ADHERENCE TO CARDIOVASCULAR REHABILITATION WITH THE USE OF EXERGAMING: A SYSTEMATIC REVIEW

ADESÃO À REABILITAÇÃO CARDIOVASCULAR COM O USO DO EXERGAMING: UMA REVISÃO SISTEMÁTICA

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Abstract: Introduction: Studies show that there is a low adherence to cardiovascular rehabilitation (CVR) implying limitations as to expected benefits. It is important to investigate whether the diversification of interventions already applied in CVR, such as the adoption of exergaming, can provide greater adherence to this treatment. **Objective:** To review studies that investigated the intragroup adherence to CVR of patients using exergaming and comparing, intergroup, with patients undergoing conventional CVR. **Methods**: This was a systematic review that included original intervention studies indexed in databases and published up to April 2021, without language restrictions. The search was performed in PubMed/Medline, Web of Science, Scopus, Cochrane, and PEDro, in April 2021. **Results:** A total of 8 studies were included. In 3 of them, the average adherence to CVR sessions with exergaming was 77%. In another study, about 60% of the participants were more than 80% adherent to the recommended playing time. In the fifth study, the average time of exergaming use was 28 ± 13 minutes/day, which is higher than the recommended 20 minutes/day. In the sixth study, the median of individual attendance was 96%. In the seventh, there was 100% adherence to the CVR sessions. And in the eighth study, there was a significant increase in adherence at 12 weeks of CVR with exergaming (72.87% vs. 82.80%) and a reduction when exergaming was discontinued (82.80% to 65.48%, p < 0.05). **Conclusion:** The best available evidence demonstrates a positive effect of exergaming on CVR patient adherence.
Keywords: Heart Diseases; Cardiac Rehabilitation; Accession to Treatment; Virtual reality.

Resumo: Introdução: Estudos mostram que há uma baixa adesão à reabilitação cardiovascular (RCV) implicando em limitações quanto aos benefícios esperados. É importante investigar se a diversificação de intervenções já aplicadas na RCV, como a adoção do exergaming, pode proporcionar maior adesão à esse tratamento. **Objetivo:** Revisar estudos que investigaram a adesão intragrupo à RCV de pacientes em uso do *exergaming* e comparar, intergrupos, com pacientes submetidos a RCV convencional. **Métodos**: Trata-se de uma revisão sistemática que incluiu estudos de intervenção originais, indexados em bases de dados e publicados até abril de 2021, sem restrições de idioma. A busca foi realizada no PubMed/Medline, Web of Science, Scopus, Cochrane e PEDro, em abril de 2021. **Resultados:** Foram incluídos 8 estudos. Em 3 deles, a média de adesão às sessões de RCV com exergaming foi de 77%. Em outro estudo, cerca de 60% dos participantes estavam mais de 80% aderentes ao tempo de jogo recomendado. No quinto estudo, o tempo médio de uso do exergaming foi de 28 ± 13 minutos/dia, superior ao recomendado de 20 minutos/dia. No sexto estudo, a mediana de atendimento individual foi de 96%. No sétimo, houve 100% de adesão às sessões de RCV. Já no oitavo estudo, houve aumento significativo na adesão em 12 semanas de RCV com exergaming (72,87% para 82,80%) e redução quando exergaming foi descontinuado (82,80% para 65,48%, p < 0,05). **Conclusão:** A melhor evidência disponível demonstra um efeito positivo do *exergaming* na adesão do paciente à RCV.
Palavras-chave: Cardiopatias; Reabilitação Cardíaca; Adesão ao Tratamento; Realidade Virtual.

INTRODUCTION

Cardiovascular disorders are the leading cause of death worldwide[1]. Among the treatment possibilities there are pharmacological, surgical[2], and non-pharmacological interventions, such as cardiovascular rehabilitation (CVR)[3]. The latter has beneficial effects on the quality of life, exercise tolerance, reduced hospital re-admission and mortality from cardiac causes[3,4,5].

