REVISTA CADERNO PEDAGÓGICO – Studies Publicações Ltda.
ISSN: 1983-0882

A systematic review of the neuropsychological functions of attention and memory of elderly people in computerized cognitive training

Revisão sistemática das funções neuropsicológicas de atenção e memória de pessoas idosas em treinamento cognitivo computadorizado

Una revisión sistemática de las funciones neuropsicológicas de atención y memoria de personas mayores en el entrenamiento cognitivo computarizado

DOI: 10.54033/cadpedv21n8-110

Originals received: 07/12/2024
Acceptance for publication: 08/02/2024

Emerson Rogério de Oliveira Junior
PhD in Human Aging
Institution: Universidade de Passo Fundo (UPF)
Address: Passo Fundo, Rio Grande do Sul, Brazil
E-mail: emerson.oliveira@sertao.ifrs.edu.br

Adriano Pasqualotti
Post-Doctorate in Society, Communication and Culture
Institution: Universidade Técnica de Lisboa
Address: Passo Fundo, Rio Grande do Sul, Brazil
E-mail: pasqualotti@upf.br

Henrique Teixeira Gil
Post-Doctorate in Social Policy, area of concentration in Digital Citizenship
Institution: Universidade Técnica de Lisboa
Address: Passo Fundo, Rio Grande do Sul, Brazil
E-mail: hteixeiragil@ipcb.pt

Mônica Luiza Kieling
Master in Human Aging
Institution: Universidade de Passo Fundo (UPF)
Address: Passo Fundo, Rio Grande do Sul, Brazil
E-mail: monicakieling@gmail.com

RESUMO
Este artigo aborda uma revisão sistemática sobre as funções neuropsicológicas da atenção e da memória em pessoas idosas submetidas a treinamento cognitivo

computadorizado. A pesquisa foi realizada em bases de dados eletrônicas, incluindo Lilacs, Medline, Scopus, Web of Science, Scielo, Sbie, Eric, IEEE Xplore, Ovid, Science Direct, SpringerLink, SAGE Journals e Wiley Online Library, considerando artigos publicados nos últimos 12 anos, em português, inglês e espanhol. Os critérios de elegibilidade incluíram a definição explícita da área de concentração, a utilização de treinamento cognitivo informatizado, a existência de resultados e um público composto por pessoas idosas. A seleção dos estudos foi realizada em três etapas: identificação, triagem e elegibilidade, contando com a participação de dois pesquisadores de forma simultânea e independente. A pesquisa bibliográfica resultou em um total de 328 estudos e, após exclusão dos estudos duplicados e revisão de títulos, resumos e textos completos, foram incluídos 20 estudos para a síntese qualitativa. A caracterização dos estudos incluídos na revisão sistemática foi apresentada em um quadro que detalha informações sobre os principais autores, ano de publicação, país de origem da pesquisa, critérios de elegibilidade, fontes de dados, instrumentos de avaliação, tipo de estudo, método, objetivos resultados esperados, resultados clínicos, métodos de análise, limitações, lacunas e implicações clínicas. Como resultado, verificou-se a importância da estimulação cognitiva como estilo de vida saudável para o cérebro, e identificou-se que a utilização do treinamento cognitivo informatizado apresenta ganhos nas funções neuropsicológicas de atenção e memória em pessoas idosas.

Palavras-chave: Treinamento Cognitivo Computadorizado. Atenção. Memória. Pessoas Idosas.

ABSTRACT

This article addresses a systematic review of the neuropsychological functions of attention and memory in elderly people undergoing computerized cognitive training. This search was carried out in electronic databases, including Lilacs, Medline, Scopus, Web of Science, Scielo, Sbie, Eric, IEEE Xplore, Ovid, Science Direct, SpringerLink, SAGE Journals and Wiley Online Library, considering articles published in the last 12 years in Portuguese, English, and Spanish. Eligibility criteria included the explicit definition of the area of concentration, the use of computerized cognitive training, the existence of results and an audience composed of elderly people. The selection of studies was carried out in three stages: identification, screening, and eligibility, with the participation of two researchers simultaneously and independently. The bibliographical research resulted in a total of 328 studies and, after excluding duplicate studies and reviewing titles, abstracts, and full texts, 20 studies were included for qualitative synthesis. The characterization of the studies included in the systematic review was presented in a table that details information about the main authors, year of publication, country of origin of the research, eligibility criteria, data sources, evaluation instruments, type of study, method, objectives expected outcomes, clinical outcomes, analysis methods, limitations, gaps, and clinical implications. As a result, the importance of cognitive stimulation as a healthy lifestyle for the brain was verified, and it was identified that the use of computerized cognitive training presents gains in the neuropsychological functions of attention and memory in elderly people.

