Effects of active videogames added to conventional exercise on cognitive function in older adults: a randomized trial

Efectos de los videojuegos activos adicionados al ejercicio convencional sobre la función cognitiva en adultos mayores: un ensayo aleatorizado

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Abstract

Introduction: Cognitive decline in older adults negatively affects independence and health-related quality of life (HRQoL). Integrating physical and cognitive stimuli through active videogames (AVGs) may enhance the benefits of conventional physical exercise (CPE).
Objective: To evaluate the effects of adding AVGs to a CPE program on cognitive function and HRQoL in community-dwelling older adults.
Methodology: A controlled trial with two parallel groups was conducted. Fifty participants aged 60–84 years were randomly assigned to an intervention group (IG: CPE+AVG) or a control group (CG: CPE alone) for eight weeks (two sessions/week). Cognitive function (primary outcome) was assessed with the Montreal Cognitive Assessment (MoCA), and HRQoL (secondary outcome) with the Short Form Health Survey Version 2 (SF-12v2).
Results: Both groups led to improvements across several cognitive domains; however, the IG showed significantly greater gains in language, delayed recall, and global cognitive function (all $p<0.05$). The proportion of participants with normal cognitive function increased by 36% in the IG ($p=0.003$) versus 12% in the CG ($p>0.05$). Compared with the CG, the IG showed significant improvements in both the physical and mental health dimensions of HRQoL (all $p<0.05$).
Conclusions: The findings suggest that adding AVGs to CPE may enhance cognitive function and HRQoL more effectively than CPE alone. AVGs appear to be a safe, engaging, and promising adjunct to promote cognitive health and well-being in older adults.

Keywords

Aged; cognitive function; exergaming; health-related quality of life.

Resumen

Introducción: El deterioro cognitivo en los adultos mayores afecta negativamente la independencia y la calidad de vida relacionada con la salud (CVRS). La integración de estímulos físicos y cognitivos mediante videojuegos activos (VJA) podría potenciar los beneficios del ejercicio físico convencional (EFC).
Objetivo: Evaluar los efectos de adicionar VJA a un programa de EFC sobre la función cognitiva y la CVRS en adultos mayores que viven en la comunidad.
Metodología: Se realizó un ensayo controlado con dos grupos paralelos. Cincuenta participantes de 60-84 años fueron asignados aleatoriamente a un grupo intervención (GI: EFC+VJA) o a un grupo control (GC: solo EFC) durante ocho semanas (dos sesiones/semana). La función cognitiva (resultado primario) se evaluó con el Montreal Cognitive Assessment (MoCA), y la CVRS (resultado secundario) con la versión 2 del Short Form Health Survey (SF-12v2).
Resultados: Ambos grupos mostraron mejoras en varios dominios cognitivos; sin embargo, el GI presentó incrementos significativamente mayores en lenguaje, recuerdo diferido y función cognitiva global ($p<0.05$). La proporción de participantes con función cognitiva normal aumentó en un 36% en el GI ($p=0.003$) frente a un 12% en el GC ($p>0.05$). En comparación con el GC, el GI mostró mejoras significativas en las dimensiones física y mental de la CVRS ($p<0.05$).
Conclusiones: Los hallazgos sugieren que añadir VJA al EFC puede mejorar la función cognitiva y la CVRS de manera más efectiva que el EFC por sí solo. Los VJA parecen ser un complemento seguro, atractivo y prometedor para promover la salud cognitiva y el bienestar en adultos mayores.

Palabras clave

Adultos mayores; función cognitiva; videojuegos activos; calidad de vida relacionada con la salud.

Introduction

Population aging is a complex global phenomenon that poses significant challenges for individual well-being, healthcare systems, and society (He et al., 2023). In older adults, cognitive decline is a major health issue, as it increases the risk of dependency and negatively affects health-related quality of life (HRQoL) (He et al., 2023; Pan et al., 2015). Therefore, the implementation of strategies that promote successful cognitive aging and functional independence is crucial (Fernández et al., 2025).