Despite scientific evidence on the positive effects of the CVR program, low patient compliance[6–8] is a major limitation[6,9]. In the United States, for example, the adherence rate varies from about 19% to 34%[10,11]. It is estimated that increasing participation in CVR from 20% to 70% could save 25,000 lives and prevent 180,000 hospitalizations annually in this country[12]. Thus, low adherence to CVR can be considered a public health problem and the adoption of strategies also focused on improving patient compliance should be considered.

Virtual reality is a rehabilitation strategy that consists in the representation of an imaginary environment where scenarios are simulated to provide the experience of various activities, with capture of sensory information on motion using a console[13]. Games involving virtual reality directed to physical training are known as exergames[14]. Exergames and exergaming have the potential to bring benefits to patients with heart disease similar to conventional CVR, and are more pleasurable for participants[15].

Due to its playful nature[14], exergaming seems to be a promising intervention to promote increased adherence to CVR. However, it is necessary to verify the tangible benefits derived from this therapeutic activity. According to online searches, the available systematic review on exergaming in CVR did not have adherence as a primary outcome[16]. Also, scientific articles on the subject were published after such review[17,18], and even a large multicenter study[18] which was included in the present review. Thus, the primary objective here was to review studies that investigated the intragroup adherence to CVR of patients using exergaming and compare, intergroup, with patients undergoing conventional CVR. As secondary objectives, the effects of exergaming on the outcomes physical activity practice, psychological factors, motivation, satisfaction, and distance walked in the six-minute walk test (6MWT) were reviewed.

METHODS

This was a systematic review of the literature carried out following the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[19].

To structure our research question, the following eligibility criteria based on the acronym PICO were established: CVR participants aged from 18 years (population), exergame (intervention), conventional CVR (control), adherence to exergame in outpatient or home CVR (primary outcome), practice of physical activity, psychological factors, motivation, satisfaction, and distance covered in the 6MWT (secondary outcomes).

Original intervention studies indexed in databases without language restriction and

published up to March 2021 were considered eligible. There was no restriction on sex or age with respect to adherence (defined as frequency of attendance to sessions, rate of individual attendance or use of established game time) to CVR (outpatient or home) with the use of exergaming.

A systematic search was performed to identify eligible studies in the following libraries: U.S. National Library of Medicine (PubMed) (PubMed) (indexed database: Medline) and Cochrane, and Physiotherapy Evidence Database (PEDro), Web of Science, and Scopus. The search strategy included the following descriptors: "Heart Diseases", "Cardiovascular Diseases", "Virtual Reality", "Virtual Reality Exposure Therapy", "Cardiac Rehabilitation" and their synonyms or related terms, as well as the terms exergame, exergames, exergaming, and Intervention Study. The Boolean operators "and" and "or" were used for combination of terms. The search strategy is attached in Appendix 1.

Two authors independently performed the search for relevant titles and abstracts during March 2021. After this step, duplicate studies were removed. Then, the selected articles were read in full length to assess their eligibility following the pre-created criteria. In the event of any divergence in the inclusion of studies, a third researcher was consulted.

The PEDro[20] scale was used to assess the methodological quality of the included studies. This scale is a tool created to evaluate controlled clinical trials published in the field of rehabilitation sciences and is composed of 11 items. The total score is the sum of the items, excluding item 1, as it aims to verify the external validity of the study. Each met item receives the score 1, and thus the total score may reach 100 points.