Keywords: Computerized Cognitive Training. Attention. Memory. Elderly People.

RESUMEN

Este artículo aborda una revisión sistemática de las funciones neuropsicológicas de la atención y la memoria en personas mayores sometidas a entrenamiento cognitivo computarizado. Esta búsqueda se realizó en bases de datos electrónicas, incluidas Lilacs, Medline, Scopus, Web of Science, Scielo, Sbie, Eric, IEEE Xplore, Ovid, Science Direct, SpringerLink, SAGE Journals y Wiley Online Library, considerando artículos publicados en los últimos 12 años en portugués, inglés y español. Los criterios de elegibilidad incluyeron la definición explícita del área de concentración, el uso de entrenamiento cognitivo computarizado, la existencia de resultados y una audiencia compuesta por personas mayores. La selección de los estudios se realizó en tres etapas: identificación, cribado y elegibilidad, con la participación de dos investigadores de forma simultánea e independiente. La investigación bibliográfica resultó en un total de 328 estudios y, después de excluir estudios duplicados y revisar títulos, resúmenes y textos completos, se incluyeron 20 estudios para síntesis cualitativa. La caracterización de los estudios incluidos en la revisión sistemática se presentó en una tabla que detalla información sobre los autores principales, año de publicación, país de origen de la investigación, criterios de elegibilidad, fuentes de datos, instrumentos de evaluación, tipo de estudio, método, objetivos. resultados esperados, resultados clínicos, métodos de análisis, limitaciones, lagunas e implicaciones clínicas. Como resultado, se verificó la importancia de la estimulación cognitiva como estilo de vida saludable para el cerebro, y se identificó que el uso del entrenamiento cognitivo computarizado presenta ganancias en las funciones neuropsicológicas de atención y memoria en personas mayores.

Palabras clave: Entrenamiento Cognitivo Computarizado. Atención. Memoria. Personas Maores.

1 INTRODUCTION

According to the World Health Organization (WHO), the increasing reduction in fertility rates and increased longevity will ensure the continued growth of the world population and the consequent aging of this population (World Health Organization, 2021), and according to the United Nations (UN), the population over 60 years old has doubled in the last four decades and is expected to reach 1.5 billion people worldwide by 2050 (United Nations, 2019). Aging can bring serious problems regarding health problems that challenge health and social security systems. The aging trend implies a significant increase in the prevalence of

diseases that affect the cognitive functioning and independence of older people, such as dementia, Alzheimer's disease, and mild cognitive impairment, among others (Alves et al., 2018). Furthermore, it is recognized that activities focusing on cognitive stimulation are treated as a healthy lifestyle for the brain when considering the preservation of cognitive functions in elderly people (Chiu et al., 2022).

Cognitive deficiencies in attention, memory, and executive functions, as well as behavioral and emotional symptoms, common in neurological diseases, can occur throughout the lives of elderly people. However, despite facing a decline in cognitive abilities, the human brain maintains the ability to adapt to changes, even at advanced ages (Rute-Pérez et al., 2023). In recent decades, non-pharmacological interventions are being used for the prevention and treatment of cognitive impairment (Smart et al., 2017). Cognitive stimulation or training has become the strategy par excellence for cognitive development. In this sense, advances in information and communication technologies (ICTs) have led to the emergence of computerized cognitive training (CCT) with the aim of preventing and reducing cognitive impairment (Klimova; Maresova, 2017, Gavelin et al., 2020). Many of these programs offer advantages such as: they present an individualized approach according to the needs and characteristics of each person; are accessible to a greater number of people, avoiding problems arising from reduced mobility and access to health resources; have a lower economic cost, and they allow for an objective analysis of performance and immediate feedback (Rute-Pérez et al., 2023).