Physical exercise exerts a positive influence on cognitive function, regardless of baseline cognitive status. Specifically, a meta-analysis indicates that it enhances executive functions, including working memory, cognitive flexibility, and inhibitory control, in cognitively healthy older adults (Xiong et al., 2021). It also improves global cognitive function, executive function, and delayed recall in individuals with mild cognitive impairment (Biazus-Sehn et al., 2020). Importantly, interventions integrating cognitive and physical components, particularly those applied simultaneously or interactively, lead to superior improvements in executive functions, processing speed, and global cognition compared to single-domain interventions (Rieker et al., 2022). In this context, virtual reality-based physical exercise has also shown promise, with studies reporting improvements in inhibition and overall cognitive performance in individuals with and without cognitive impairment (Sakaki et al., 2021). Beyond cognitive benefits, physical exercise also contributes to improvements in HRQoL among older adults with mild cognitive impairment, likely due to the interplay of multiple physical, mental, social, and emotional factors (Song & Yu, 2019).

Despite the well-established benefits of physical exercise, low adherence remains a serious barrier among older adults (Cigarroa et al., 2022). Factors influencing adherence include program structure, professional supervision, social support, enjoyment, and technological integration (Collado-Mateo et al., 2021). Additionally, motivation plays a key role, as participation is often driven by individuals' perceived health status and by the belief that exercise can restore function and improve daily living (Stødle et al., 2019). In this context, promoting regular physical exercise remains a challenge, and active videogames (AVGs), or exergames, have emerged as an innovative, engaging, and effective approach to exercise.

AVGs combine digital gaming with physical activity, requiring players to perform body movements that are continuously translated into game inputs, thereby simultaneously engaging motor and cognitive domains through integrated demands on motor execution, attention, information processing, and decision-making. This concurrent engagement generates dual-task–like conditions, in which physical actions must be performed while processing cognitively challenging stimuli (Costa et al., 2019; Yang et al., 2023), a characteristic that is not typically present in conventional physical exercise programs and that may explain the added value of AVGs as a complementary training modality. These games utilize various motion-based technologies, including sensors, cameras, and interactive platforms based on immersive or non-immersive virtual reality systems (Fusco & Tieri, 2022). While immersive systems (e.g., head-mounted displays) enhance the sense of presence in virtual environments, their widespread adoption in exercise settings is limited due to potential side effects including motion sickness and visual discomfort, collectively known as cybersickness (Cossio et al., 2025). Consequently, AVG interventions using non-immersive virtual systems provide a promising alternative for older adults, as they offer greater comfort, ease of use, and applicability across diverse clinical and community settings (Ren et al., 2024).

Several controlled trials have supported the positive effects of AVGs and conventional physical exercise (CPE) on global cognitive function and specific domains including attention, memory, and executive functions (Bacha et al., 2018; Carrasco et al., 2020; Gouveia et al., 2021; Gui et al., 2024; Liao et al., 2021; Moret et al., 2022). However, several reviews emphasize that although AVGs, used either as standalone interventions or as adjuncts to CPE, are safe and well tolerated, further research is required to establish their efficacy in improving cognitive function (Cai et al., 2023; López-Nava et al., 2023; Manser et al., 2024; Soares et al., 2021). Furthermore, examining changes in cognitive performance levels based on previously reported cut-off points in the literature (Gaete et al., 2023) is an approach that, to the best of our knowledge, has not been previously addressed in clinical trials in this field. Therefore, this study aimed to evaluate the effects of adding AVGs to a CPE program on cognitive function and, secondarily, on HRQoL in community-dwelling older adults.

Method

Design and participants

This study, which forms part of a larger project that included the assessment of physical performance variables, was designed as a two-arm, parallel-group randomized controlled trial (RCT), in which one group received a CPE plus AVG intervention (intervention group, IG), while the other received CPE alone (control group, CG). The study protocol was approved by the Scientific Ethics Committee of the Concepción Health Service (code: 18-06-35), and all participants provided written informed consent. The inclusion criteria were community-dwelling men and women aged 60 to 84 years with independent walking ability, normal or corrected vision and hearing, and without contraindications or limitations that would prevent engagement in physical exercise. Persons with uncontrolled chronic diseases or musculoskeletal, neurological, or cognitive conditions that could hinder the proper use of AVGs were excluded. Participants were recruited from a community-based active aging center in Concepción, Chile.

