Effects of non-immersive exergames on executive functions in healthy older adults. A systematic review and meta-analysis

Efectos de los exergames no inmersivos en funciones ejecutivas de adultos mayores sanos. Una revisión sistemática y metaanálisis

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Abstract

Introduction: Exergames have been proposed as an innovative and accessible strategy to stimulate cognitive functions in older adults. However, available evidence has shown heterogeneous and methodologically limited findings.
Objective: The aim was to evaluate the effects of chronic exergame interventions on the main dimensions of cold executive functions in cognitively healthy older adults, compared with active or passive control groups.
Methodology: A systematic review and meta-analysis were conducted according to PRISMA guidelines. Randomized and non-randomized trials lasting at least eight weeks were included if they compared exergames with control groups and reported pre- and post-intervention measures of executive functions using validated instruments. Searches were conducted on PubMed, Scopus, Web of Science, and CINAHL Complete.
Results: Ten studies were included, applying programs through platforms such as Nintendo Wii, Xbox Kinect, and Nintendo Switch. The meta-analysis revealed very small and non-significant effects on working memory, cognitive flexibility, and inhibition, with moderate to high heterogeneity across studies. Sensitivity analyses confirmed the robustness of the results.
Discussion: The findings partially coincided with previous reviews, although differences in duration, intensity, and type of exergame explained the heterogeneity. It was highlighted that, despite their limited cognitive effectiveness, exergames offer motivational and adherence benefits.
Conclusions: Exergames may specifically benefit inhibition in older adults, while effects on working memory and cognitive flexibility remain uncertain.

Keywords

Aging; cognition; executive functions; exergames; review.

Resumen

Introducción: Los exergames se han propuesto como una alternativa innovadora y accesible para estimular funciones cognitivas en adultos mayores. Sin embargo, la evidencia existente ha mostrado resultados diversos y con limitaciones metodológicas.
Objetivo: El objetivo fue evaluar los efectos de intervenciones crónicas con exergames sobre las principales dimensiones de las funciones ejecutivas frías en adultos mayores cognitivamente sanos, en comparación con grupos control activos o pasivos.
Metodología: Se realizó una revisión sistemática y metaanálisis siguiendo las directrices PRISMA. Se incluyeron ensayos aleatorizados y no aleatorizados con duración mínima de ocho semanas, que compararon exergames con grupos control y reportaron medidas pre y post intervención de funciones ejecutivas evaluadas mediante instrumentos validados. La búsqueda se efectuó en PubMed, Scopus, Web of Science y CINAHL Complete.
Resultados: Se incorporaron diez estudios, que aplicaron programas con consolas como Nintendo Wii, Xbox Kinect y Nintendo switch. El metaanálisis mostró efectos pequeños y no significativos en memoria de trabajo, flexibilidad cognitiva e inhibición, con heterogeneidad moderada a alta entre estudios. Los análisis de sensibilidad confirmaron la robustez de los hallazgos.
Discusión: Los resultados coincidieron parcialmente con revisiones previas, aunque las diferencias en la duración, intensidad y tipo de exergame explicaron la heterogeneidad. Se destacó que, pese a la limitada eficacia cognitiva, los exergames ofrecen ventajas motivacionales y de adherencia.
Conclusiones: Los exergames podrían beneficiar específicamente la inhibición en adultos mayores, mientras que los efectos sobre la memoria de trabajo y la flexibilidad cognitiva siguen siendo inciertos.

Palabras clave

Cognición; envejecimiento; exergames; funciones ejecutivas; revisión.

Introduction

Human aging is a progressive, multisystemic, and heterogeneous process that involves structural and functional changes at the cellular, systemic, and behavioral levels (Kaspar et al., 2021; López-Otín et al., 2023). According to estimates from the World Health Organization (WHO), by the year 2050, more than 2 billion people worldwide will be aged 60 years or older (World Health Organization: WHO, 2024), posing a major public health challenge (Smith & Wesselbaum, 2023). It affects both quality of life and the global economy (Dinneweth & Gadeyne, 2024).

Aging is accompanied by structural and functional alterations in the central nervous system that directly impact the efficiency of cognitive processing (Bhagwat & Deodhe, 2023). Among these changes are the progressive atrophy of cortical regions, particularly the prefrontal cortex (You et al., 2024) and hippocampus (Armstrong et al., 2020), as well as reductions in gray and white matter volume, synaptic density, and dendritic length (Farokhian et al., 2017; Toyonaga et al., 2023). In parallel, the expression of neurotrophins, such as brain-derived neurotrophic factor (BDNF), which are critical for synaptic plasticity and neurogenesis is also diminished (Camuso et al., 2021; Numakawa & Odaka, 2022). These changes are further exacerbated by chronic low-grade neuroinflammation and increased production of cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) (Goshi et al., 2025), which contribute to neuronal dysfunction and synaptic degeneration (Lecca et al., 2022).

Such alterations reflect anatomical and functional transformations of the aging brain, with cold executive functions being particularly vulnerable (Idowu & Szameitat, 2023). These encompass a set of top-down cognitive processes responsible for planning, organizing, monitoring, and adapting behavior in response to novel or demanding situations (Colautti et al., 2022). The primary components include working memory, the ability to maintain and manipulate information in real-time (D'Esposito & Postle, 2014); inhibition, the voluntary suppression of automatic or impulsive responses (Shende et al., 2021); and cognitive flexibility, the capacity to switch between tasks, rules, or mental sets (Xia et al., 2024). Brain aging contributes to an adaptive reorganization that ultimately reduces executive functioning performance, even in older adults without clinical cognitive impairment (Nguyen et al., 2019; Aron et al., 2021).

Considering this, non-pharmacological interventions have gained prominence as viable strategies to mitigate age-related cognitive decline (Yu et al., 2024). Exergames, or active video games, are interactive digital applications that require physical movement to play, thereby combining motor tasks with cognitive challenges (Yang et al., 2023). Unlike immersive virtual reality, whose effects are primarily associated with sensory experience rather than a strong physical component (Street et al., 2017) and which is typically classified into different categories (Stanmore et al., 2017), the exergames employ motion sensors, cameras, and interactive platforms to encourage physical engagement while simultaneously stimulating attention, memory, and other cognitive domains (Torre & Temprado, 2022). The exergames offer a playful and motivating environment, which may improve adherence and treatment engagement, two essential factors for success in older adult interventions (Marques et al., 2023). Their effects may be explained by the principle of dual-tasking, in which simultaneous cognitive and physical demands activate multiple neural networks concurrently (Campo-Prieto et al., 2025). Neuroimaging studies have demonstrated increased activation in prefrontal and parietal areas during such tasks (Stojan et al., 2023), which are critical regions for executive regulation (Dany et al., 2025). Additionally, exergames have been associated with structural brain changes, such as increased gray matter volume in regions linked to cognitive control (Attoh-Mensah et al., 2024).

A study by Sturnieks et al. (2024) reported the benefits of an exergame-based intervention in older adults (≥60 years), compared to both a passive control group and an active control group undergoing computerized cognitive training, supporting the use of active video game interventions as low cost, low complexity alternatives. This is supported by studies such as those by Olyaei et al. (2022), which highlight the cognitive-motor component of exergames, as well as their accessibility.

Previous systematic reviews and meta-analyses have explored the effects of exergames in cognitively healthy older adults (Soares et al., 2021; Jiang et al., 2022; Chen et al., 2023). However, only two of these included unrestricted database searches without time filters (Jiang et al., 2022; Chen et al., 2023). The review by Chen et al. (2023) aimed to compare the health benefits of exergames with conventional exercise on physical and mental function in older adults; however, their findings suggested no significant differences between the two interventions. Notably, the review only included active control groups and did not consider intervention duration. In contrast, the present review focuses on comparing exergames with both active and passive control groups, with a minimum intervention period of 8 weeks, which has been suggested as the minimum duration required to produce gains in executive functioning through exergames (De Bruin et al., 2020; Huber et al., 2021). Jiang et al. (2022) examined the effects of exergames on executive functioning in older adults and reported positive results, which appeared dependent on intervention frequency. That review included acute (≤8 weeks) and single-session interventions up to 2022. Given that approximately 25% of systematic reviews and meta-analyses become outdated within two years, and nearly 50% within five years, regular updates to this body of evidence are warranted (Shojania et al., 2007).