RESULTS

The initial search identified 7335 potentially eligible articles (Pubmed: 1616, Web of Science: 2676, Scopus: 3390, PEDro: 8, Cochrane: 45) and 2 studies were included via manual search. A total of 2643 studies were excluded because they were duplicates. In the screening of titles and abstracts, 28 studies were selected, and 8 were included for qualitative synthesis after full reading (Figure 1).
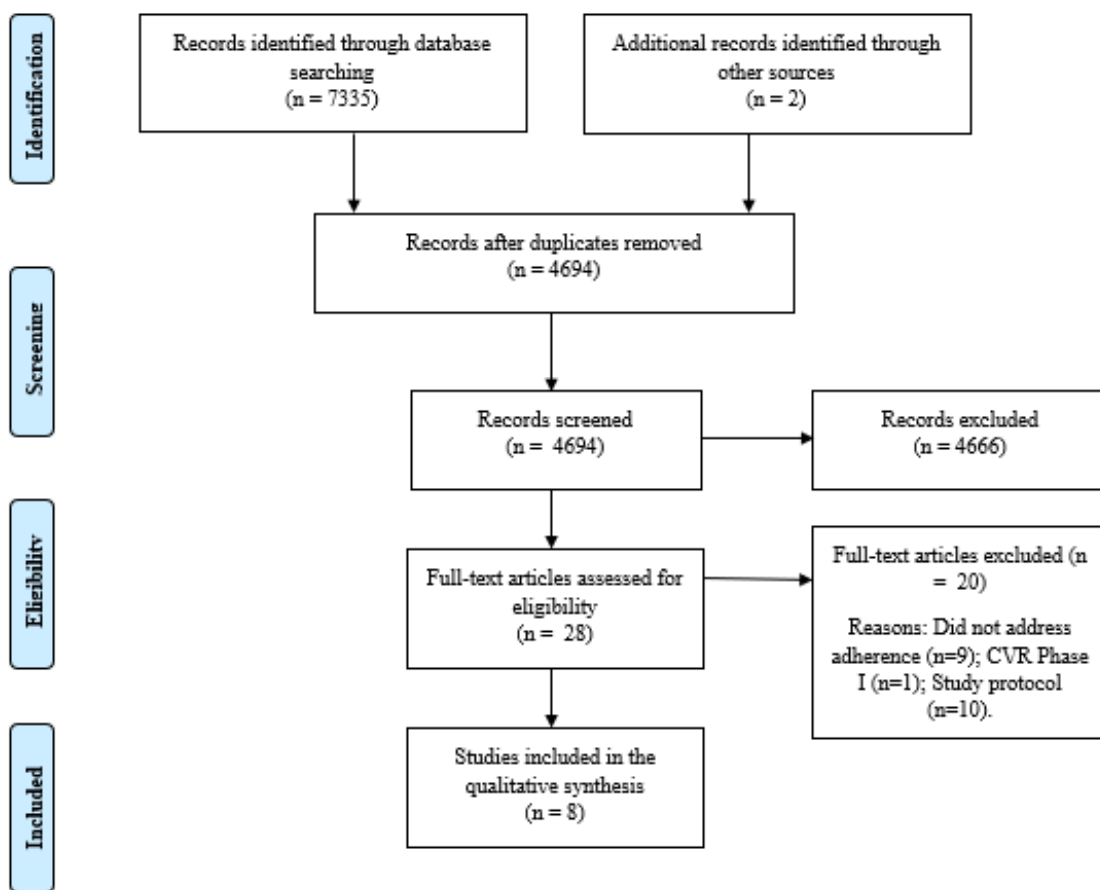
Figure 1. PRISMA flowchart of the search steps.

Methodological quality

As for the methodological quality of the studies analyzed, the mean value was 6.2 on the PEDro scale (Table 1).

Table 1. Detailed intention to treat analysis for the included clinical trials.

Study	1*	2	3	4	5	6	7	8	9	10	11	Total
							Criteria					
Vieira et al.[23]	√	√	√	√						√	√	5
Vieira et al.[24]	√	√		√				√		√	√	5
Ruivo et al.[15]	√	√	√				√	√	√	√	√	7
Jaarsma et al.[18]	√	√		√			√		√	√	√	6

Study	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	Total
García-Bravo et al.[17]	√	√	√	√			√	√	√	√	√	8
da Cruz et al.[25]	√	√	√	√	√		√	√			√	7
Total	6	6	4	5	1	0	4	3	4	6	6	

Legend: (2) Random allocation; (3) Concealed allocation; (4) Baseline comparability; (5) Blind subjects; (6) Blind therapists; (7) Blind appraisers; (8) Adequate follow-up; (9) Intention to treat analysis (10) Comparisons between groups; (11) Point measures and measures of variability
*Item not considered in the total score of the studies.

General characteristics of the studies

The sample size of the exergaming group (EG) ranged from 10 to 305, totaling 426 participants, with a mean age ranging from 48.7 to 66 years. The study population consisted mainly of patients with coronary artery disease and heart failure. Cardiovascular rehabilitation was performed at home in a total of six of the studies, and in an outpatient clinic in two studies. Information on the articles included is compiled in Table 2.