Experimental procedures

An investigator independent from the recruitment process generated a simple random allocation sequence with a 1:1 ratio and concealed the assignments until the start of the interventions. Sample size estimation using G*Power 3.1.9.7 indicated that 46 participants would be required to detect a moderate effect size (ES), with $\alpha = 0.05$ and $1\text{-}\beta = 0.8$. In total, 50 participants were recruited to ensure sufficient statistical power and compensate for potential losses during the study.

Before starting the interventions, sociodemographic characteristics including age, sex, height, weight, body mass index, and educational level were recorded to characterize the sample. The interventions supervised by two professionals were conducted twice a week for eight weeks (16 sessions in total). The intensity of both CPE and AVG exercises was monitored using a 0–10 rating of perceived exertion scale (Liguori, 2021), maintaining a moderate intensity (5–6) during the first four weeks, which was progressively increased to vigorous intensity (7–8) from weeks five to eight to ensure exercise progression.

The CG followed a structured session plan divided into three phases. First, the warm-up lasted five minutes and included free joint mobility exercises. Next, the main phase lasted 50 minutes and consisted of four components: i) aerobic activities such as stair climbing and stationary cycling, ii) general flexibility exercises involving controlled stretching on mats or in a standing position, iii) muscle strengthening for the limbs and trunk using elastic bands, dumbbells, and bodyweight exercises, and iv) postural balance training on unstable surfaces, alternating single-leg support and tandem walking. Each component was performed for 10 to 12 minutes, with a two-minute rest period between them. Finally, the session concluded with a five-minute cool-down phase incorporating free joint movements and breathing exercises.

The IG followed the same session structure as the CG, with an additional 30-minute AVG component after a 5-minute rest period. A total of eight games (Happy Fish, Take a Pineapple, Dance Fun, Balance Ball, Step by Step, Plane, Apple Juice, and Party Bubbles) were selected from the Kinemotion platform (kinemotion.cl/), which operates with the Kinect sensor (Microsoft Corp., Redmond, WA). These games involved coordinated movements of the upper and lower limbs through diverse motor tasks that combined aerobic, strength, coordination, and balance demands. For example, Dance Fun required participants to step on illuminated floor targets to the rhythm of the music, enhancing lower-limb strength, agility, and balance, while Step by Step involved walking across virtual stones placed in different directions to improve dynamic balance and endurance. Upper-limb coordination and precision were trained with Take a Pineapple and Apple Juice, which required collecting and manipulating virtual objects through wide and repetitive arm movements. Happy Fish and Party Bubbles emphasized fast, bilateral, and dissociated arm actions to catch or pop moving objects, reinforcing coordination and flexibility. In Plane, participants steered a virtual aircraft by performing controlled trunk rotations, improving trunk stability and upper-limb strength. Finally, Balance Ball required maintaining a virtual ball on a moving platform by adjusting pelvic and trunk positions, training postural control and lower-limb balance. In each session, the games were arranged into four blocks, each containing three games (2 minutes per game), with a 2-minute pause between blocks. Figure 1 shows representative images of the AVGs used in the experimental protocol.

Figure 1. Active videogames (AVGs) used in the experimental protocol: (A) Happy Fish, (B) Take a Pineapple, (C) Dance Fun, (D) Balance Ball, (E) Step by Step, (F) Plane, (G) Apple Juice, and (H) Party Bubbles.

Measurement instruments

The assessments were conducted at baseline and at the end of the intervention. The primary outcome measure was cognitive function, and the secondary outcome was HRQoL.

Cognitive function was assessed using the Spanish version of the Montreal Cognitive Assessment (MoCA), validated in Chilean adults (Delgado et al., 2019; Gaete et al., 2023). This test assesses global cognitive status across seven domains: visuospatial/executive function (0–5 points), naming (0–3 points), attention (0–6 points), language (0–3 points), abstraction (0–2 points), delayed recall (0–5 points), and orientation (0–6 points). The total score ranges from 0 to 30 points, with higher scores indicating better cognitive performance. Scores were categorized according to the cut-off points and age ranges proposed for the Chilean population (Gaete et al., 2023): i) normal, ≥22 points; ii) mild-to-moderate cognitive impairment, 21–15 points and 21–13 points for individuals aged 60–65 and 66–90 years, respectively; and iii) severe cognitive impairment, ≤14 and ≤12 points for individuals aged 60–65 and 66–90 years, respectively. The test includes an additional point for individuals with ≤12 years of schooling. The MoCA was selected for its wide clinical and research applicability, adequate psychometric properties in older adults, and brief administration time (Islam et al., 2023; Nasreddine et al., 2005).