Therefore, the aim of this study is to conduct a systematic review and meta-analysis to evaluate the effects of exergames on cold executive functions in cognitively healthy older adults. Synthesizing this evidence will provide useful guidance for future clinical interventions, randomized controlled trials, public health policies, and the design of cognitive training programs based on active video games.

Method

Study design

The review protocol was developed in accordance with the guidelines established by the methodology Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (Page et al., 2021). The study was registered in the international systematic review registry PROSPERO with the registration number CRD420251035852.

Eligibility criteria

The inclusion and exclusion criteria for studies for the review are detailed below (Table 1). Studies were selected according to predefined methodological and population-based criteria aligned with the objectives of this review. Eligible articles examined the effects of chronic exergame interventions on the main domains of cold executive functions in cognitively healthy older adults, using validated neuropsychological measures. Only experimental or quasi-experimental designs providing pre- and post-intervention data and a comparison group were considered. The selection process prioritized studies that ensured methodological rigor and conceptual consistency with the research question, while excluding those that did not meet these methodological standards or focused on populations or interventions outside the scope of this analysis.

Search strategy and selection process

Two researchers (F.J.S. and O.V.G.) independently performed the search for relevant studies. This process involved a systematic search across multiple databases, including PubMed, Web of Science, Scopus, and CINAHL Complete. The specific search strategy for each database, including the terms used, is detailed in the Supplementary Material (Table S1). No filtering by publication date, sex, or language was applied for the inclusion of relevant studies in this review. In the event of discrepancies, a third reviewer was designated to resolve disagreements (C.P.A.).

Data extraction and management

The essential data from each selected study were systematically and independently extracted by two researchers (F.J.S. and O.V.G.) and compiled into structured tables to facilitate qualitative analysis. The variables of interest encompassed authorship, year of publication, sample characteristics (total number of participants, distribution across experimental and control groups), and demographic factors such as age, sex, and educational attainment. In addition, comprehensive details regarding the interventions and control conditions were recorded, including specific intervention characteristics, attrition rates, total duration (weeks), session frequency per week, session length (hours), intensity (e.g., percentage of maximal heart rate), and outcome measures (e.g., Trail Making Test–Part B for cognitive flexibility, N-Back for working memory, or Stroop test for inhibitory control). A third reviewer verified data consistency and addressed any discrepancies (C.P.A.). In cases where essential information was unavailable within the selected studies, the original authors were contacted in accordance with established methodological protocols. This process involved sending email requests once per week for a maximum period of two weeks. If no response was obtained or the information provided remained incomplete, the study was excluded from the quantitative synthesis (Jerez-Salas et al., 2025).

Table 1. Eligibility criteria for studies

	Inclusion	Exclusion
Population	Healthy older adults with normal cognition (mean age of the sample ≥60 years) or clinical conditions associated with cognitive impairment, without restriction according to sex or fitness level	Studies include participants with diagnosed neurological, psychiatric, or cognitive disorders that may compromise executive function performance, or where the population characteristics are not clearly defined or reported.
Intervention	Chronic interventions (lasting ≥8 weeks): Interventions that use exergames as its sole component, without restriction on the type of exercise (e.g., Xbox Kinect, Nintendo Wii, dance mat). Only non-immersive exergames (screen-based or camera-based systems without the use of virtual reality headsets or immersive equipment) are included	Interventions integrating exergames as a secondary or complementary element within multi-component programs, or those in which the gamified component cannot be isolated or described in sufficient methodological detail.
Comparator	Group not exposed to the intervention program. The control group may be active (alternative training methods such as a balance or stretching program) or passive (continuing their usual activities of daily living)	Studies lacking a valid comparison group, or where the control condition does not allow distinguishing the specific effects of the exergame intervention
Outcomes	Direct assessment measures pre- and post-intervention for at least one of the main dimensions of executive function: Working memory, inhibition, or cognitive flexibility, obtained from a validated instrument (e.g., Trail Making Test, Flanker Task, or N-Back Task).	Studies that rely exclusively on subjective reports, global cognitive screenings, or indirect measures not specific to executive functioning
Study design	Longitudinal randomized controlled trials (RCTs), and non-RCTs that provide pre- and post-intervention measures.	Qualitative designs, case reports, cross-sectional analyses, or reviews that do not provide pre–post quantitative comparisons.

RCT = Randomized controlled trial.

Risk-of-Bias assessment

The risk of bias of the included studies was assessed by two independent reviewers (F.J.S. and O.V.G.) using the Risk of Bias 2 (RoB 2) tool for randomized controlled trials (Sterne et al., 2019) and the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool for non-randomized studies (J. A. Sterne et al., 2016). These tools are widely used in health and rehabilitation research to evaluate the internal validity of primary studies (Thomson et al., 2018; Hu et al., 2024). In case of disagreement between the two reviewers, discrepancies were resolved through discussion and, if necessary, by consultation with a third reviewer (C.P.A.). A formal assessment of the overall certainty of the body of evidence (e.g., using the GRADE approach) was not conducted, as the aim of this review was to summarize and synthesize the available evidence rather than to formulate clinical recommendations (Kolaski et al., 2023).

Statistical analysis

Once data extraction was completed, a meta-analysis was conducted for outcome measures reported in at least three studies (V.L.C.). The three core dimensions of executive functions (working memory, inhibition, and cognitive flexibility) were analyzed independently. Hedges' g was used as the measure of effect size, along with its corresponding 95% confidence interval (CI). As the same underlying construct was assessed using different instruments across studies, the use of a standardized effect size allowed the combination of outcomes measured on different scales (Higgins et al., 2024). Effect sizes were estimated from pre- and post-intervention means and standard deviations for both experimental and control groups. In cases where only the mean change and its standard deviation were reported, these values were directly used to compute the effect size. A random-effects model (DerSimonian and Laird) was applied to account for methodological variability across studies and potential variability related to measurement tools (Davey et al., 2011). Effect sizes were classified following widely adopted thresholds, as follows: trivial (<0.2), small (0.2–0.6), moderate (>0.6–1.2), large (>1.2–2.0), very large (>2.0–4.0), and extremely large (>4.0) (Lane et al., 2022). To prevent disproportionate influence on pooled estimates, studies with standardized effect sizes ≥ 3.0 were considered potential outliers and were examined separately. Heterogeneity was evaluated using the I^2 statistic, interpreted according to conventional guidelines as low (<25%), moderate (25–75%), or high (>75%) (Higgins & Thompson, 2002; Moran et al., 2018). Publication bias was examined through Egger's regression test, Kendall's Tau coefficient, and the Fail-safe N method, which estimates the number of missing null-effect studies required to invalidate the overall result. No imputation procedures were applied to correct for potentially missing studies. Finally, a leave-one-out sensitivity analysis was conducted to assess the individual impact of each study on the pooled estimates. All statistical analyses were conducted using R software (version 4.5.0), employing the meta and metafor packages to compute standardized effect sizes (Hedges' g), confidence intervals, heterogeneity indices (I^2 and τ^2), and to generate forest plots.

Results

Study selection

The database search yielded 1,022 records, which were screened according to the predefined eligibility criteria. After removing duplicates and performing title and abstract screening, a smaller subset of studies was assessed in full text. Following this evaluation, ten studies met all methodological and conceptual criteria and were included in both the qualitative synthesis and the meta-analysis (Table 2). The complete screening and selection process, conducted in accordance with PRISMA 2020 guidelines, is detailed in Supplementary Figure S2.

Study characteristics

Interventions were based exclusively on active video games (exergames), implemented through platforms such as Nintendo Switch (e.g., Fitness Boxing, Zumba), Xbox Kinect, or step-based systems (e.g., Dance Dance Revolution). Some interventions incorporated cognitive dual-tasks or elements grounded in self-determination theory (n = 1). The majority of control groups followed passive conditions such as usual daily routines or health education (n = 4), while others engaged in active controls, including traditional aerobic or video game tasks devoid of physical movement (n = 2).