This systematic mapping aims to investigate studies in the literature that were concerned with verifying the impact on improving the neuropsychological functions of attention and memory in elderly people using computerized cognitive training. To meet this objective, this SLR intends to answer the following research questions: RQ1: What are the effects of CCT on the attention and memory functions of older people? RQ2: What are the most effective types, characteristics, and frequencies of use of CCT to improve attention and memory functions in older people? RQ3: What are the eligibility criteria, data sources, assessment instruments, analysis methods and clinical outcomes used in studies evaluating the

impact of CCT on the neuropsychological functions of attention and memory in older people? RQ4: What are the limitations, gaps and clinical implications of studies evaluating the impact of CCT on the neuropsychological functions of attention and memory in older people?

2 METHODS

This study follows the PRISMA method - Preferred Reporting Items for Systematic Reviews and Meta-Analysis (Moher et al., 2009). Furthermore, as indicated by Kitchenham and Charters (2007), a Systematic Literature Review is "a means of evaluating and interpreting all available research that is relevant to a given specific research question, topic, or phenomenon of interest. Systematic reviews aim to present a fair assessment of a research topic using a reliable, rigorous, and auditable methodology."

2.1 SEARCH STRATEGY

Considering the guiding research questions, some terms were used to compose the string used in the search. Synonyms were consulted in the literature to compose the search string according to the PICo strategy - Population (P), Intervention (I), Context (Co). The terms used to define the search string are indicated in Table 1.

Table 1: Search terms defined with the PICo strategy

Population (P)	*Intervention (I)*	*Context (Co)*
aging elderly elderly people elderly person senior citizen senior citizens oldest old elder people elder person older old older adult older adults	randomized randomized control trial computer computerized computerized cognitive training	attention memory cognitive cognition

older people older person people aged

Authors (2024).

For search, the following electronic databases were considered: Lilacs, Medline, Scopus, Web of Science, Scielo, Sbie, Eric, IEEE Xplore, Ovid, Science Direct, SpringerLink, SAGE Journals, and Wiley Online Library. The search expression needed to be adapted in some databases. Were considered articles written in Portuguese, English and Spanish were considered. The filter was applied to the title, abstract, keywords and full text. Articles published in the last 12 years (from 2013 to 2024) were considered.

2.2 ELIGIBILITY AND SELECTION

The eligibility criteria for carrying out this systematic literature review were considered: i) explicit definition of the area of concentration and the problem to be addressed; ii) use of computerized cognitive training; iii) existence of results; iv) public served made up entirely, or in part of elderly people. Articles whose data were incomplete were disregarded, as well as those in which, after exhausting all alternatives, the complete texts were not located in the searched databases.

The selection of studies was structured in three stages: a) Identification: application of the search string performed in the databases; b) Screening: titles and abstracts identified through the search strategy were reviewed with a preliminary examination to determine whether they had sufficient information related to the objective of this systematic review; c) Eligibility: potentially relevant studies, determined as eligible based on the title or abstract, were retrieved and evaluated by reading the full text, to establish their suitability for the eligibility criteria for the qualitative synthesis.

The study selection steps were carried out by two researchers simultaneously and independently. Assessments with identical results were maintained, divergent assessments underwent a new analysis conducted jointly by the two

researchers, to reach the final decision. When investigators were unable to reach an agreement, the situation was resolved with the assistance of a third investigator. Duplicate studies were removed.