HRQoL was assessed using the Chilean Spanish version of the 12-Item Short Form Health Survey Version 2 (SF-12v2), a validated instrument for measuring physical and mental health status (Cheak-Zamora et al., 2009). The SF-12v2 comprises 12 items covering eight health domains: physical functioning (PF), general health (GH), bodily pain (BP), role-physical (RP), role-emotional (RE), social functioning (SF), vitality (VT), and mental health (MH). Four domains (PF, GH, BP, and RP) are combined into a Physical Component Summary (PCS), while the remaining four domains (RE, SF, VT, and MH) form a Mental Component Summary (MCS). Raw scores were computed and transformed into a 0–100 scale according to standardized scoring procedures, where higher values indicate better self-perceived health (Ware et al., 2002).

Data analysis

Normality and homoscedasticity were evaluated using the Shapiro–Wilk and Levene's tests, respectively. Due to violations of these assumptions, robust statistical methods based on 20% trimmed means were applied (Mair & Wilcox, 2020). Between-group comparisons were performed using Yuen's robust t-test for independent samples, and within-group comparisons were conducted using its paired-sample counterpart. ES were estimated using the robust measure ξ (xi), with values interpreted as small ($\approx$ 0.10), medium ($\approx$ 0.30), and large ($\geq$ 0.50) (Wilcox & Tian, 2011). Categorical variables were analyzed using contingency tables and compared with chi-square tests for between-group comparisons and McNemar's exact test for within-group changes. All subsequent analyses were conducted under an intention-to-treat approach, applying a multiple-data estimation method based on Multivariate Imputation by Chained Equations (MICE) to address missing values. All statistical analyses were performed using Jamovi software, version 2.4.6 (The Jamovi project, Sydney, Australia; https://www.jamovi.org), considering a significance level of α = 0.05.

Results

A total of 25 participants per group were recruited, of whom nine discontinued the intervention for reasons unrelated to the study (Figure 2). The mean attendance rate across sessions exceeds 90%, with no deviations from the planned intervention protocols, and no relevant adverse events are reported. At baseline, there are no significant sociodemographic differences between groups, as shown in Table 1.

Figure 2. Study flow chart.

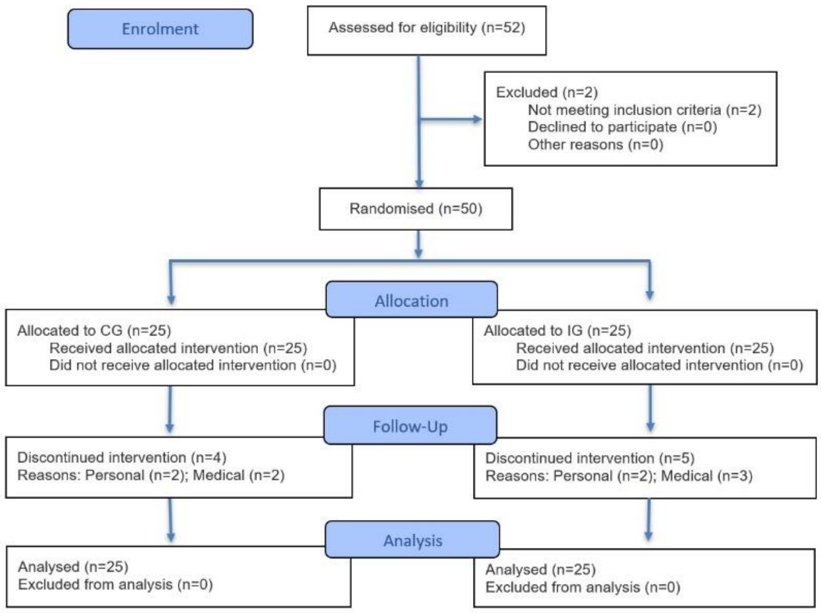

Table 1. Sociodemographic characteristics of the participants.