The duration of interventions ranged from 8 to 12 weeks, with frequencies of 2 to 3 sessions per week. Sessions lasted between 30 and 75 minutes, and most were delivered at moderate intensity, occasionally monitored via heart rate or perceived exertion scales. Participant compliance was consistently high across studies, ranging from 84% to 92%, with minimal dropout rates.

All included studies assessed cold executive functions, with working memory being the most frequently evaluated domain (n = 5), followed by cognitive flexibility (n = 4), and inhibitory control (n = 4). Executive functions were assessed using validated neuropsychological tests such as the N-back, Operation Span, Stroop, Go/No-Go, and Trail Making Test (TMT-B). A complete breakdown of intervention characteristics and outcome measures can be found in Table 3

Table 2. Subjects' characteristics from the included studies

Reference	Study Design	N	Sex	Age yrs (SD)	Education Years
Chan et al., 2024	RCT	42; EG: 21, CG: 21	20 M/32 F	EG: 68.2 (6.0); GC: 71.4 (5.1)	NR
Eggenberger et al., 2016	RCT	33; EG: 19, CG: 14	12 M/21 F	EG: 72.8 (5.9); GC: 77.8 (7.4)	EG: 13.4 (1.8); CG: 13.6 (2.1)
Ghasemian et al., 2024	Non-RCT	24; EG: 12, CG: 12	NR	NR	NR
Hou & Li, 2022	RCT	44; EG: 23, CG: 21	11 M/33 F	EG: 67.04 (3.78); GC: 66.52 (4.94)	EG: 11.00 (2.58); CG: 12.24 (2.88)
Hou et al., 2023	RCT	84; EG: 41, CG: 43	26 M/58 F	EG: 67.41 (3.86); GC: 67.44 (4.94)	EG: 9.24 (3.20); CG: 8.93 (3.33)
Maillot et al., 2011	Non-RCT	32; EG: 16, CG: 16	NR	EG: 73.47 (4.10); GC: 73.47 (3.00)	EG: 11.20 (1.78); CG: 11.40 (2.22)
Ogawa et al., 2019	Non-RCT	29; EG: 15, CG: 14	5 M/24 F	EG: 72.20 (7.31); GC: 78.85 (7.13)	NR
Phirom et al., 2020	Non-RCT	40; EG: 20, CG: 20	7 M/33 F	EG: 70.21 (4.18); GC: 69.40 (3.38)	EG: 12.79 (5.15); CG: 11.20 (4.80)
Zhao et al., 2022	RCT	37; EG: 21, CG: 16	13 M/24 F	EG: 65.2 (3.7); GC: 65.8 (3.2)	NR
Zhao et al., 2022	RCT	38; EG: 22, CG: 16	14 M/24 F	EG: 65.64 (4.2); GC: 65.75 (3.24)	NR

CG = Control Group; EG = Experimental Group; F = Female; M = Male; N = Total sample size; Non-RCT = Non-Randomized Controlled Trial; NR = Not Reported; RCT = Randomized Controlled Trial; SD = Standard Deviation; yrs = Years of age.

Table 3. Intervention characteristics of the included studies

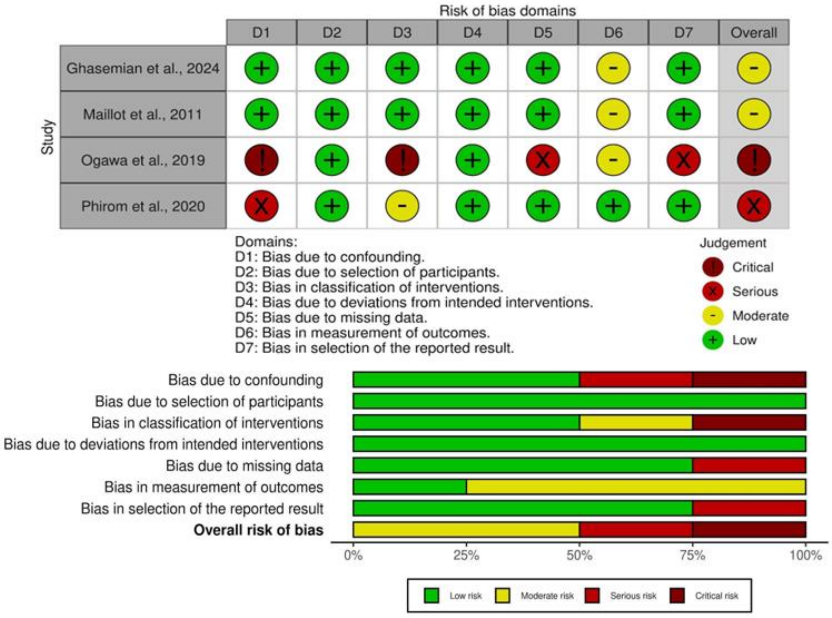
Reference	Exergame Program	Control Condition	Compliance	Intervention Length	Frequency	Session Length	Intensity	EF Dimension and Instrument
Chan et al., 2024	Nintendo Ring Fit Adventure™: balance and strengthening exercises,	Control group: general health advice and usual daily activity, no supervised program	88% (mean attendance)	12 weeks	2×/week	45–60 min	Moderate intensity (individualized, adjusted through game settings)	Cognitive flexibility (Color Trails Test)
Eggenberger et al., 2016	Exergame (Step training and memory tasks via Dance Dance Revolution pad, with increasing cognitive load)	Balance training group (same physical effort but without cognitive challenge)	82% completed (49/60)	8 weeks	3×/week	45 min	Moderate; HR monitored (61–66% HRmax)	Inhibitory control (Stroop Test), Working memory (Verbal Memory), Cognitive flexibility (Task-switching reaction time)
Ghasemian et al., 2024	Cognitive exergame or physical and cognitive tasks	Passive control (no intervention)	100% (no dropouts)	8 weeks	3 x/week	45 min	Low to moderate	Cognitive flexibility (TMT), inhibition (Stroop)
Hou & Li, 2022	Exergame via Kinect (balance, coordination, cognitive mini-games)	Traditional video games (non-active, cognitive-only)	90.5% retention; adherence ≥ 90%	8 weeks	2×/week	60 min	Moderate (not quantified physiologically)	Working memory (Spatial Span), Cognitive flexibility (Wisconsin Card Sorting Task), Inhibitory control (Go/No-Go task)
Hou et al., 2023	Exergame cycling (stationary bike + cognitive tasks via screen)	Traditional cycling group and control (no exercise)	89.3% retention (67/75); 90% compliance rate	12 weeks	3×/week	30 min	Moderate (RPE 12–14); individualized resistance load	Working memory (Digit Span), Inhibitory control (Stroop Task), Cognitive flexibility (TMT-B)
Maillot et al., 2011	Interactive physical activity video game (EyeToy PS2)	Passive control (no intervention)	High compliance (1 dropout)	12 weeks	2 x/week	60 min	Low to moderate	Inhibition (Stroop), cognitive flexibility (TMT)
Ogawa et al., 2019	Group-based exergaming (Kinect dance/movement games)	Active control (therapeutic physical exercise)	83% completed (6 dropouts)	12 weeks	2 x/week	60 min	Moderate (monitored by Borg scale)	Cognitive flexibility (TMT)
Phirom et al., 2020	Interactive physical-cognitive video game training (Nintendo Wii Fit with cognitive tasks)	Passive control (no intervention)	Very high (1 dropout)	12 weeks	3 x/week	60 min	Low to moderate (supervised)	Working Memory (MoCA), Inhibition (MoCA), Cognitive flexibility (MoCA)
Zhao et al., 2022	Exergames with Nintendo Switch (Fitness Boxing 2, Zumba, Mario Tennis Ace)	Usual daily routine (no intervention)	21/25 completed in ET group (84%)	12 weeks	3×/week	75 min	Moderate (65–75% MHR)	Working memory (N-back), Inhibitory control (Stroop)
Zhao et al., 2022	Home-based exergames (Zumba, FitBoxing2, Mario Tennis Ace) framed by self-determination theory	Usual routine (no exercise control group)	22/24 completed (92%)	12 weeks	3×/week	50–55 min	Moderate to vigorous (monitored via HR)	Working memory (Operation Span Task), Inhibitory control (Stroop Task), Cognitive flexibility (Spatial cognition test)

EF = Executive Function; ET = Exergame Training; HR = Heart Rate; HRmax = Maximum Heart Rate; MHR = Maximum Heart Rate Reserve; min = Minutes; MoCA = Montreal Cognitive Assessment; N = Total sample size; NR = Not Reported; PS2 = PlayStation 2; RPE = Rating of Perceived Exertion; TMT = Trail Making Test; wk = Week.