Table 2. Characteristics of the included studies.

Author and year/ Characteristics	Sample	Phase of CVR	Exergaming protocol	Instrument	Adherence to exergaming
Klompstra et al.[21]	32 patients with HF, mean age 63 ± 14 years, 69% male.	III	Advised to use exergaming for 20 min/day for 12 weeks (n=16).	Nintendo Wii, Wii sports (bowling, tennis, baseball, golf or boxing).	Mean time of exergaming use of 28 ± 13 min/day.
Vieira et al.[22]	11 participants with CAD, 100% male, mean age 55 years.	III	Warm-up, conditioning, balance, and flexibility exercises, progressing from 65% to 70% of HRR. Walk.	Kinect RehabPlay.	Mean of 77% adherence to the sessions of the CVR program using exergaming.

Vieira et al.[23]	33 patients with CAD (11 per group), between 40 and 75 years, 100% male, EG age 55 ± 9.0 years.	III	Warm-up, conditioning, balance and flexibility exercises, progressing from 65% to 70% of HRR. Walk.	Kinect RehabPlay	Mean of 77% adherence to the sessions of the CVR program using exergaming.
Vieira et al.[24]	33 patients with CAD (11 per group), between 40 and 75 years, 100% male, EG age 55 ±9.0 years.	III	Warm-up, conditioning, balance and flexibility exercises, progressing from 65% to 70% of HRR. Walk.	Kinect RehabPlay	Mean adherence of 77% to sessions of the CVR program using exergaming.
Ruivo et al.[15]	Patients susceptible to CVR, EG age 59.4 ± 11.8 years, 87.5% male.	II	Nine-station circuit: aerobic, resistance, and flexibility training. Exergaming in two stations.	Nintendo Wii, Wii sports (boxing and canoeing).	96% median in the individual attendance rate in the EG.
Jaarsma et al.[18]	605 participants with HF (305 EG, 300 CG) EG mean age 66±12 years, 72% male.	III	Instructed to perform exergaming 30 min a day, five days a week (or as long as possible until reaching 30 min a day).	Nintendo Wii, Wii sports (bowling, tennis, baseball, golf or boxing).	About 60% of participants were >80% adherent to the recommended exergaming time.
García-Bravo et al.[17]	20 participants (10 per group), EG mean age 48.70 years.	II	Exergaming for 20 min, at 75 and 85% of maximal heart rate, plus 20 min of resistance and strength exercises, two sessions per week for 8 weeks.	Microsoft XBOX® One e Kinect 2®.	EG adhered 100% to the CVR sessions.

| da Cruz et al.[25] | 61 patients (30 EG, 31 CG) EG mean age 63.27 ±12.68 years, 50% male. | II | EG: Conventional CVR + exergaming for 24 weeks. Intensity 40% to 80% of HRR. Crossover: exergaming used in the initial 12 weeks and removed in the following 12 weeks. | XboxOne Kinect®, Microsoft® | Significant increase in adherence in 12 weeks (72.87% to 82.80%), significant reduction when exergaming was removed from the EG (from 82.80% to 65.48%, p<0.05). |

Legend: CAD – coronary artery disease, HRR – heart rate reserve, CG – control group, EG – exergaming group; HF – heart failure, CVR – cardiovascular rehabilitation.

Intervention with exergaming

A total of three studies used the Nintendo Wii® console in their interventions[15,18,21]. Klompstra et al.[21] used Wii Sports games (bowling, tennis, baseball, golf, and boxing). Participants were encouraged to use the exergame for 20 minutes a day (and increased the time if they felt good) for 12 weeks. The study protocol by Ruivo et al.[15] consisted of aerobic, resistance, and flexibility training in a nine-station circuit with the application of Wii Sports games (boxing and canoeing) reaching an individual target heart rate in two stations. The sessions lasted one hour and were held twice a week for six weeks. Participants in another study who used the Nintendo Wii®[18] were instructed to play sports games (baseball, bowling, boxing, golf, and tennis) for 30 minutes a day, five days a week (or as long as possible until reaching 30 minutes per day). Calls encouraging the use of games were interrupted after three months, with patients being followed up for 12 months.