	Control group (CG)	Intervention group (IG)	*p*-value
Age (y); M (SD)	71.3 (7.4)	71.8 (6.8)	0.829
Height (m); M (SD)	1.53 (0.09)	1.52 (0.07)	0.653
Weight (kg); M (SD)	73.9 (16.3)	71.0 (14.4)	0.506
BMI (kg/m²); M (SD)	31.2 (5.1)	30.5 (5.3)	0.631
Female / male; no.	20 / 5	20 / 5	1.000
Education level; no. (%)			
Primary	19 (76 %)	18 (72 %)	
Secondary	4 (16 %)	6 (24 %)	0.684
Tertiary	2 (8 %)	1 (4 %)	

CG control group; IG intervention group; M mean; SD standard deviation; BMI body mass index; no. number; % percentage.

The effects on cognitive function are presented in Table 2. The CG shows significant changes in the visuospatial/executive function and attention domains, as well as in global cognitive function (all $p < 0.05$). The IG exhibits significant improvements in visuospatial/executive function, attention, language, delayed recall, and global cognitive function (all $p < 0.05$). ES values are small to moderate, except for delayed recall and global cognitive function in the IG, where they are large. In the post-test evaluation, the IG shows better performance than the CG in language, delayed recall, and global cognitive function (all $p < 0.05$), with moderate-to-large ES.

Table 2. Results on cognitive function (MoCA).

Domain	Control group (CG)			Intervention group (IG)			Intergroup comparison		
	Pre-test	Post-test	ES	Pre-test	Post-test	ES	Baseline, p-value	Post-test, p-value	Post-test, ES
Visuospatial/EF	2.84 (1.24)	3.47 (1.60)*	0.235	2.95 (1.32)	3.84 (1.16)*	0.377	0.807	0.473	0.156
Naming	3.00 (0.33)	2.89 (0.41)	0.148	2.95 (0.37)	3.00 (0.20)	0.000	0.602	0.343	0.000
Attention	3.53 (1.78)	4.53 (1.65)*	0.297	4.11 (1.59)	4.79 (1.06)*	0.315	0.314	0.574	0.118
Language	1.42 (0.82)	1.68 (0.84)	0.183	1.84 (0.85)	2.42 (0.79)*	0.394	0.098	0.005	0.490
Abstraction	1.11 (0.76)	1.47 (0.76)	0.250	1.58 (0.87)	1.74 (0.57)	0.174	0.130	0.275	0.276
Delayed recall	1.26 (1.29)	1.32 (1.50)	0.025	1.89 (1.19)	3.11 (1.40)*	0.575	0.109	<0.001	0.638
Orientation	5.89 (0.41)	6.00 (0.28)	0.000	5.89 (0.41)	6.00 (0.20)	0.000	1.000	1.000	0.000
Global function	20.11 (3.77)	21.89 (5.08)*	0.260	21.89 (4.50)	25.21 (3.13)*	0.556	0.213	0.026	0.518

Results expressed as means and standard deviations; EF executive function; ES effect size; * statistically significant difference (p<0.05).

Changes in MoCA categories are presented in Table 3. At baseline, both groups show similar proportions of participants with normal cognitive function and mild-to-moderate cognitive impairment ($p > 0.05$). After the intervention period, the CG shows a 12% increase in the proportion of participants with normal cognitive function ($p > 0.05$), whereas the IG exhibits a 36% increase ($p < 0.05$).

Table 3. Changes in cognitive function categories.

Categories	Control group (CG)				Intervention group (IG)			
	Pre-test	Post-test	Δ	p-value	Pre-test	Post-test	Δ	p-value
Normal	11 (44%)	14 (56%)	3 (12%)	0.250	12 (48%)	21 (84%)	9 (36%)	0.003
MMCI	14 (56%)	11 (44%)			13 (52%)	4 (16%)		

Results expressed as number and percentage; Δ delta; MMCI mild-to-moderate cognitive impairment.