Risk-of-Bias assessment

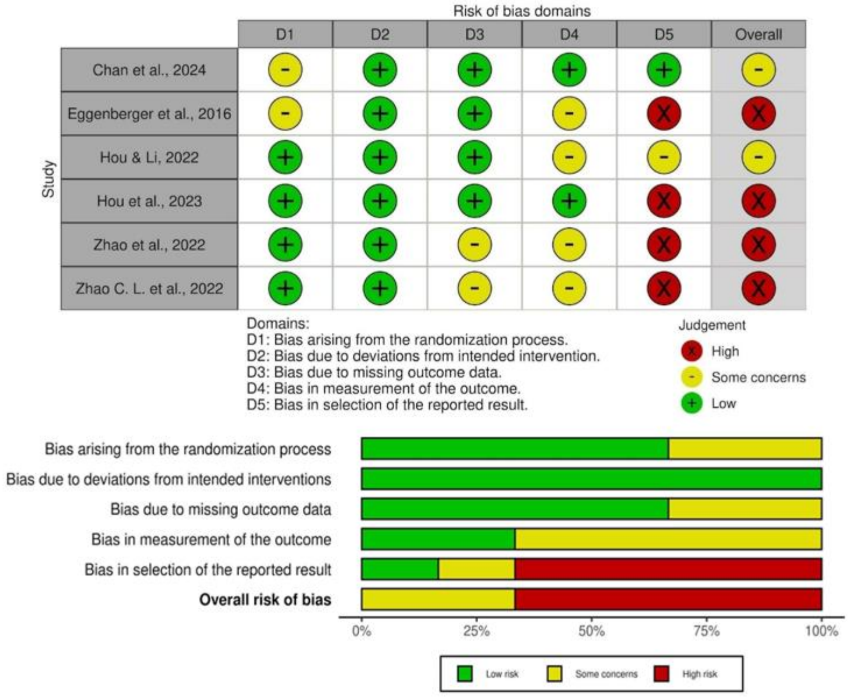
The risk of bias for randomized controlled trials (n = 6) was evaluated using the Cochrane Risk of Bias 2 (RoB 2) tool. As depicted in Figure 1, all studies presented a low risk of bias due to deviations from the intended intervention (domain 2). Random sequence generation and missing outcome data (domains 1 and 3) were generally well reported, with a low risk of bias in most studies. Regarding outcome measurement (domain 4), 33% of studies presented a low risk of bias, and 66% presented some concerns. The most frequent problem was selection bias in the reported outcome, classifying more than a majority of studies (n = 4) as high risk. Overall, four out of six RCTs were classified as having a high risk of bias, and only two studies were rated as presenting “some concerns”.

Figure 1. Risk of bias for randomized controlled trial studies.



For non-randomized studies (n = 4), the ROBINS-I tool was applied to assess potential sources of bias across seven domains. As shown in Figure 2, the studies by Ghasemian et al. (2024) and Maillot et al. (2011) showed an overall moderate risk of bias, primarily due to limitations in outcome measurement (D6), while the domains of confounding (D1), participant selection (D2), intervention classification (D3), deviations from planned interventions (D4), missing data (D5), and selection of reported outcome (D7) showed a low risk. In contrast, the studies by Ogawa et al. (2019) and Phirom et al. (2020) showed a severe or critical risk of bias, particularly in the domains of confounding (D1) and intervention classification (D3), and, in the case of the Ogawa et al. study, also in missing data (D5) and selection of reported outcome (D7).

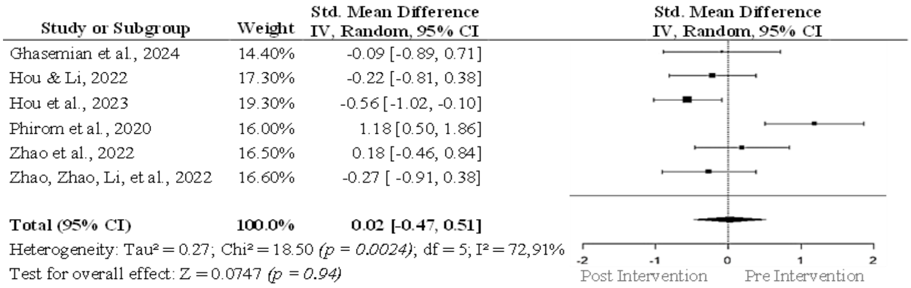
Figure 2. Risk of bias for non-randomized controlled trial studies.



Effects of exergames on working memory

The outcomes for working memory are shown in the forest plot in Figure 3. The forest plot contains the standardized mean differences (SMD) and corresponding 95% confidence intervals (CIs) for working memory measurements, as well as the overall effect test and heterogeneity analysis of the working memory in the experimental groups of the included studies. The pooled estimate included six study groups from six studies. Moderate heterogeneity was detected in this subgroup ($Tau^2 = 0.27$; $Chi^2 = 18.50$, df = 5, p = 0.0024; $I^2 = 72.91\%$), indicating substantial variability across studies. When a random-effects model was applied, the overall effect size was very small and not statistically significant (Hedges' g = 0.02, 95% CI [-0.47, 0.51]; Z = 0.07, p = 0.94).

Figure 3. Forest plot of effects on working memory (n = 6 studies).



Study or Subgroup	Weight	Std. Mean Difference IV, Random, 95% CI
Ghasemian et al., 2024	14.40%	-0.09 [-0.89, 0.71]
Hou & Li, 2022	17.30%	-0.22 [-0.81, 0.38]
Hou et al., 2023	19.30%	-0.56 [-1.02, -0.10]
Phirom et al., 2020	16.00%	1.18 [0.50, 1.86]
Zhao et al., 2022	16.50%	0.18 [-0.46, 0.84]
Zhao, Zhao, Li, et al., 2022	16.60%	-0.27 [-0.91, 0.38]
Total (95% CI)	**100.0%**	**0.02 [-0.47, 0.51]**

Heterogeneity: Tau² = 0.27; Chi² = 18.50 *(p = 0.0024)*; df = 5; I² = 72,91%

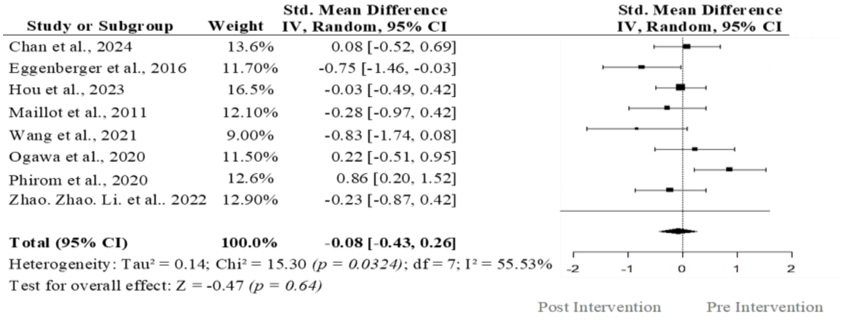
Test for overall effect: Z = 0.0747 *(p = 0.94)*

The vertical line indicates the overall estimate of the combined studies' standardized mean effect size (Hedges' g) using a random-effects model. The diamond represents the overall pooled effect estimate with its 95% confidence interval using a random-effects model (DerSimonian-Laird method). Heterogeneity was moderate ($Tau^2 = 0.27$; $Chi^2 = 18.50$, df = 5, p = 0.0024; $I^2 = 72.91\%$), indicating substantial variability among studies. The overall effect was very small and non-significant (Hedges' g = 0.02, 95% CI [-0.47, 0.51]; Z = 0.07, p = 0.94).