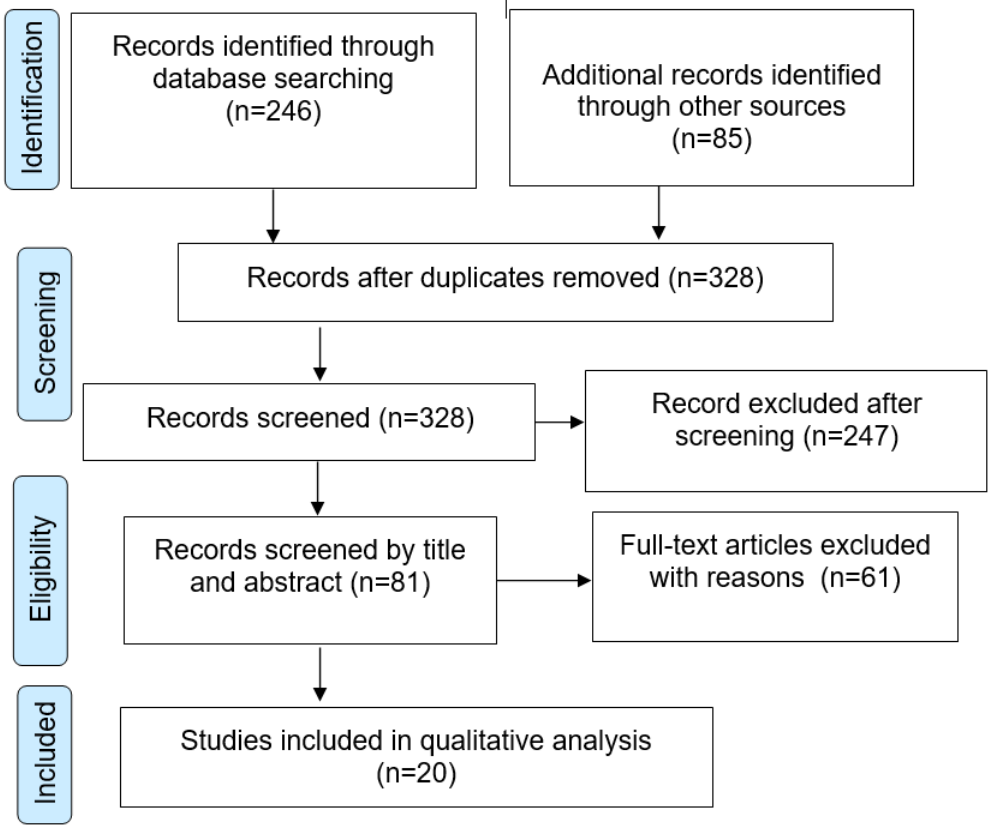
2.3 DATA EXTRACTION

A extraction table was used, whose lines correspond to data on the following aspects: i) main author, year of publication, and the research origin country; ii) study type, sample size, and characterization; iii) description of the computerized technology used in the study; iv) used method characterization; v) description of the objectives expected from the study; vi) presentation of the cognitive results obtained for attention of elderly people; vii) presentation of the cognitive results obtained for the memory of elderly people; viii) other results obtained with the intervention. The columns list the studies included.

3 RESULTS AND DISCUSSION

The bibliographic search resulted in a total of 328 studies, 246 in databases, and 85 in other sources. Three duplicate articles were found. Subsequently, 247 studies were excluded during the review of titles and abstracts, leaving 81 complete articles for eligibility assessment. Of these, 61 studies were excluded due to any eligibility criteria, resulting in 20 studies included for the qualitative synthesis. Figure 1 represents the study selection flow of the bibliographic search.

Figure 1. PRISMA flowchart



Authors (2024).

Table 2 presents the characterization of the studies included for this systematic review.