The effects on HRQoL are presented in Table 4. The IG shows significant changes in the physical domains RP, BP, GH, and PCS (all $p < 0.05$), with moderate-to-large ES, whereas the CG shows no significant differences. In the post-test evaluation, the IG presents higher scores than the CG in all physical domains (all $p < 0.05$), as well as in the mental domains SF, MH, and MCS (all $p < 0.05$), with large ES.

Table 4. Results on health-related quality of life (SF-12v2).

Domain	Control group (CG)			Intervention group (IG)			Intergroup comparison		
	Pre-test	Post-test	ES	Pre-test	Post-test	ES	Baseline, p-value	Post-test, p-value	Post-test, ES
PF	38.2 (10.50)	36.2 (9.03)	0.132	40.8 (10.50)	46.7 (9.03)	0.286	0.579	0.004	0.763
RP	43.1 (7.98)	38.8 (10.70)	0.286	44.5 (7.98)	52.6 (10.70)*	0.556	0.677	0.001	0.911
BP	39.7 (12.0)	37.9 (7.68)	0.102	40.9 (12.00)	47.1 (7.68)*	0.368	0.767	0.003	0.582
GH	39.3 (8.13)	36.0 (6.32)	0.226	38.5 (8.13)	45.7 (6.32)*	0.476	0.813	0.004	0.644
PCS	36.8 (6.65)	36.1 (6.70)	0.073	38.7 (6.65)	45.6 (6.70)*	0.483	0.173	0.019	0.779
VT	51.7 (7.55)	48.8 (10.40)	0.224	56.3 (7.55)	57.0 (10.40)	0.046	0.882	0.060	0.355
SF	45.6 (8.55)	43.9 (9.66)	0.182	46.2 (8.55)	49.5 (9.66)	0.196	0.125	<0.001	0.651
RE	41.7 (10.00)	37.3 (14.30)	0.204	47.6 (10.00)	52.3 (14.30)	0.253	0.523	0.176	0.272
MH	47.4 (7.47)	47.0 (8.21)	0.032	49.3 (7.47)	51.1 (8.21)	0.123	0.585	<0.001	0.753
MCS	48.3 (8.82)	45.9 (9.62)	0.165	52.2 (8.82)	53.3 (9.62)	0.107	0.194	0.012	0.668

Results expressed as means and standard deviations; ES effect size; PF physical functioning; RP role-physical; BP bodily pain; GH general health; PCS physical component summary; VT vitality; SF social functioning; RE role-emotional; MH mental health; MCS mental component summary; * statistically significant difference (p<0.05).

Discussion

This study, conducted on community-dwelling older adults, evaluates the effects of adding AVGs to a CPE program on cognitive function and, secondarily, on HRQoL over an eight-week period. The findings indicate that incorporating AVGs into a CPE program enhances cognitive function and HRQoL more effectively than CPE alone, with moderate-to-large effect sizes. Both interventions lead to improvements across several cognitive domains; however, the IG shows significantly greater gains in language, delayed recall, and global cognitive function. Interestingly, a higher proportion of participants in the IG achieves normal cognitive function after the intervention, suggesting a clinically meaningful effect. Similarly, the IG demonstrates greater improvements in multiple HRQoL domains related to both physical and mental health. These results support AVGs as a safe, engaging, and effective complement to structured exercise programs for older adults.

Due to their cognitive and motor demands, AVGs are considered dual-task activities (Costa et al., 2019), which can enhance cognitive and motor performance (Ogawa et al., 2016), thereby contributing to HRQoL gains (Cugusi et al., 2021). According to the neuroplasticity framework, the mechanisms underlying cognitive improvements may involve increased signal transduction of brain neurotrophins, including brain-derived neurotrophic factor, insulin-like growth factor 1, and vascular endothelial growth factor, among others, which help preserve neuronal structure and function in key brain regions (Yang et al., 2023). However, it has been suggested that cognitive engagement during play, rather than physical activity alone, may be the primary factor driving improvements in executive function (Flynn & Richert, 2018), which could explain the findings of the present study.