Effects of exergames on cognitive flexibility

The forest plot in Figure 4 presents the standardized mean differences (SMD) and corresponding 95% confidence intervals (CI) from eight studies examining cognitive flexibility outcomes. Individual study weights ranged from 9.0% to 16.5%, reflecting differences in sample size and variance across trials. Moderate heterogeneity was detected among the studies ($Tau^2 = 0.14$; $Chi^2 = 15.30$, df = 7, p = 0.0324; $I^2 = 55.53\%$), suggesting some variability in effect sizes. When using a random-effects model, the pooled effect size was small and not statistically significant (Hedges' g = -0.08, 95% CI [-0.43, 0.26]; Z = -0.47, p = 0.64).

Figure 4. Forest plot of effects on cognitive flexibility (n = 8 studies).



Study or Subgroup	Weight	Std. Mean Difference IV, Random, 95% CI
Chan et al., 2024	13.6%	0.08 [-0.52, 0.69]
Eggenberger et al., 2016	11.70%	-0.75 [-1.46, -0.03]
Hou et al., 2023	16.5%	-0.03 [-0.49, 0.42]
Maillot et al., 2011	12.10%	-0.28 [-0.97, 0.42]
Wang et al., 2021	9.00%	-0.83 [-1.74, 0.08]
Ogawa et al., 2020	11.50%	0.22 [-0.51, 0.95]
Phirom et al., 2020	12.6%	0.86 [0.20, 1.52]
Zhao, Zhao, Li, et al., 2022	12.90%	-0.23 [-0.87, 0.42]
Total (95% CI)	**100.0%**	**-0.08 [-0.43, 0.26]**

Heterogeneity: Tau² = 0.14; Chi² = 15.30 *(p = 0.0324)*; df = 7; I² = 55.53%

Test for overall effect: Z = -0.47 *(p = 0.64)*

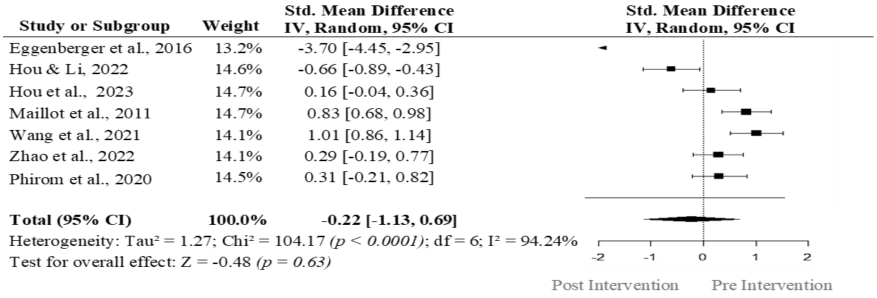
The vertical line indicates the overall estimate of the combined studies' standardized mean effect size (Hedges' g) using a random-effects model (DerSimonian and Laird). The horizontal lines represent 95%

confidence intervals (CI). Squares indicate individual study effect estimates, with size proportional to study weight. The diamond represents the pooled estimate and its 95% CI. IV = inverse variance. Heterogeneity was assessed using the I^2 statistic.

Effects of exergames on inhibition

The forest plot in Figure 5 displays the standardized mean differences (SMD) and 95% confidence intervals (CI) for the included studies on the outcome of interest. The meta-analysis included seven studies with varying weights contributing to the overall estimate. High heterogeneity was observed among the studies ($Tau^2 = 1.27$; $Chi^2 = 104.17$, df = 6, $p < 0.0001$; $I^2 = 94.24\%$), indicating substantial variability in effect sizes across studies. The combined effect size was small and not statistically significant (Hedges' g = -0.22, 95% CI [-1.13, 0.69]; Z = -0.48, p = 0.63).

Figure 5. Forest plot of effects on Inhibition (n = 7 studies



The vertical line indicates the overall estimate of the combined studies' standardized mean effect size (Hedges' g) using a random-effects model (DerSimonian and Laird). The horizontal lines represent 95% confidence intervals (CI). Squares indicate individual study effect estimates, with size proportional to study weight. The diamond represents the pooled estimate and its 95% CI. IV = inverse variance. Heterogeneity was assessed using the I^2 statistic.

Eggenberger et al. (2016) reported an exceptionally large negative effect size (g = −3.70), raising concerns about its potential disproportionate influence on the pooled estimate. Therefore, a sensitivity analysis was conducted excluding this study. After its removal, the pooled effect size shifted slightly (g = 0.26; 95% CI: −0.38 to 0.91; Z = 1.16; p = 0.24), and heterogeneity was moderately reduced ($I^2 = 67.6\%$, $\tau^2 = 0.22$). These findings suggest that, although the exclusion of Eggenberger et al. led to a small change in the estimated effect size and heterogeneity, the overall result remained statistically non-significant, supporting the robustness of the findings.

Discussion

The primary aim of this systematic review and meta-analysis is to assess the effects of exergames on cold executive functions (working memory, inhibition, and cognitive flexibility) in cognitively healthy older adults, compared with both active and passive control groups. The findings indicate that, although some individual studies report positive effects, the overall pooled effect sizes are small and not statistically significant across all executive domains.

Working memory

Working memory involves the manipulation of real-time information to perform complex cognitive activities (Baddeley, 1992). In the present study, exergame-based interventions show a small and non-significant effect with moderate heterogeneity (Hedges' g = 0.02; $I^2 = 72.91$), suggesting a limited influence of this intervention modality on working memory in cognitively healthy older adults.

These results are consistent with those reported by Jiang et al. (2022), who assess working memory using the Digit Span, N-back, and Digit-Symbol Substitution tests and include studies involving participants with mild cognitive impairment. In contrast, the findings differ from those reported by Chen et al.

(2023), whose analysis includes populations with neurological or health conditions, such as Parkinson's disease or frailty, that may directly affect executive functioning.

Within the present review, two studies report positive effects on working memory (Phirom et al., 2020; Zhao et al., 2022), assessed using the N-back task and MoCA subtests. These findings are attributed to the dual-task nature of exergames, which combine concurrent motor coordination and cognitive processing (Zhao et al., 2022). Additionally, longer intervention durations appear to be associated with greater effects, as improvements are observed primarily after 12 weeks of training (Phirom et al., 2020). Both studies relate these improvements to increased engagement of dorsolateral prefrontal cortex regions involved in sustained attention and working memory processes (Phirom et al., 2020; Zhao et al., 2022).

Conversely, four of the six studies examining this domain report null or inconsistent effects (Ghassemian et al., 2024; Hou & Li, 2022; Hou et al., 2023; Zhao, Zhao, Li et al., 2022). These findings are commonly associated with relatively low intervention intensity or duration, which may be insufficient to elicit exercise-induced physiological adaptations (Hou et al., 2023). Furthermore, the inclusion of predominantly active older adults may limit the observable benefits of physical activity–based interventions due to ceiling effects (Ghassemian et al., 2024; Hou et al., 2022; Phirom et al., 2020).

Cognitive flexibility

Cognitive flexibility refers to the ability to shift attention and adapt behavioral strategies in response to changing task demands (Chang et al., 2012). In the present study, exergame-based interventions demonstrate a small and non-significant effect with moderate heterogeneity (Hedges' $g = -0.08$; $I^2 = 55.53$), indicating a limited impact on cognitive flexibility in cognitively healthy older adults.

These findings align with previous evidence showing mixed results. Jiang et al. (2022) reports significant effects favoring exergames on cognitive flexibility, assessed through the Trail Making Test, set-shifting tasks, and the Color Trails Test, which they attribute to the dynamic and variable nature of game environments requiring frequent task switching. In contrast, Soares et al. (2021) do not observe significant effects, attributing their findings to population heterogeneity and insufficient adaptation of cognitive task difficulty to participants' abilities.

