco-Peris is an experienced project manager who works in the Alicante Institute of Health and Biomedical Research (ISABIAL). Postgraduate in Research and Intervention in Science and PhD student at the University of Valencia and Miguel Hernández University of Elche.

Blasco-Peris holds over 7 years of experience in the health and biomedical field, expert in preparation of competitive proposals, participation in consortia, project monitoring and results dissemination.

Team member in projects related to Physical Activity and Physical Exercise as prevention in the development and management of diseases.

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Notes/Comments: