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CAN EXERGAMES LOWER BLOOD PRESSURE AND ENHANCE CARDIOVASCULAR HEALTH? A SYSTEMATIC REVIEW

OS EXERGAMES PODEM REDUZIR A PRESSÃO ARTERIAL E MELHORAR A SAÚDE CARDIOVASCULAR? UMA REVISÃO SISTEMÁTICA

¿PUEDEN LOS EXERGAMES REDUCIR LA PRESIÓN ARTERIAL Y MEJORAR LA SALUD CARDIOVASCULAR? UNA REVISIÓN SISTEMÁTICA

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Abstract

Objective: To systematically review the scientific evidence on the effects of exergames on blood pressure and cardiovascular outcomes. Methods: A systematic review was conducted between January and June 2024, following PRISMA guidelines. Searches in six databases (PubMed, PEDro, Web of Science, VHL, ACM Digital Library, and Cochrane Library) initially yielded 575 studies, from which 10 clinical trials met the inclusion criteria for analysis. Results: The findings revealed that exergames are at least as effective as conventional physical exercise in managing hypertension. Significant reductions were reported in both systolic and diastolic blood pressure, alongside improvements in other cardiovascular markers like heart rate and fitness. These benefits were observed across different ages, genders, and even in individuals with comorbidities. Conclusion:

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Exergames represent a viable, safe, and engaging non-pharmacological tool for managing and preventing hypertension, capable of complementing or even surpassing traditional exercise programs as a versatile strategy for improving cardiovascular health.
Keywords: Video Games; Blood Pressure; Exercise; Cardiovascular Diseases.

Resumo

Objetivo: Revisar sistematicamente as evidências sobre os efeitos dos exergames na pressão arterial e nos desfechos cardiovasculares. Método: Uma revisão sistemática foi conduzida entre janeiro e junho de 2024, seguindo as diretrizes PRISMA. As buscas em seis bases de dados (PubMed, PEDro, Web of Science, BVS, ACM Digital Library e Cochrane Library) resultaram inicialmente em 575 estudos, dos quais 10 ensaios clínicos atenderam aos critérios de inclusão para análise. Resultados: Os achados revelaram que os exergames são, no mínimo, tão eficazes quanto o exercício físico convencional no manejo da hipertensão. Reduções significativas foram reportadas tanto na pressão arterial sistólica quanto na diastólica, juntamente com melhorias em outros marcadores cardiovasculares, como frequência cardíaca e aptidão física. Esses benefícios foram observados em diferentes idades, gêneros e mesmo em indivíduos com comorbidades. Conclusão: Os exergames representam uma ferramenta não farmacológica viável, segura e engajadora para o manejo e a prevenção da hipertensão, sendo capazes de complementar ou até superar os programas de exercício tradicionais como uma estratégia para melhorar a saúde cardiovascular.
Palavras-chave: Videojogos; Pressão Arterial; Exercício Físico; Doenças Cardiovasculares.

Resumen

Objetivo: Revisar sistemáticamente la evidencia científica sobre los efectos de los exergames en la presión arterial y los resultados cardiovasculares. Método: Se realizó una revisión sistemática entre enero y junio de 2024, siguiendo las directrices PRISMA. Las búsquedas en seis bases de datos (PubMed, PEDro, Web of Science, BVS, ACM Digital Library y Cochrane Library) produjeron inicialmente 575 estudios, de los cuales 10 ensayos clínicos cumplieron los criterios de inclusión para el análisis. Resultados: Los hallazgos revelaron que los exergames son, como mínimo, tan efectivos como el ejercicio físico convencional en el manejo de la hipertensión. Se reportaron reducciones significativas tanto en la presión arterial sistólica como en la diastólica, junto con mejoras en otros marcadores cardiovasculares como la frecuencia cardíaca y la aptitud física. Estos beneficios se observaron en diferentes edades, géneros e incluso en individuos con comorbilidades. Conclusión: Los exergames representan una herramienta no farmacológica viable, segura y atractiva para el manejo y la prevención de la hipertensión, capaces de complementar o incluso superar los programas de ejercicio tradicionales para mejorar la salud cardiovascular.
Palabras clave: Juegos de Video; Presión Arterial; Ejercicio Físico; Enfermedad Cardiovascular.

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1. INTRODUCTION

Arterial hypertension (AH) is a non-transmissible chronic multifactorial disease associated with functional, structural, and metabolic changes (Malachias et al., 2016). It is an asymptomatic disorder characterized by elevated pressure in the arteries, with an average of 140 mmHg in systolic pressure or more and 90 mmHg or more in diastolic pressure (Freitas et al., 2020). Drug therapy is the primary measure to control AH (Whelton et al., 2018). However, studies have demonstrated the effectiveness of non-pharmacological therapies for reducing blood pressure and sympathetic nervous system activity, including dietary modifications, regular physical exercise, self-monitoring of blood pressure, and other behavior and lifestyle health habits (Gkaliagkousi; Gavriilaki; Douma, 2015; Hering et al., 2013; Do Amaral Sartori et al., 2018; Volpi et al., 2021; Martins; Goessler; De Marchi, 2022; O'Neil et al., 2018). Non-pharmacological treatment is an essential resource, especially for patients with resistant or refractory hypertension when medication is ineffective.

AH is a severe public health problem since about a third of patients have not yet been diagnosed, and about half do not follow the treatment properly (Kitt et al., 2019). In addition to low adherence to pharmacological treatment (~40 to 60% adherence) (Kitt et al., 2019), patients with hypertension are also less adherent to regular exercise when compared to normotensive individuals (Singh; Keer, 2020). The costs of AH to the Unified Health System (SUS) are also expressive. In 2018, estimated hospitalizations, outpatient procedures, and medication expenses for hypertensive patients were US$ 523.7 million (Nilson et al., 2020).

Strategies should be developed to prevent, monitor, and encourage disease control, to reduce these costs (Bakris; Ali; Parati, 2019). In this sense, the practice of physical exercise is globally recommended as a first-line approach for the treatment of AH (Whelton et al., 2018), contributing positively to its improvement (Freitas et al., 2020; Cassiano et al., 2020; Costa et al., 2018; Sabbahi et al., 2016), even in patients with resistant hypertension (Lopes et al., 2021; Saco-Ledo

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et al., 2022). Aerobic training is superior to resistance training in improving blood pressure (Huang et al., 2013; Pescatello et al., 2015). In addition, other exercise modalities can also be beneficial, such as high-intensity interval training and medium-intensity training (Leal; Galliano; Del Vecchio, 2020). However, the authors of a recent systematic review state that well-designed studies are needed to assess the role of different volumes, intensities, and types of physical training with long-term intervention in improving the health of patients with AH (Lu et al., 2022).

The regular practice of exercise is influenced by different personal, social, and environmental factors, and lack of motivation is reported as one of the main barriers (Trost et al., 2002). In this sense, attractive exercise modalities, such as exergames, should be incorporated, which have been used systematically. Exergames are also known as electronic motion games, which aim to increase the practice of physical activity through body movements (Viana; De Lira, 2020).
Positive results on the effectiveness of exergames were found in improving motor coordination, endurance, muscle strength (Henrique; Colussi; De Marchi, 2019; Cordeiro et al., 2020; Stanmore et al., 2019), balance (Ku et al., 2019; Padala et al., 2017), increased motivation and satisfaction during sessions, with greater adherence to treatment (Da Silva et al., 2017) and in the acute improvement of blood pressure and cardiovascular variables of hypertensive patients (Da Silva et al., 2018).

In this context, exergames have developed as a promising approach to increase physical activity levels and enable a pleasurable exercise experience, as they encourage an active gaming experience, creating new opportunities to expand the practice of exercise in different settings and age groups (Lins et al., 2023). In view of this, the present systematic review aimed to seek evidence regarding the effects of exergames on blood pressure and other cardiovascular variables in adults and elderly individuals and compare their impact with established exercise protocols.

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2. METHODS

This study was conducted and reported following the PRISMA statement for reporting systematic reviews and meta-analyses (Page et al., 2021). This study had two key questions: What are the effects of exergames on blood pressure in adults and the elderly? Do exergames affect cardiovascular variables similarly to physical exercises/kinesiotherapy?

2.1. Search Strategy

Keywords for investigation were defined using the authors' knowledge based on the research problem and question. Synonyms were consulted in DeCS Health Sciences Descriptors and medical subject headers (MeSH) to compose the search string according to Population, Interest, Context strategy (PICo) (Lockwood; Munn; Porritt, 2015). The search string used is presented in Table 1. The first set lists the population related to hypertension, the second set lists terms related to games, and the third set addresses the outcome of physical activity.

Table 1. Search terms used.

P - Population	I - Interest	Co - Context
Hypertension	Game	Kinesiotherapy
Blood pressure	Exergame	Physiotherapy
arterial pressure	Video game	Physical activity
high pressure		Physical Exercise
		Physical therapy
		Exercise

The search was conducted between January and July 2024 within electronic databases PubMed, PEDro Physiotherapy Evidence Database, Web of Science, Virtual Health Library (VHL), ACM Digital Library, and Cochrane Library. The search expression remained unmodified for all databases, considering the specifications of each search engine. All primary studies published until the date of the database search were considered. There were no language or timeframe restrictions.

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These databases were selected because they aggregate considerable work within the research area considered (human-computer interaction) and are available within the educational institution where the RSL was developed. It should be noted that each engine has a particular syntax in its search string structure, requiring adaptations to each one (Da Costa et al., 2018; Law; Brühlmann; Mekler, 2018).

2.2. Eligibility Criteria

For the selection of studies, the following criteria were considered:

1. Studies use an exergame combined with a kinesiotherapy intervention protocol, which involved physical activity/exercise in healthy individuals or individuals with comorbidities.
2. Studies use of the exergame in the search for answers about cardiovascular variables.
3. Blood pressure is one of the outcomes evaluated in the study.

2.3. Study selection process

The study selection process was structured in four stages:

Step 1 – Identification of searches in the selected databases, excluding duplicates.

Step 2 - Reading the title and abstract of the studies found in the databases according to the eligibility criteria.

Step 3 – Full reading of the articles selected in step 2, to determine the articles to include in the study.

Stage 4 - Eligibility: Full reading of selected articles was performed to determine eligible articles for inclusion.

The review process was conducted by pairs of independent reviewers (title and abstract eligibility process, full-text reading, and data extraction). Any disagreement during the process was resolved by consensus, referring to the original articles. The Mendeley reference manager software was used to organize the papers and exclude duplicates.

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2.4. Data Extraction and Analysis

Using a standardized extraction form, baseline data extracted from included studies were authors, year of publication, country, study design, sample size, age of participants, duration of protocol (in weeks), frequency and time of sessions, tools used, types of games, results on blood pressure and cardiovascular variables evaluated. After data extraction, the forms were cross-checked to verify the consistency of the extracted information.

3. RESULTS

A total of 575 studies were retrieved in the initial database search, from which 91 were excluded for being duplicates. A further 451 studies were peer-excluded from the remaining 484. Four studies were searched for retrieval, but these could not be retrieved. After the peer exclusion, 33 studies were evaluated according to the eligibility criteria selected in the first screening. In the second screening, 23 studies were excluded for not meeting the eligibility criteria. After completing the final stage (eligibility), 10 studies were included in this review (Figure 1).

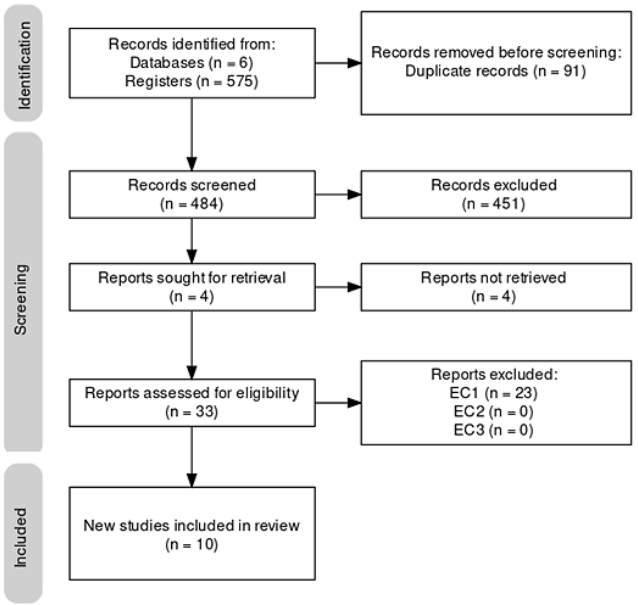

Figure 1. Selection process flow diagram.

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Table 2 shows the characteristics of the studies included, such as the origin and type of study, aspects about the study participants, intervention time, frequency of sessions, main tools used, type and time of the exergame, as well as the results on blood pressure and other cardiovascular variables. The included publications varied in origin, design, participant characteristics (e.g., healthy normotensives versus individuals with comorbidities), intervention lengths, frequencies of exergame sessions, and measurement tools for physiological indicators. Aerobic exercises of moderate intensity appeared as a unifying theme across all protocols, ranging from dance activities to simulated sports like bowling and walking, while some studies incorporated resistance components. Table 2 presents an overview of these protocols, detailing the type and duration of exergames, primary instruments for data gathering, and key outcome variables.

4. DISCUSSION

Per the findings, six of the ten included studies reported statistically significant decreases in blood pressure following the exergame protocols. Five studies (Da Silva et al., 2018; Alves da Cruz et al., 2020; Kircher et al., 2022; Lee et al., 2015; Li et al., 2021) explored acute adaptations, ranging from 1–3 sessions per week, and five (Huang et al., 2021; Tollár et al., 2021; Carvalho et al., 2020; Santana et al., 2016; Mejia Dows et al., 2011) focused on chronic cardiovascular responses. Despite the variety of age groups and comorbidities represented, outcomes remained favorable in both acute and longer-term interventions. For example, three chronic-effect studies (Tollár et al., 2021; Carvalho et al., 2020; Santana et al., 2016) detected pressure reductions in participants regardless of comorbidity status, suggesting that the presence of underlying health issues did not hamper exergame effectiveness.

Table 2. Summary of included studies for analysis.

Study	Country	Type	Age	Sample	Duration (weeks)	Frequency of sessions (per week)				Main Tools used							Session time	Type of game		Blood pressue outcome		Cardiovascular variables analyzed			
						1	2	3	More than 3	Nintendo Wii	X box	Exercube	Joystick (keyboard)	Wii Sports	IVDG (virtual reality)	Kinect Sports	Minutes	Commercial games	Proprietary	BP increased	Reduced BP	Heart rate	Peripheral oxygen saturation	Subjective perception of effort	Cardiovascular fitness
Da Silva et al. 2018	Brazil	Randomized controlled	≥ 47	14	2		✓				✓						40	✓			✓	✓			
Huang et al. 2021	EUA	Pilot study	≥ 36	8	8		✓			✓	✓						60	✓				✓		✓	✓
Alves da Cruz et al. 2020	Brazil	Crossover	≥ 63	27	1		✓				✓						85	✓				✓	✓	✓	
Kircher et al. 2022	Germany	Crossover	≥ 24	28	1		✓					✓					30		✓		✓	✓			
Tollár et al. 2021	Hungary	Pseudo randomized	≥ 61	641	5				✓			✓					60	✓			✓	✓			✓
Carvalho et al. 2020	Brazil	Randomized controlled	≥ 32	35	7			✓		✓							60	✓			✓	✓	✓	✓	✓
Lee et al. 2015	Korea	Almost experimental	≥ 65	15	12		✓						✓				15	✓	✓	✓		✓			✓
Li et al.2021	China	Randomized clinic	≥ 60	23	1			✓						✓		✓	15	✓		✓		✓		✓	
Santana et al. 2016	Brazil	Randomized clinic	≥ 60	16	8			✓		✓							30	✓			✓	✓	✓		✓
Mejia Dows et al. 2011	EUA	Non-randomized clinic	≥30	27	6			✓									50	✓				✓			

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Comorbidities similarly did not offset acute pressure improvements; one study (Da Silva et al., 2018) observed post-exercise hypotension in hypertensive subjects, another (Alves da Cruz et al., 2020) in cardiac rehabilitation patients, and yet another (Kircher et al., 2022) in healthy individuals. Only one pilot trial (Huang et al., 2021) failed to find statistical significance, likely from limited sample size, although it did record trends toward lower pressure in participants with type 2 diabetes mellitus. Exergames that remained brief in duration, such as 15-minute sessions (Lee et al., 2015; Li et al., 2021), tended to deliver less robust cardiovascular benefits compared to interventions lasting longer.