Previous studies focusing on older adults with and without cognitive impairment have evaluated the effects of AVG-based interventions on global cognitive function and its specific domains (Bacha et al., 2018; Carrasco et al., 2020; Gouveia et al., 2021; Liao et al., 2021; Litz et al., 2021; Moret et al., 2022). For example, Gouveia et al. (2021) found that an exergaming program combining functional and cognitive fitness with multicomponent CPE, or multicomponent CPE alone, increased short- and long-term memory and global cognitive function after 12 weeks, but only the AVG group continued improving during follow-up (Gouveia et al., 2021). Liao et al. (2021) demonstrated that two 12-week multicomponent exercise interventions (AVG-based and CPE-based, respectively) improved global cognitive function, executive function, and attention. However, AVGs enhanced global cognition to a greater extent than CPE, and only the AVG group showed improvements in verbal and working memory. Despite the absence of intergroup differences, both groups showed reduced prefrontal cortex activation, suggesting greater neural efficiency (Liao et al., 2021). Bacha et al., 2018 also reported that an AVG intervention involving multidirectional coordinative and cognitive activities and a seven-week multicomponent conventional physical therapy program improved global cognitive function, although without intergroup differences (Bacha et al., 2018). Interestingly, Gui et al. (2024) demonstrated that a cognitively demanding adventure videogame performed simultaneously with aerobic exercise on a recumbent bike enhanced executive and global cognitive functions after 16 weeks. Although no significant differences were found in the functional connectivity of frontoparietal neural networks, the observed changes were behaviorally relevant, as increased connectivity was associated with greater improvements in executive function, providing a neural basis for the cognitive benefits observed (Gui et al., 2024). Collectively, these studies indicate that AVGs combined with multicomponent exercise enhance global cognitive function and specific cognitive domains in older adults compared with CPE, findings that are consistent with our results despite differences in assessment methods and intervention protocols.

Diverse research protocols have been proposed, ranging from active control groups involving strength, flexibility, aerobic endurance, balance, and coordination exercises (Bacha et al., 2018; Gouveia et al., 2021; Liao et al., 2021) to non-intervention control groups (Carrasco et al., 2020; Moret et al., 2022). Additionally, AVGs have been applied either as standalone interventions (Bacha et al., 2018; Liao et al., 2021) or as adjuncts to conventional outpatient programs across preventive, therapeutic, and recreational settings (Gouveia et al., 2021; Litz et al., 2021). Although all these approaches have demonstrated relevance, the present study incorporated AVGs as an addition to CPE to enhance the physical and cognitive complexity of training. Moreover, it compared this mixed intervention against an exercise-only group, a challenging design given that improvements were also expected in this group (Wang et al., 2024).

The results of this research contribute to strengthening the body of evidence, which has been emphasized as a need in recent literature reviews (Cai et al., 2023; López-Nava et al., 2023; Manser et al., 2024; Soares et al., 2021). In this regard, Soares et al. (2021), through a meta-analysis, reported significant differences favoring AVG interventions over CPE, particularly in measures of global cognition such as MoCA and MMSE. However, the high statistical heterogeneity limits the ability to reliably establish the superiority of AVGs (Soares et al., 2021). A scoping review also highlighted the multiple benefits of AVGs on quality of life, functional physical capacity, and cognitive function, emphasizing the crucial interactions among these outcomes. Nonetheless, it acknowledged that the evidence remains more consistent for mobility and postural balance than for cognition, underscoring the need for additional RCTs (López-Nava et al., 2023). Moreover, a recent review identified key moderating factors influencing the effectiveness and ecological validity of AVG-based training on cognitive function. These include body position (step-based movements), training type (simultaneous-incorporated motor-cognitive), exercise intensity (moderate), training location (either at home or in specialized centers under optimal conditions), administration (enriched social interaction), and supervision (professional guidance and feedback) (Manser et al., 2024).

In this regard, our study addressed several of these moderators by incorporating three games (Dance Fun, Step by Step, and Balance Ball) that specifically targeted postural control, dynamic balance, agility, and coordination through single-leg stances and multidirectional steps. Additionally, all games involved varying degrees of cognitive demands, including attention, perception, visuospatial skills, processing speed, and executive functions, specifically set shifting, inhibition of prepotent responses, and updating and monitoring of working memory. The intervention also included adjustments to exercise intensity, set at moderate-to-high levels based on perceived exertion. Finally, the sessions were conducted in an environment adapted to the needs of the population at a public community center under direct professional supervision. Therefore, the combination of these factors likely contributed to the cognitive gains observed.