In the present review, three studies report benefits of exergame interventions on executive functioning (Chang et al., 2024; Ogawa et al., 2020; Phirom et al., 2020), with cognitive flexibility assessed using the Color Trail Test, Trail Making Test, and MoCA subtests. These benefits are attributed to the integration of simultaneous cognitive and motor demands characteristic of exergames (Ogawa et al., 2020; Phirom et al., 2020), as well as to the progressive increase in cognitive load embedded within the game structure (Phirom et al., 2020).

Additional evidence suggests that exergames promote exercise induced neuroplasticity through activation of frontal, cingulate, parietal, and subcortical networks associated with cognitive control (Wang et al., 2021). Maillot et al. (2021) report that exergame interventions elicit approximately 41.5% of maximal heart rate, corresponding to moderate-intensity physical activity. Furthermore, neuroimaging evidence indicates reduced prefrontal cortex activation following exergame training despite neutral behavioral outcomes, which is interpreted as increased neural efficiency (Eggenberger et al., 2016).

Limitations reported across studies include short intervention durations (e.g., 8 weeks) (Ogawa et al., 2020) and difficulties in tailoring cognitive stimuli to individual abilities (Chang et al., 2024). These findings emphasize the importance of selecting appropriate game characteristics and cognitive demands to induce domain specific effects on cognitive flexibility (Hou et al., 2023).

Inhibition

Inhibition involves the ability to suppress internal or external stimuli that interferes with goal-directed behavior (Wager et al., 2013). The present analysis shows a small and non-significant effect with moderate heterogeneity (Hedges' $g = 0.26$; $I^2 = 67.6$), suggesting that exergame-based interventions do not produce statistically or clinically meaningful improvements in inhibitory control in cognitively healthy older adults.

Most included studies report positive effects on inhibition, with only one study failing to observe improvements (Hou & Li, 2022). However, the overall pooled effect remains non-significant. These findings contrast with Jiang et al. (2022), who report significant effects favoring exergames, assessed primarily through the Stroop Test and Go/No-Go tasks. The authors attribute these effects to the continuous demand to inhibit inappropriate responses in dynamic gaming environments.

The present findings are consistent with those reported by Chen et al. (2023) and Soares et al. (2021), who also observe no significant differences. These authors attribute the absence of effects to methodological heterogeneity, including active control groups engaging in similarly demanding exercise protocols and ceiling effects related to participants preserved baseline cognitive function.

In this review, inhibition is primarily assessed using the Stroop Test. Neurophysiological evidence suggests that the dual task demands of exergames increase activation in the right prefrontal cortex as a compensatory mechanism, potentially supporting synaptic plasticity in executive control regions (Eggenberger et al., 2016; Wang et al., 2021). Positive findings reported by Phirom et al. (2020) are attributed to game characteristics requiring decision-making and selective attention to inhibit irrelevant stimuli.

Maillot et al. (2011) compared an exergame intervention with both a passive control group and an active control group performing conventional exercise. Results comparing experimental intervention with active control were inconclusive. The authors highlighted the cardiovascular benefits achieved in both physical activity conditions, with heart rate reaching 40–59% of heart rate reserve levels consistent with moderate-intensity exercise. However, they also noted that intrinsic features of exergames (e.g., motivation, feedback, and task difficulty) could have contributed to the observed patterns.

Hou et al. (2023) did not observe significant effects of exergame interventions compared with a control group. The authors suggested that future research should focus on specific components that may modulate the effectiveness of exergame-based physical activity interventions, such as intervention duration (≥8 weeks) and the presence of vascular comorbidities.

The inhibition appears to be particularly engaged by exergame tasks, which commonly require rapid response selection and suppression of inappropriate actions. This close correspondence between task demands and inhibitory processes may explain why this domain shows more consistent trends toward improvement compared with other executive functions.

Strength and limitation for futures research

Exergames present several strengths, including their ability to integrate cognitive and motor demands through dual-task paradigms, stimulate executive-related neural networks, and be implemented in community or home-based settings at relatively low cost. However, the findings of this review must be interpreted considering key limitations, including short intervention durations, variability in game characteristics and cognitive assessments, heterogeneous participant profiles, and the frequent use of active control groups performing equally demanding exercise.

Future research should focus on standardizing intervention protocols, optimizing training parameters such as intensity, frequency, and cognitive load, and incorporating multimodal outcome measures, including neurophysiological assessments. Tailoring exergame interventions to individual cognitive and physical profiles may enhance their effectiveness in targeting executive functions in older adults

Conclusions

This meta-analysis did not find significant effects of exergames on cold executive functions (working memory, inhibition, and cognitive flexibility) in cognitively healthy older adults. However, the interpretation of these findings is limited by the overall moderate to high risk of bias across the included studies. Therefore, conclusions regarding the inefficacy of exergames should be made cautiously.

Future research should address current methodological limitations by employing more rigorous study designs and standardized cognitive assessments. While definitive cognitive benefits remain uncertain, the safety, accessibility, and motivational appeal of exergames continue to position them as promising tools for promoting engagement and activity among older adults. Their integration into broader preventive health strategies should not be dismissed, particularly given their potential to enhance adherence and participation in cognitive and physical training programs.

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References

Armstrong, N. M., Dumitrescu, L., Huang, C., An, Y., Tanaka, T., Hernandez, D., Doshi, J., Erus, G., Davatzikos, C., Ferrucci, L., Resnick, S. M., & Hohman, T. J. (2020). Association of hippocampal volume polygenic predictor score with baseline and change in brain volumes and cognition among cognitively healthy older adults. *Neurobiology Of Aging, 94*, 81-88. https://doi.org/10.1016/j.neurobiolaging.2020.05.007

Aron, L., Zullo, J., & Yankner, B. A. (2021). The adaptive aging brain. *Current Opinion In Neurobiology, 72*, 91-100. https://doi.org/10.1016/j.conb.2021.09.009

Attoh-Mensah, E., Bel, J.-F., El Ayoubi, K., Boujut, A., Ramanoel, S., & Perrochon, A. (2024). Neural correlates of exergame interventions in older adults with or without a neurocognitive disorder: A systematic review. *En Preprints*. https://doi.org/10.20944/preprints202410.0965.v1

Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559. https://doi.org/10.1126/science.1736359

Bhagwat, A. P., & Deodhe, N. P. (2023). The Effect of Perturbation-Based Balance Training vs Step Training on Reaction Time in Older Persons: A Review. *Cureus*. https://doi.org/10.7759/cureus.48104

Campo-Prieto, P., Cancela-Carral, J. M., Peña, S. M. T., & Rodríguez-Fuentes, G. (2025). Una experiencia de ejercicio terapéutico gamificado en un paciente con síndrome Wernicke- Korsakoff. *Retos, 72*, 117-127. https://doi.org/10.47197/retos.v72.116820

Camuso, S., La Rosa, P., Fiorenza, M. T., & Canterini, S. (2021). Pleiotropic effects of BDNF on the cerebellum and hippocampus: Implications for neurodevelopmental disorders. *Neurobiology Of Disease, 163*, 105606. https://doi.org/10.1016/j.nbd.2021.105606

Chan, W. L. S., Chan, C. W. L., Chan, H. H. W., Chan, K. C. K., Chan, J. S. K., & Chan, O. L. W. (2024). A randomised controlled pilot study of a Nintendo Ring Fit AdventureTM balance and strengthening exercise program in community-dwelling older adults with a history of falls. *Australasian Journal On Ageing, 43*(3), 533-544. https://doi.org/10.1111/ajag.13297

Chen, X., Wu, L., Feng, H., Ning, H., Wu, S., Hu, M., Jiang, D., Chen, Y., Jiang, Y., & Liu, X. (2023). Comparison of Exergames Versus Conventional Exercises on the Health Benefits of Older Adults: Systematic Review With Meta-Analysis of Randomized Controlled Trials. *JMIR Serious Games, 11*, 42374. https://doi.org/10.2196/42374