Table 2: Characterization of the studies included

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
Anguera 2013 United States	between 20 and 79 years old, no history of neurological or psychiatric diseases, no use of medications that affect the central nervous system, have visual and motor skills to play the video game	IG (n=174) neurophysiological behavioral measures collected before and after video game training, as well as at a 6-month follow-up EEG, behavioral tasks	RCT test 1: (n = 174), from 20 to 79 years old, response assessed based on the ability to complete the two tasks simultaneously; test 2: (n = 46), aged 60 and 85, divided into three groups: one played the full and simultaneous version of NeuroRacer at home, 60 minutes, three times a week, for four weeks. Another, with the two game tasks, independently, and the last group did not use NeuroRacer. After six months, participants underwent new tests	improving the performance of multitasking activities and reducing cognitive deficits	improved sustained attention, working memory and processing speed in older people, but there were no significant effects on long-term memory Analysis of variance (ANOVA) and analysis of covariance (ANCOVA)	more research is needed to determine long-term effectiveness
Bahar-Fuchs 2017 Australia	65 years old or older, EPMCI or age-related memory problems, have access to a computer with internet at home	IG (n=21) CG (n=23) neuropsychological assessments, self-report questionnaires, and daily activities assessments Memory tests (logic and face recognition); verbal fluency; attention	RCT EPMCI (n = 9), with mood-related neuropsychiatric symptoms (n = 11), or both (n = 25) were randomized into an individually tailored, home-based, Cognifit-based computerized training. Interventions	cognition improvement in EPMCI	significant improvement in attention (with effects maintained for 12 weeks after the intervention), logical memory (with effects maintained for 12 weeks after the	small sample size, short duration of participant follow-up time, did not evaluate the relationship between cognitive improvements and the prevention or delay of dementia, individually adapted

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
		(continuous, divided, and sustained visual); processing speed	lasted 8 to 12 weeks and results were assessed post-intervention and at a 3-month follow-up		intervention) and mood Analysis of variance (ANOVA) and mixed models	computerized cognitive training can improve cognitive functions in EPMCI, and more research is needed to determine ng-term effectiveness term
Ballesteros 2017 Spain	be a volunteer, 60 years old or older, be independent, have normal or corrected hearing and vision, not have neurological, psychiatric disorders or drug addiction	IG (n=30) CG (n=25) standardized cognitive tests, self-report questionnaires, and video game performance assessments MMSE, Yesavage Depression Scale, WAIS-III subtest	RCT elderly people (n = 30) in the experimental group and (n = 25) in the control group performed 16 sessions with the Lumosity video game (experimental group) or strategy simulation games (control group), tested before and after training	improvement in selective attention and working memory in older people	improves performance on selective attention and working memory tasks ANOVA and independent samples t-test	lack of control group, video game training may improve cognitive function in older people, more research is needed to determine long-term effectiveness
Belchior 2019 Switzerland	65 years old or older, MMSE score of at least 24, little video game use in the last 6 months, visual acuity, be in the study region during the study	IG (n=37) CG (n=18) cognitive and daily functioning assessments carried out immediately before (pre-test), after (post-test) and 3 months after (follow-up) training MMSE, GDS	RCT three intervention groups: one group played video games; the second group played InSight and the third group received no training. There were 60 sessions of 1 hour each, over 3 months (5 hours per week)	compare cognitive gains between different groups	improvement in visual attention (with gains up to three months after the intervention) and processing speed Analysis of variance and covariance	more research is needed to determine long-term effectiveness

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
					(ANOVA and ANCOVA)	
Chiu 2022 Taiwan	65 years old or older, resident of one of the study institutions, have a MMSE score of at least ≥ 13, and be able to communicate sufficiently	IG (n=30) CG (n=30) cognitive assessments, health and well-being questionnaire, interviews with participants and their families MMSE and cognitive assessment	RCT EPMCI (n = 60), 60 minutes per week for 8 weeks. Each intervention group session (n = 30) included 12 virtual reality-based cognitive training tasks, and the control group (n = 30) with usual care	improvement in quality of life and changes in cognitive functions in institutionalized elderly people	improvement in selective attention and working memory tasks Student's t test, Analysis of variance and covariance (ANOVA and ANCOVA)	more research is needed to determine long-term effectiveness
Eggenberger 2015 Switzerland	between 60 and 75 years old, with no history of neurological or psychiatric illnesses, who were not involved in regular physical exercise or cognitive training programs	IG (n=30) standardized neuropsychological testing, physical assessments, and interviews Stroop Test, Verbal Fluidity Test, Digit Working Memory Test, Visual Long-Term Memory Test, Processing Speed Test	RCT elderly people were distributed into three groups: 1) virtual reality video game dancing (DANCE), 2) treadmill walking with simultaneous verbal memory training, and 3) treadmill walking. Two 1-hour training sessions were carried out per week for 6 months. Cognitive performance was assessed at baseline, after 3, 6 and 12 months	investigate the benefits of combining physical and cognitive activities for older people	improved selective attention and sustained attention (with effects maintained after 12 months), and improved working memory ANOVA and Student's t-test for independent samples	more research is needed to determine long-term effectiveness
Gonzales-Palau 2014	60 years old or older, fluent in Spanish, and	IG (n=44) neuropsychological assessments,	RCT healthy elderly people (n = 33), and EPMCI (n =	show the efficiency of LLM on	improvement in EPMCI attention, verbal memory,	lack of consensus on the ideal duration and