Multiple investigations have emphasized that total exercise time and aerobic intensity are decisive factors for eliciting meaningful post-exercise hypotension (Pescatello; Kulikowich, 2001; Pescatello et al., 2004; World Health Organization, 2020). Indeed, protocols employing aerobic exercise (65–75% heart rate reserve) for 90–150 minutes weekly are thought to reduce systolic pressure by approximately 5–8 mmHg (Bakris; Ali; Parati, 2019; Perrier-Melo et al., 2020), and these principles underlie the most successful outcomes in the studies at hand. Meanwhile, some research has integrated resistance exercises into exergaming protocols and also documented blood pressure improvements (Alves da Cruz et al., 2020; Kircher et al., 2022; Tollár et al., 2021), which aligns with earlier findings by Bakris, Ali and Parati (2019).

Although the conversation primarily revolved around blood pressure, other cardiovascular measures such as heart rate, peripheral oxygen saturation, perceived exertion (BORG scale), and functional capacity (step test, six-minute walk test—6MWT) received attention as well. Several investigations determined that exergames provoke cardiovascular changes analogous to standard physical exercise, often with similar or even more pronounced improvements in key indicators. In older adults, for instance, Santana et al. (2016) showed that exergames significantly lowered HR and elevated 6MWT performance, matching outcomes of traditional training. Li et al. (2021) reported that exergaming corresponded to light-intensity exercise with minimal discomfort, reinforcing its tolerability in aging populations. Klompstra, Jaarsma and Strömberg (2014)

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observed no adverse events and supported exergames' safety profile in older cohorts, broadening their potential applicability to rehabilitation and health promotion settings.

In both younger and older individuals, exergames sometimes triggered higher HR peaks, as noted by Tollár et al. (2021), which might reflect more dynamic movement patterns and heightened peripheral vascular adaptations (MacDonald; Pescatello, 2019). Cardiac rehabilitation patients additionally benefited: Alves da Cruz et al. (2020) recorded elevated HR, respiratory rate, and exertion levels comparable to traditional CR sessions but reported an acute pressure-lowering effect. Da Silva et al. (2018) similarly found that a single session of active exergaming elicits blood pressure reductions on par with walking.

Evidence from all 10 studies underscores that exergames can function as viable alternatives to conventional exercise programs, with some protocols effectively matching or surpassing standard exercise in lowering cardiovascular risk factors. Although most research has emphasized aerobic modalities, these positive findings extend to combined aerobic-resistance strategies. This reveals multiple avenues for future studies, which might further refine exergaming interventions to optimize improvements in vascular function and arterial compliance. The variety of sample populations, durations, intensities, and game types ultimately showcases exergames' flexibility and capacity to match traditional exercise's protective effect on cardiovascular health, especially when exercise guidelines (e.g., sufficient session lengths and moderate intensities) are satisfied.

Limitations of the present systematic review include the heterogeneity of the sample, with very different comorbidities. In addition, the protocols used varied greatly in terms of the number of sessions, time and types of exercise, which may make it difficult to attribute positive effects to a specific variable.

5. CONCLUSION

Collectively, the reviewed studies suggest that physical exercise protocol with exergames produces similar or even more expressive beneficial effects on blood pressure and other cardiovascular variables in healthy individuals and those with

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comorbidities, regardless of gender and age, compared to conventional exercise protocols. Although the use of a exercise protocol with exergames is a promising alternative for the management of AH and the improvement of other cardiovascular variables, studies that report the effects of exergames on the blood pressure of normotensive and hypertensive individuals are scarce, especially those concerning resistance exercises. Therefore, future studies must elucidate the impact of different exercise modalities with exergames on cardiovascular variables in diverse populations.

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CONFLICT OF INTEREST

The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript.

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