Other platforms were used as exergaming in the analyzed articles. In three studies[22–24], the participants used a game associated with Kinect® installed on a computer (RehabPlay, developed at the Faculty of Engineering of the University of Porto) at home and with remote supervision, three sessions a week, for a period of six months. The training had two progressive levels of intensity (initial 65% of heart rate reserve, going to 70% of heart rate reserve after three months), and the participants were instructed to keep the Borg rating between 12 and 13. The protocol included warm-up, conditioning, balance, and flexibility exercises, as well as 30-minute walks on the other days, in addition to the three exergaming sessions.

Two studies used Microsoft XBOX® games[17,25]. García-Bravo et al.[17] applied a 60-min protocol (10 minutes of warm-up, 40 minutes of training and 10 minutes of cool down or return to calm). Aerobic training was performed with Microsoft XBOX® One and Kinect 2® for 20 min, at 75 and 85% of maximum heart rate. Resistance (10 min) and strength (10 min) exercises were also applied. The protocol had a frequency of two sessions per week, lasting 8 weeks. Supervised outpatient sessions were performed in a randomized controlled crossover trial[25] that included exercises and educational lectures. Cardiovascular rehabilitation sessions were performed 3 times a week (two of conventional CVR and one with the addition of

exergaming), for 24 weeks. Each session lasted 50 minutes, including 15 minutes of warm-up, 30 minutes of physical training, and 5 minutes of cool down. Warming up was performed with the game Just Dance 2015 (Xbox One Kinect®, Microsoft®) and training was through exercises in the Shape Up game. The training intensity ranged from 40% to 70% of heart rate reserve in patients with cardiovascular diseases and 60% to 80% of the reserve heart rate in those with cardiovascular risk factors, with perceived exertion on the Borg scale between 12 and 16. Exergaming was used in the initial 12 weeks in the EG and removed in the following 12 weeks.

Procedures in comparison groups

Five of the seven included studies had control or comparison groups. Two studies[23,24] had two comparison groups: a second intervention group for comparison with the main intervention (IG2), and a third control group (CG). The IG2 received a booklet with guidelines for the practice of physical exercise and the CG received educational instructions on cardiovascular risk factors and encouragement for daily walks (as well as the other groups). Another study[18] had only one CG in which individuals received a protocol-based physical activity advice and telephone motivational follow-up (as well as the EG)[18]. In another study[17], a protocol of 60 min (10 minutes of warm-up, 40 minutes of training, and 10 minutes of cool down) was applied in the CG. Training consisted of exercises on the treadmill for 30 min and strength exercises for 10 min. The CG of another study[15] performed aerobic, resistance and flexibility training in a nine-station circuit with video and music projection in two stations. A crossover study[25] applied 50-minute sessions in the CG, including 15 minutes of warm-up, 20 minutes of physical training on a treadmill and ergometric bicycle, and five minutes of cool down. The training intensity was stipulated in the same way as it was for the EG.

Adherence

In three studies[22–24], the mean rate of adherence to CVR using exergaming was 77% in six months (82% in the initial three months and 70% in the final three months). In two of these studies[23,24], there was no significant difference in adherence between the studied groups.

In a clinical trial[18], about 60% of participants were > 80% adherent to the recommended playing time whereas 17% reported never having exergamed during the study. The sample of a pilot study[21] used exergaming in an average time of 28 ±13 minutes per day, above the 20 minutes per day recommended for the participants. In another study[15] there was a lower trend of CVR discontinuation in the EG (6.3% vs. 18.8%, p > 0.05), but the median individual attendance rate was equal in both groups, 96% in the EG and in the CG. In a clinical trial[17] both the EG and the CG had an adherence of 100% to CVR sessions. The EG of a crossover study[25] showed a significant increase in adherence at 12 weeks of protocol (initial adherence of 72.87%, and adherence of 82.80% at 12 weeks), with significant reductions when exergaming was removed (from 82.80% to 65.48%, p < 0.05). There was significantly greater adherence in the EG at 12 weeks (82.80% vs. 73.51%).

Physical activity practice

In a pilot study[21], there was no significant difference in energy expenditure from the beginning to the end of the 12 weeks of intervention (2,368 ± 847 kJ/day to 2,807 ± 1,807 kJ/day, p = 0.291). At the end of the protocol used by Ruivo et al.[15], the EG participants showed improvement in the practice of physical activity (median of 255 to 322 arbitrary acceleration units, p = 0.039), a significant increase in energy expenditure (median of 9 to 13 kcal/kg/day, p = 0.007) and in total energy expenditure (median of 32 to 34 kcal/kg/day, p = 0.005). In a clinical trial[18], there was no significant change in the number of participants who reported being physically inactive from the beginning to the end of the study.

Psychological factors

Anxiety, depression, and stress were investigated using the Depression Anxiety and Stress Scale (DASS-21) in one of the studies[24]. Initially, only the depression dimension showed a difference between the EG and IG2 (p = 0.012), and only EG versus CG and GI2 versus CG were comparable. There was no difference in intragroup and intergroup analyses in the other steps of the protocol. The authors of the pilot study[15] assessed anxiety and depression through the Hospital Anxiety and Depression Scale (HADS) and mood through the Positive and Negative Affect Scale (PANAS). The groups were homogeneous at baseline. No significant difference was found in these psychological aspects between the EG and CG at the end of the interventions [HADS - anxiety component: median 6 (3-11) vs. 7 (5-8), p = 0.72; HADS - depression component: 1 (1-6) vs. 2 (1-4), p=0.89); PANAS - negative component: 14 (11-21) vs. 14 (11-20), p = 0.98; PANAS - positive component: 37 (31-41) vs. 36 (34-37), p = 0.78]. In the clinical trial by Jaarsma et al.[18], the EG and CG were similar at the beginning of the study (HADS - anxiety component: 5.22 ± 3.7 vs. 5.26 ±3.9, HADS - depression component: 5.36 ± 4.3 vs. 5.76 ± 4.2). Depression was assessed in the study by Garcia et al.[17] using the Beck Depression Inventory-II (BDI-II). There was a significant reduction in depression in the EG before and after the interventions (p = 0.012), with a moderate effect size (> 0.50), but no difference between groups (pre- and post-intervention, p = 0.08 and p = 0.42, respectively).

Motivation and satisfaction

A total of 64% of participants in one of the studies reported being motivated to continue performing the intervention with games after the end of the study[22]. In another study, there was no difference between EG and CG in the mean value of motivation for exercise after the protocol[18]. The authors of the clinical trial[17] investigated the degree of satisfaction using the Client Satisfaction Questionnaire, with a small difference between the total score in EG and CG: 31.60 ± 0.96 and 30.70 ± 2.86 points, respectively. However, in a specific questionnaire about satisfaction with the treatment with virtual reality and video games, the EG had a mean of 82.5 ± 8.33 in 90 points. Participants of the EG of a crossover trial[25] showed a significant reduction in motivation from the beginning to 12 weeks of the protocol and a significant increase when exergaming was

removed from the intervention in the following weeks. The CG did not show significant changes in motivation throughout the protocol.

Distance covered in the 6MWT

The average distance covered by the sample of the pilot study[21] increased from 501 ± 95 m to 521 ±101 m and a difference of 30 meters was found in 53% of the patients in 12 weeks. Patients who increased their walking distance in the 6MWT were in a lower New York Heart Association (NYHA) functional class and and had been diagnosed for a significantly shorter period of time compared to patients who decreased their walking distance (44% NYHA II, p value = 0.021; 22% diagnosed within the test last year, p-value = 0.043)[21]. In the study by Jaarsma et al.[18], a significant difference was found in the 6MWT in the 3rd month of the protocol, favoring the EG (454 ± 123 m vs. 420 ± 127 m, 95% CI 8.8-48, 9; p = 0.005). In the 6th month the difference was 452 m vs. 426 m, from IG to CG (95% CI 5.1-47.6; p = 0.015) and in the 12th month, 456 vs. 420 m (CI 10.2 - 54.2; p = 0.004). However, there was no effect of the intervention on the distance covered in the 6MWT after correction for the initial test and confounding factors. In three months, the mean change in distance covered was 16 m in the EG and 15 m in the CG[18]. In the intragroup analysis, the EG of the clinical trial[17] had a large effect size (> 0.8) for the distance covered in the 6MWT (median 457.80 m to 513.00 m, p = 0.005), but no difference was found in the final distance compared to the CG (p = 0.97).