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
Spain	not enrolled in another study	questionnaires, and interviews standardized tests of memory, attention, and other cognitive functions, and self-report questionnaires	11) received 60 minutes of physical training, and 35 minutes of cognitive training, 3 times a week, for 12 weeks. Before and after the intervention, they were evaluated using neuropsychological tests	cognitive functions, and symptoms of depression	episodic memory, and depression levels Student's t-test, ANOVA, regression analysis	intensity of training, using these programs as a non-pharmacological intervention to improve cognitive function in older people, and more research is needed to determine long-term effectiveness
Hagovská 2017 Slovakia	have mild cognitive impairment confirmed based on clinical examinations administered by a neurologist, psychiatrist, or clinical psychologist	IG (n=30) CG (n=30) diagnosis of mild cognitive impairment in the database of outpatient psychiatric clinics clinical examinations, neuropsychological tests of working memory, attention, executive functions, verbal fluency, depression, and intelligence	RCT EPMCI (n = 60) were distributed into two groups: intervention (n = 30) using Cogniplus, and control (n = 30) using classic cognitive training. There were two 30-minute sessions per week for 10 weeks	verify the effectiveness of cognitive training	significant improvements in attention and quality of life Student's t-test, Chi-Square, Shapiro-Wilk, D'Agostino-Pearson, Greenhouse-Geisser correction, and Cohen	more research is needed to determine long-term effectiveness
Han 2014 South Korea	65 years old or older, EPMCI	IG (n=10) *Korean Longitudinal Study on Cognitive Aging and Dementia* (KLOSCAD) *Consortium to Establish a Registry for*	PPS EPMCI (n = 10) performed the USMART for 60 minutes, once a week, for 4 weeks	evaluate the feasibility and effectiveness of USMART in EPMCI	significant improvement in episodic memory and working memory Mann-Whitney U-test and Repeated	sample size was small, treatment period was short, type of cognitive impairment was not uniform, and long-

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
		Alzheimer's Disease (CERAD-K)			measures analysis of variance (RM-ANOVA)	term efficacy was not evaluated
Hyer 2016 United States	65 years old or older, EPMCI, and have access to a caregiver	IG (n=34) CG (n=34) referrals from doctors at a family health clinic Rivermead Memory Test and Wechsler Memory Test	RCT EPMCI (n = 68) were divided into the intervention group (n = 34) using COGMED, and the control group (n = 34), using another software, 5 to 7 sessions of 40 minutes per week, 25 sessions	evaluate efficacy in EPMCI	improved working memory and executive functions ANOVA	small sample size, no control group used, short intervention period, and more research is needed to determine long-term effectiveness
Hsieh 2018 Taiwan	65 years old or older, EPMCI, ability to: walk without assistance; follow simple instructions; participate in a virtual reality Tai Chi exercise program	IG (n=31) CG (n=29) cognitive and physical assessments, attendance records, and movement accuracy during exercises *Cognitive Abilities Screening Instrument* (CASI)	QERPS EPMCI (n = 60) were divided into the intervention group (n = 31) that used the VRTC, and the control group (n = 29). The intervention took place twice a week, for 60 minutes, for six months	evaluate cognitive and physical effects of VRTC in EPMCI	significant improvement in episodic memory and working memory Student's t-test, Chi-square, Generalized Estimating Equation	lack of participant selection criteria, lack of a control group. Furthermore, virtual reality-based Tai Chi may be an effective non-pharmacological therapy, more research is needed to confirm these results
Hughes 2014 United States	65 years old or older, good vision, good hearing, no motor problems, and no history of	IG (n=10) CG (n=10) Acceptable score on *Monongahela-Youghiogheny Healthy Aging Team* (MYHAT)	RCT EPMCI (n = 20) were distributed in the intervention group (n = 10) which used interactive video games in groups,	evaluate the effectiveness of using interactive games in improving	significant improvement in attention, memory, and executive functions	small sample size, more research is needed to determine long-term effectiveness