Colautti, L., Antonietti, A., & Iannello, P. (2022). Executive Functions in Decision Making under Ambiguity and Risk in Healthy Adults: A Scoping Review Adopting the Hot and Cold Executive Functions Perspective. *Brain Sciences, 12*(10), 1335. https://doi.org/10.3390/brainsci12101335

Dany, D., Arianti, D., Rossa, M., Prayitno, D. A., Erfarenata, F., & Wibawa, J. C. (2025). Physiological responses of resistance training in increasing brain-derived neurotrophic factor levels: a systematic review. *Retos, 68*, 1250-1261. https://doi.org/10.47197/retos.v68.115912

Davey, J., Turner, R. M., Clarke, M. J., & Higgins, J. P. (2011). Characteristics of meta-analyses and their component studies in the Cochrane Database of Systematic Reviews: a cross-sectional, descriptive analysis. *BMC Medical Research Methodology, 11*(1), 160. https://doi.org/10.1186/1471-2288-11-160

D'Esposito, M., & Postle, B. R. (2014). The Cognitive Neuroscience of Working Memory. *Annual Review Of Psychology, 66(*1), 115-142. https://doi.org/10.1146/annurev-psych-010814-015031

De Bruin, E. D., Baur, H., Brülhart, Y., Luijckx, E., Hinrichs, T., & Rogan, S. (2020). Combining Stochastic Resonance Vibration With Exergaming for Motor-Cognitive Training in Long-Term Care; A Sham-Control Randomized Controlled Pilot Trial. *Frontiers In Medicine, 7*. https://doi.org/10.3389/fmed.2020.507155

Dinneweth, J., & Gadeyne, S. (2024). Socioeconomic Disparities in Neurodegenerative Disease Mortality: A Population-Based Study among Belgian Men and Women Aged 65 or Older. INQUIRY The Journal Of Health Care *Organization Provision And Financing, 61*. https://doi.org/10.1177/00469580241237113

Eggenberger, P., Wolf, M., Schumann, M., & De Bruin, E. D. (2016). Exergame and Balance Training Modulate Prefrontal Brain Activity during Walking and Enhance Executive Function in Older Adults. *Frontiers In Aging Neuroscience, 8*, 66. https://doi.org/10.3389/fnagi.2016.00066

Farokhian, F., Yang, C., Beheshti, I., Matsuda, H., & Wu, S. (2017). Age-Related Gray and White Matter Changes in Normal Adult Brains. *Aging And Disease, 8*(6), 899. https://doi.org/10.14336/ad.2017.0502

Ghasemian, M., Tajpour, M., Mollanuri, P., Zamanpour, E., & Moradi, H. (2024). Computerized cognitive games versus cognitive exergame: the comparison of motor and cognitive functions enhancement in the elderly. *BMC Psychology, 12*(1), 549. https://doi.org/10.1186/s40359-024-02064-2

Goshi, N., Lam, D., Bogguri, C., George, V. K., Sebastian, A., Cadena, J., Leon, N. F., Hum, N. R., Weilhammer, D. R., Fischer, N. O., & Enright, H. A. (2025). Direct effects of prolonged TNF-α and IL-6 exposure on neural activity in human iPSC-derived neuron-astrocyte co-cultures. *Frontiers In Cellular Neuroscience, 19.* https://doi.org/10.3389/fncel.2025.1512591

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (Eds.). (2024). *Cochrane handbook for systematic reviews of interventions* (Version 6.5, updated August 2024). Cochrane. https://www.cochrane.org

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics In Medicine*, *21*(11), 1539-1558. https://doi.org/10.1002/sim.1186

Hou, H., Chen, J., Hai, L., Wang, P., Zhang, J., & Li, H. (2023). Effects of exergame and bicycle exercise intervention on blood pressure and executive function in older adults with hypertension: A three-group randomized controlled study. *Experimental Gerontology, 173*, 112099. https://doi.org/10.1016/j.exger.2023.112099

Hou, H., & Li, H. (2022). Effects of exergame and video game training on cognitive and physical function in older adults: A randomized controlled trial. *Applied Ergonomics, 101*, 103690. https://doi.org/10.1016/j.apergo.2022.103690

Hu, M., Wang, S., Wu, C., Li, K., Geng, Z., Xu, G., & Dong, L. (2024). Efficacy of robot-assisted gait training on lower extremity function in subacute stroke patients: a systematic review and meta-analysis. *Journal Of NeuroEngineering And Rehabilitation, 21*(1). https://doi.org/10.1186/s12984-024-01463-1

Huber, S. K., Held, J. P. O., De Bruin, E. D., & Knols, R. H. (2021). Personalized Motor-Cognitive Exergame Training in Chronic Stroke Patients—A Feasibility Study. *Frontiers In Aging Neuroscience, 13*. https://doi.org/10.3389/fnagi.2021.730801

Idowu, M. I., & Szameitat, A. J. (2023). Executive function abilities in cognitively healthy young and older adults—A cross-sectional study. *Frontiers In Aging Neuroscience, 15*. https://doi.org/10.3389/fnagi.2023.976915

Jerez-Salas, F., Campos-Jara, C., Sierralta, S. A., Jerez-Mayorga, D., Ramirez-Campillo, R., Contreras-Díaz, G., Carrasco-Alarcón, V., Martínez-Cortés, H., Arellano-Roco, C., Hernández-Cifuentes, V., & Contreras-Osorio, F. (2025). Effects of Resistance Training on Executive Functions of Cognitively Healthy Older Adults: A Systematic Review and Meta-Analysis Protocol. *Healthcare, 13*(2), 165. https://doi.org/10.3390/healthcare13020165

Jiang, J., Guo, W., & Wang, B. (2022). Effects of exergaming on executive function of older adults: a systematic review and meta-analysis. *PeerJ, 10*, 13194. https://doi.org/10.7717/peerj.13194

Kaspar, R., Wahl, H., & Diehl, M. (2021). Awareness of Age-Related Change as a Behavioral Determinant of Survival Time in Very Old Age. *Frontiers In Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.727560

Kolaski, K., Logan, L. R., & Ioannidis, J. P. A. (2023). Guidance to best tools and practices for systematic reviews. *British Journal Of Pharmacology, 181*(1), 180-210. https://doi.org/10.1111/bph.16100

Lane, B., McCullagh, R., Cardoso, J. R., & McVeigh, J. G. (2022). The effectiveness of group and home-based exercise on psychological status in people with ankylosing spondylitis: A systematic review and meta-analysis. *Musculoskeletal Care, 20*(4), 758-771. https://doi.org/10.1002/msc.1641

Lecca, D., Jung, Y. J., Scerba, M. T., Hwang, I., Kim, Y. K., Kim, S., Modrow, S., Tweedie, D., Hsueh, S., Liu, D., Luo, W., Glotfelty, E., Li, Y., Wang, J., Luo, Y., Hoffer, B. J., Kim, D. S., McDevitt, R. A., & Greig, N. H. (2022). Role of chronic neuroinflammation in neuroplasticity and cognitive function: A hypothesis. *Alzheimer S & Dementia, 18*(11), 2327-2340. https://doi.org/10.1002/alz.12610

López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., & Kroemer, G. (2023). Hallmarks of aging: An expanding universe. *Cell, 186*(2), 243-278. https://doi.org/10.1016/j.cell.2022.11.001

Maillot, P., Perrot, A., & Hartley, A. (2011). Effects of interactive physical-activity video-game training on physical and cognitive function in older adults. *Psychology And Aging, 27*(3), 589-600. https://doi.org/10.1037/a0026268

Marques, L. M., Uchida, P. M., & Barbosa, S. P. (2023). The impact of Exergames on emotional experience: a systematic review. *Frontiers In Public Health, 11*. https://doi.org/10.3389/fpubh.2023.1209520

Moran, J., Ramirez-Campillo, R., & Granacher, U. (2018). Effects of Jumping Exercise on Muscular Power in Older Adults: A Meta-Analysis. *Sports Medicine, 48*(12), 2843-2857. https://doi.org/10.1007/s40279-018-1002-5