Safety

Three studies analyzed the safety of using exergaming. In one of them[15] there was no significant difference between CG and EG regarding adverse medical events (0 vs. 1, p = 1.00). Jaarsma et al.[18] reported that there were no major adverse events related to the use of exergaming. No adverse effects were found in GC and EG in another clinical trial[17]

DISCUSSION

This study found a positive intragroup effect of exergaming on the adherence of patients to the CVR program.

Patient are considered adherent to CVR when they participate in least 80% of the stipulated treatment and non-adherence when they participate in less than 20%[26]. In one of the clinical trials[18], approximately 60% of the individuals in the EG was > 80% adherent to the recommended playing time. The average time of use of exergaming was higher than recommended in the study by Klompstra et al[21]. In three studies[22–24], the average adherence to sessions was 77%. All EG participants in another clinical trial[17] showed adherence, with 100% attendance. In a pilot study[15], the median attendance to CVR sessions was 96%. Thus, it was observed that exergaming resulted in satisfactory adherence, especially in phase II CVR studies. This can be explained by the greater supervision typical during this phase.

According to the World Health Organization, several factors related to the patient, social and economic issues, the health system, the patient's clinical condition, and the therapy used interfere with adherence[26]. One of the patient-related factors that can interfere

with exercise adherence is age group[6,7,27]. The mean age of participants in the intervention group with exergaming in the reviewed studies ranged from 48.7 to 66 years. Three studies used an age-range between 40 and 75 years as inclusion criterion[22–24]. It was observed that the mean age in these three studies was lower than in the others (55 ± 9.0 vs. 66 ± 1218, for example). There is evidence that patients aged 70 years and older adhere less to exercise[6]. However, other studies indicate that being older is associated with better adherence to exercise[27], with a peak of adherence between 50 and 65 years[28], and that being young can be considered a barrier to adherence to CVR[7].

Being female has been indicated as a possible predictor of exercise dropout[29]. In some of the studies included, the sample consisted only of male individuals[22–24], which may have influenced the satisfactory adherence found. Other studies[15,18] showed a predominance of male participants. Although the EG participants of one of the clinical trials[15] showed an increase in physical activity practice, there was no significant change in the number of participants who reported being physically inactive during the protocol in the multicenter study[18].

A total of five of the analyzed studies addressed CVR at the participant's home. Although home CVR is commonly indicated for patients at lower clinical risk[30,31], one of the studies[18] included patients with NYHA IV functional class. Presenting classification IV or III is considered a barrier to adherence to CVR when compared to class II[7]. However, the groups analyzed in this study were homogeneous in this aspect at the beginning of the protocol, with two functional class IV patients allocated to the EG and two to the CG. After 6 months, 246 of the 305 EG participants were analyzed. There were three losses due to medical reasons and two due to death. However, adverse events did not occur exactly during the use of exergame[18].

Other aspects considered as barriers to exercise are the short baseline distance covered in the 6MWT and the low VO_2 peak.[15] Three studies included in this review evaluated exercise capacity using the 6MWT6[17,18,21]. At the beginning of the protocol, the mean distance covered by EG and CG participants was 413 ± 139 m and 393 ± 144 m in one of these studies; in another, the median was 457.80 m and 462.30 m[17], respectively. Similar to the initial walked distance, no significant difference was found between the groups in the follow-up of the protocol regarding motivation and self-efficacy[21] or with respect to the degree of satisfaction with treatment[17]. However, in one study[17], EG participants presented an average satisfaction score with the treatment with virtual reality and video game close to the maximum (82.50 ± 8.33 of 90 points), with 100% adherence to CVR sessions.

Emotional aspects such as anxiety and depression also influence adherence. Higher HADS score is a predictor of early CVR dropout[28]. In two studies[15,18], EG and CG had similar HADS scores at the beginning of the protocol. Thus, it is unlikely that these psychological aspects influenced the adherence values found. And in the pilot study[15], there was a lower tendency to discontinue CVR in the EG, despite similar

individual attendance medians between EG and CG.