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
	neuropsychological problems	CAMCI	and in the control group (n = 10). The intervention took place twice a week, for 90 minutes, 24 weeks	cognitive functioning	Wilcoxon test, Fisher's exact test	
Jirayucharoensak 2019 Thailand	60 years old or older, scores of 0.5 on the Clinical Dementia Scale, no diagnosis of dementia, schizophrenia or psychoorganic syndromes, no neurological disorders, adequate verbal, visual and auditory skills, and at least 4 years of education	IG (n=65) CG (n=54) neuropsychological assessments, health and well-being questionnaires, electroencephalogram, and functional magnetic resonance imaging MMSE and tests of visual memory, sustained attention, animal verbal fluency, word memory, and picture memory	RCT healthy elderly people (n = 54) and EPMCI (n = 65) were classified into three groups: group with usual care and NFT (n = 58), group with usual care and exergames (n = 36), and group with usual care (n = 25). There were 20 sessions, 2 to 3 times a week, 30 minutes each	evaluate the clinical efficacy of NFT in EPMCI	improvement in sustained visual attention, working memory, the ability to retain spatial information, and the definition of strategies to complete tasks	possibility of using neurofeedback training games as a non-pharmacological intervention for EPMCI. More research is needed to determine the effectiveness and generalizability of these interventions in other populations and clinical settings
Mrakic-Sposta 2018 Italy	65 years old or older, with visual and spatial abilities, with preserved mental faculties, and without cardiovascular pathology	IG (n=5) CG (n=5) open questions and free comments MEEM, *Bateria per la valutazione del deterioramento mentale*, A and B trail test, verbal fluency test, and semi-structured interview	CPS EPMCI (n = 10) were distributed in the intervention group (n = 5), which performed cognitive training based on virtual reality, with three 60-minute sessions per week, for 6 weeks, and in the control group (n = 5)	verify the effects of virtual reality-based activities and physical activities	improvement in visual-spatial attention tests, recognition memory, and reduction in anxiety levels Non-parametric tests and Mann Whitney-U Test	short intervention time, small sample size, and more research is needed to determine long-term effectiveness

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
Monteiro-Junior 2017 Brazil	60 years old or older, medical consent, communication skills, understanding simple commands	IG (n=29) neuropsychological assessments, physical tests, and questionnaires Tests of verbal fluency, tracks A and B, working memory, and logical memory; GDS and Fall Effectiveness Scale	CPS elderly people (n = 29) performed exergames together with physical exercises, with an intervention of 2 sessions of 30 to 45 minutes per week, for 6 to 8 weeks	investigate the effects of physical exercise with virtual reality on the cognitive functions of IEP	positive effects on attention, short-term memory, and mobility Analysis of variance and covariance (ANOVA and ANCOVA)	more research is needed to determine long-term effectiveness
Rute-Pérez 2023 Spain	65 years old or older, have a minimum educational level of 4 years, do not have dementia or other serious neurological conditions, and have not participated in cognitive training programs in the last 6 months	IG (n=55) CG (n=20) standardized neuropsychological tests Rivermead Memory Test, Verbal Fluency Test, Stroop Test, health, and well-being assessment questionnaires	QERPS elderly people (n = 75) were divided into an intervention group (n = 55), using VIRTRAEL, and a control group (n = 20), receiving face-to-face cognitive stimulation with a paper and pencil methodology, during nine sessions of 45 to 60 minutes each	investigate the benefits of VITRAEL on cognitive function in older people	improves attention and verbal memory Student's t-test, analysis of covariance (ANCOVA)	inclusion of the use of computerized cognitive training programs as a non-pharmacological intervention to improve cognitive functions, small sample
Simon 2018 Sweden and United States	65 years old or older, speak English or Sweden, IQ of at least 90,	IG (n=41) CG (n=41) structured interview, neuropsychological assessment, normal vision, and hearing	RCT elderly people (n = 82) were assigned to the intervention group (n = 41), with computerized	evaluate the effectiveness of computerized cognitive	improves working memory ANOVA and Chi-Square	small sample size, more research is needed to determine long-term effectiveness