Under a health promotion approach, HRQoL is recognized as a relevant outcome measure in older adults with or without functional limitations (Thompson et al., 2012). Evidence indicates that cognitive impairment negatively influences HRQoL (Pan et al., 2015) and that better cognitive function is positively associated with higher quality of life and well-being (He et al., 2023). In this regard, our AVG intervention yielded positive results in several physical and mental dimensions of quality of life, aligning with previous RCTs (Gonçalves et al., 2021; Lee, 2023; Stanmore et al., 2019) and systematic reviews synthesizing evidence in healthy older adults and those with chronic or age-related conditions. For example, Cacciata et al. (2019) concluded that AVGs represent an emerging and well-accepted alternative for exercise practice among older adults. Nevertheless, the reviewed results are not sufficiently robust due to small sample sizes and substantial heterogeneity in participants, exergaming systems, intervention protocols, and HRQoL assessment tools (Cacciata et al., 2019). Other reviews focusing on people with chronic diseases have found that AVGs significantly improve HRQoL (Cugusi et al., 2021; Guede-Rojas et al., 2024), although Cugusi et al. (2021), in their meta-analysis, reported that this improvement had a small ES (Cugusi et al., 2021). More recently, Vasodi et al. (2023) performed a meta-analysis in healthy older adults and found that exercise with AVGs has a significant but small effect on overall quality of life and on the physical and mental summary components. However, when examining specific subscales such as social relationships and psychological, physical, and environmental health, the ES was moderate (Vasodi et al., 2023). In summary, although these studies consistently report positive effects of AVGs on HRQoL, they also highlight persisting methodological limitations, thereby reinforcing the relevance of our findings.

The strengths of this study include its randomized controlled design conducted in a real-world community-based setting, where AVGs were used as a complementary physical-cognitive exercise modality to enhance CPE rather than replace it. The implemented protocol incorporated several moderating factors, including step-based movements, combined physical-cognitive demands, and a supervised context, which are known to enhance cognitive function and support the ecological validity highlighted by current evidence (Manser et al., 2024). Additionally, this study not only provides descriptive statistics of central tendency and variability but also reports cognitive function outcomes based on changes in clinical categories defined by established cut-off points for the studied population (Gaete et al., 2023), facilitating their translation into clinical and community practice.

The present study has several limitations. First, participants were recruited from a single community-based center, which may limit sample representativeness and restrict the generalizability of the findings to other settings or populations. In addition, no follow-up assessment was conducted to observe the evolution of the results after the intervention period. Another limitation is that, in addition to the conventional exercise regimen, the intervention group received an extra 30 minutes of active videogame training, which may have influenced the results obtained. From a pragmatic perspective, however, the total exercise volume per session, conducted twice per week, was safe, well tolerated, and could serve as a reference for future trials. Outcome assessments were conducted without assessor blinding, which may have introduced a risk of detection bias during the administration of cognitive performance measures; nevertheless, the use of standardized scoring procedures and structured test administration may have mitigated this potential source of bias. Moreover, the relatively short intervention duration and modest sample size may have limited the ability to detect and maintain meaningful cognitive changes. Finally, cognitive function was assessed solely using the MoCA. Although this instrument provides scores for several cognitive domains, it remains a screening tool and does not offer the level of depth or precision provided by domain-specific neuropsychological tests. Thus, future research should incorporate more detailed neuropsychological assessments and functional dual-task paradigms to enable a more comprehensive understanding of cognitive effects. Consequently, although the results are promising and suggest a positive influence of AVGs, they should be interpreted with caution and considered exploratory in nature, highlighting the need for further studies to address these limitations and advance the clinical application of virtual gamification systems in older adults.

Conclusions

In conclusion, this study found that adding AVGs to a CPE plan yielded greater benefits for cognitive function and, secondarily, for HRQoL, compared with CPE alone in community-dwelling older adults. These findings may help inform the design of future randomized controlled trials investigating the effects of different AVG modalities integrated into CPE programs on cognitive function, quality of life, and other clinically and scientifically relevant outcomes in older adults.

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