After the intervention protocol, no significant difference was found between EG and CG as to the effect of the treatment on the distance covered in the 6MWT, after correction of baseline values and confounding factors in in the study by Jaarsma et al.[18]. Furthermore, the mean change in the distance covered in the test was not clinically significant (greater than 30 m)[32] in any of the groups. It is important to emphasize that energy expenditure varies according to the chosen game[33]. For example, among Wii Sports games, golf and boxing make the participants to achieve, respectively, lower and higher metabolic equivalents (2 ± 0.3 vs. 4.2 ± 0.9). In the study by Jaarsma et al[18], the participants were allowed to choose the game, and most preferred the bowling game, which reaches 2.7 ± 0.6 metabolic equivalents. This intensity may have influenced the treatment effect. However, it is known that the freedom to choose the exercise itself has the potential to promote greater adherence to CVR[25].

It is important to emphasize the distinct characteristics of the games used in the analyzed studies. Among those performed at home, three used the RehabPlay software, which applies a protocol with 10 exercises and covers warm-up, conditioning, and flexibility training[22–24]. This program was more diverse than that of other studies carried out at home, which used the Nintendo Wii[18,21] and, thus, possibly had greater potential to promote different physical benefits. However, we do not know the workload, in metabolic equivalents, achieved in the games offered in this software.

The greater the individual's interest in the active video game, the better the possibility that they spend more energy because the level of pleasure and involvement with the exergame is associated with energy expenditure[34]. However, when compared with traditional interventions, although exergaming promotes greater pleasure and less perceived effort, walking on a treadmill can provide more moderate-to-vigorous physical activity[35]. However, accessing a treadmill can be more difficult than accessing an active video game in the home environment for RCV.

The studies included in this review had samples composed of patients with coronary artery disease or heart failure. These are populations commonly studied in the context of CVR[30]. However, the variation in the sample size of the studies hinders the interpretation of the results, as three of the studies had an intervention group with only 11 participants[22–24]. In only one of the studies[18] there was a robust sample of 605 patients, of whom 300 were allocated to the control group and 305 to the intervention group. However, the sample was heterogeneous in terms of functional capacity and ejection fraction of the participants.

This systematic review has limitations, such as the reduced number of studies analyzed, what resulted from the lack of articles on the theme. Another limitation was the inclusion of two uncontrolled studies and some studies of low methodological quality. Thus, daution should be exercised in the interpretation of the results found.

CONCLUSION

The best available evidence suggests a positive effect of exergaming on CVR patient adherence to CVR. There was a predominance of more than 80% of adherence to the sessions of the protocols studied in the groups that performed exergaming. However, the difference in adherence was not significant when compared to a control group (no exercise or controls with another intervention) in most of the analyzed studies.

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Appendix 1. Search strategies used.

1 - (((((((((((("Heart Diseases"[MeSH Terms]) OR (Heart Disease)) OR (Cardiac Diseases)) OR (Cardiac Disease)) OR (Cardiac Disorders)) OR (Cardiac Disorder)) OR (Heart Disorders)) OR (Heart Disorder)) OR (((("Cardiovascular Diseases"[MeSH Terms]) OR (Cardiovascular Disease)) OR (Disease, Cardiovascular)) OR (Diseases, Cardiovascular))) AND (((((((("Virtual Reality Exposure Therapy"[MeSH Terms]) OR (Virtual Reality Immersion Therapy)) OR (Virtual Reality Therapy)) OR (Reality Therapies, Virtual)) OR (Reality Therapy, Virtual)) OR (Therapies, Virtual Reality)) OR (Therapy, Virtual Reality)) OR (Virtual Reality Therapies)) OR (("Virtual Reality"[MeSH Terms]) OR (Reality, Virtual)) OR (((exergame) OR (exergames)) OR (exergaming))) AND (Intervention Study)

2 - Cardiovascular Diseases AND Virtual Reality

3 - Cardiac Rehabilitation AND Virtual Reality

4- Heart Disease AND Virtual Reality