Nguyen, L., Murphy, K., & Andrews, G. (2019). Cognitive and neural plasticity in old age: A systematic review of evidence from executive functions cognitive training. *Ageing Research Reviews, 53*, 100912. https://doi.org/10.1016/j.arr.2019.100912

Numakawa, T., & Odaka, H. (2022). The Role of Neurotrophin Signaling in Age-Related Cognitive Decline and Cognitive Diseases. *International Journal Of Molecular Sciences, 23*(14), 7726. https://doi.org/10.3390/ijms23147726

Ogawa, E. F., Huang, H., Yu, L., Gona, P. N., Fleming, R. K., Leveille, S. G., & You, T. (2019). Effects of Exergaming on Cognition and Gait in Older Adults at Risk for Falling. *Medicine & Science In Sports & Exercise, 52(*3), 754-761. https://doi.org/10.1249/mss.0000000000002167

Olyaei, G., Khanmohammadi, R., Talebian, S., Hadian, M. R., Bagheri, H., & Najafi, M. (2022). The effect of exergaming on cognition and brain activity in older adults: A motor- related cortical potential study. *Physiology & Behavior, 255*, 113941. https://doi.org/10.1016/j.physbeh.2022.113941

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Alonso-Fernández, S. (2021). Declaración PRISMA 2020: una guía actualizada para la publicación de revisiones sistemáticas. *Revista Española de Cardiología, 74*(9), 790-799. https://doi.org/10.1016/j.recesp.2021.06.016

Shende, S. A., Nguyen, L. T., Lydon, E. A., Husain, F. T., & Mudar, R. A. (2021). Cognitive Flexibility and Inhibition in Individuals with Age-Related Hearing Loss. *Geriatrics, 6*(1), 22. https://doi.org/10.3390/geriatrics6010022

Shojania, K. G., Sampson, M., Ansari, M. T., Ji, J., Doucette, S., & Moher, D. (2007). How Quickly Do Systematic Reviews Go Out of Date? A Survival Analysis. *Annals Of Internal Medicine, 147*(4), 224. https://doi.org/10.7326/0003-4819-147-4-200708210-00179

Smith, M. D., & Wesselbaum, D. (2023). Global evidence of inequality in well-being among older adults. *Journal Of The American Geriatrics Society, 72*(3), 842-849. https://doi.org/10.1111/jgs.18694

Soares, V. N., Yoshida, H. M., Magna, T. S., Sampaio, R. A. C., & Fernandes, P. T. (2021). Comparison of exergames versus conventional exercises on the cognitive skills of older adults: a systematic review with meta-analysis. *Archives Of Gerontology And Geriatrics, 97*, 104485. https://doi.org/10.1016/j.archger.2021.104485

Stanmore, E., Stubbs, B., Vancampfort, D., De Bruin, E. D., & Firth, J. (2017). The effect of active video games on cognitive functioning in clinical and non-clinical populations: A meta-analysis of randomized controlled trials. *Neuroscience & Biobehavioral Reviews, 78*, 34-43. https://doi.org/10.1016/j.neubiorev.2017.04.011

Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., . . . Higgins, J. P. (2016). ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ, i4919*. https://doi.org/10.1136/bmj.i4919

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., . . . Higgins, J. P. T. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ, l4898*. https://doi.org/10.1136/bmj.l4898

Stojan, R., Mack, M., Bock, O., & Voelcker-Rehage, C. (2023). Inefficient frontal and parietal brain activation during dual-task walking in a virtual environment in older adults. *NeuroImage, 273*, 120070. https://doi.org/10.1016/j.neuroimage.2023.120070

Street, T. D., Lacey, S. J., & Langdon, R. R. (2017). Gaming Your Way to Health: A Systematic Review of Exergaming Programs to Increase Health and Exercise Behaviors in Adults. *Games For Health Journal, 6*(3), 136-146. https://doi.org/10.1089/g4h.2016.0102

Sturnieks, D. L., Hicks, C., Smith, N., Ratanapongleka, M., Menant, J., Turner, J., Lo, J., Chaplin, C., Garcia, J., Valenzuela, M. J., Delbaere, K., Herbert, R. D., Sherrington, C., Toson, B., & Lord, S. R. (2024). Exergame and cognitive training for preventing falls in community-dwelling older people: a randomized controlled trial. *Nature Medicine, 30*(1), 98-105. https://doi.org/10.1038/s41591-023-02739-0

Thomson, H., Craig, P., Hilton-Boon, M., Campbell, M., & Katikireddi, S. V. (2018). Applying the ROBINS-I tool to natural experiments: an example from public health. *Systematic Reviews, 7*(1). https://doi.org/10.1186/s13643-017-0659-4

Torre, M. M., & Temprado, J. (2022). Effects of Exergames on Brain and Cognition in Older Adults: A Review Based on a New Categorization of Combined Training Intervention. *Frontiers In Aging Neuroscience, 14*. https://doi.org/10.3389/fnagi.2022.859715

Toyonaga, T., Khattar, N., Wu, Y., Lu, Y., Naganawa, M., Gallezot, J., Matuskey, D., Mecca, A. P., Pittman, B., Dias, M., Nabulsi, N. B., Finnema, S. J., Chen, M., Arnsten, A., Radhakrishnan, R., Skosnik, P. D., D'Souza, D. C., Esterlis, I., Huang, Y., . . . Carson, R. E. (2023). The regional pattern of age-related synaptic loss in the human brain differs from gray matter volume loss: in vivo PET measurement with [11C]UCB-J. *European Journal Of Nuclear Medicine And Molecular Imaging, 51*(4), 1012-1022. https://doi.org/10.1007/s00259-023-06487-8

Wager, T. D., Spicer, J., Insler, R., & Smith, E. E. (2013). The neural bases of distracter-resistant working memory. Cognitive *Affective & Behavioral Neuroscience, 14*(1), 90-105. https://doi.org/10.3758/s13415-013-0226-y

World Health Organization: WHO. (2024, 1 october). *Ageing and health*. https://www.who.int/newsroom/fact-sheets/detail/ageing-and-health

Xia, H., Hou, Y., Li, Q., & Chen, A. (2024). A meta-analysis of cognitive flexibility in aging: Perspective from functional network and lateralization. *Human Brain Mapping, 45*(14). https://doi.org/10.1002/hbm.70031

Yang, Y., Wang, K., Liu, S., Liu, H., Zhang, T., & Luo, J. (2023). Exergames improve cognitive function in older adults and their possible mechanisms: A systematic review. *Journal Of Global Health, 13*. https://doi.org/10.7189/jogh.13.04177

You, M., Lindbergh, C. A., La Joie, R., Paolillo, E. W., Saloner, R., Diaz, V., Cotter, D. L., Walters, S., Altendahl, M., Staffaroni, A. M., Kramer, J. H., Gaynor, L. S., & Casaletto, K. B. (2024). Predicting brain atrophy and cognitive aging trajectories with baseline subjective cognitive concerns in cognitively normal older adults. *Neurobiology Of Aging, 143*, 1-9. https://doi.org/10.1016/j.neurobiolaging.2024.08.006

Yu, X., Li, X., Du, Z., Zhang, Y., Fei, Y., Tang, W., Li, X., & Zhao, Q. (2024). Effects of non-pharmacological interventions for adults with subjective cognitive decline: a network meta-analysis and component network meta-analysis. *BMC Medicine, 22*(1). https://doi.org/10.1186/s12916-024-03491-z

Zhao, C., Zhao, C., Li, Y., Zhao, M., Wang, L., Guo, J., Zhang, L., Sun, Y., Ye, X., & Zhu, W. (2022). The Effects of Active Video Game Exercise Based on Self-Determination Theory on Physical Fitness and Cognitive Function in Older Adults. *Journal Of Clinical Medicine, 11*(14), 3984. https://doi.org/10.3390/jcm11143984

Zhao, C., Zhao, C., Zhao, M., Wang, L., Guo, J., Zhang, L., Li, Y., Sun, Y., Zhang, L., Li, Z., & Zhu, W. (2022). Effect of Exergame Training on Working Memory and Executive Function in Older Adults. *Sustainability, 14*(17), 10631. https://doi.org/10.3390/su141710631

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