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
	MMSE score 26 or higher, average performance on memory and logic tests	MMSE	cognitive training, and to the control group (n = 41). The intervention took place with 5 sessions per week, for 5 weeks	training focusing on working memory		
Savulich 2017 United Kingdom	45 years old or older, normal, or corrected vision, Alzheimer's type EPMCI, no neurological disorders that affect memory	IG (n=21) CG (n=21) patients from memory clinics and the clinical research network Cambridge neuropsychological test battery and questionnaires	RCT amnestic EPMCI (n = 42) were assigned to cognitive training (n = 21), 8 hours of the GAMESHOW game, over 4 weeks, or to the control group (n = 21), with usual clinical visits	evaluate the effectiveness of a memory game to improve episodic memory	improves episodic memory, visuospatial memory, and self-confidence Student's t-test, Mann Whitney-U test, ANOVA, Chi-Square	small sample size, no control group, and more research is needed to determine long-term effectiveness
Wais 2021 United States	65 years old or older, at least 12 years of education, tests that scored 1.5 standard deviations or higher for your age	IG (n=48) standardized neuropsychological assessments MMSE, GDS, Trail Making Test A and B, Stroop Test, Letter Test, and Verbal Fluency Test	RCT elderly people (n = 48), with the intervention group using LABYRINTH-VR, and a control group using a “placebo” game, with sessions lasting 12 hours	evaluate virtual reality games in improving long-term memory in elderly people	significant improvement in long-term memory capacity Student's t-test, Mann Whitney-U test, ANOVA, and Chi-Square	small sample size and more research is needed to determine long-term effectiveness
Vermeiji 2016 Netherlands	65 years old or older, medical examination, medical history, neuropsychological assessment and/or	IG (n=41) neuropsychological assessments, questionnaires, and cognitive tests Tests of working memory, reading,	RCT elderly people (n = 23) and EPMCI (n = 18) performed online training of working memory activities, with 5 sessions	assess whether there has been an improvement in working memory and whether the	improvement of working memory in normal elderly people and in EPMCI	small sample size, no control group was used, more research is needed to determine long-term effectiveness

Main author Year Country	Eligibility criteria	N Data sources Assessment instruments	Type of study Method	Expected objectives	Clinical outcomes Analysis methods	Limitations, gaps, and clinical implications
	neuroradiological evidence	image, audio, digits, and letters	of 45 minutes per week, with a total of 25 sessions	effects are maintained	ANOVA and Pearson Correlation	

RCT = Randomized Controlled Trial, QERPS = quasi-experimental repeated measures study, PPS = Pre and Post Study; CPS=Controlled Pilot Study, NEURORACER=custom-designed three-dimensional video game, COGNIFIT=computerized cognitive training platform, LUMOSITY=online brain training program, INSIGHT= training software focused on visual attention and processing speed, DANCE=dance virtual reality video game, LLM=long-lasting memories, COGNIPLUS=computer-based cognitive training platform, USMART=Ubiquitous Spaced Retrieval-based Memory Advancement and Rehabilitation Training, COGMED=working memory training software, VRCTI=software that simulates Tai Chi movements with virtual reality, CAMCI=Computerized Assessment of Mild Cognitive Impairment, NFT=neuro feedback training, VIRTRAEL=Computerized Assessment of Mild Cognitive Impairment, GAMESHOW=episodic memory game, LABYRINTH-VR= virtual reality based spatial orientation game, EPMCI=elderly people with mild cognitive impairment, IG=intervention group, CG=control group, EEG=Electroencephalogram, MEEM=Mini-Mental State Examination.
Authors (2024).

The studies were conducted in different countries: United States (n = 4), Spain (n = 3), Switzerland (n = 2), Taiwan (n = 2), Australia (n = 1), Brazil (n = 1) , South Korea (n = 1), Slovakia (n = 1), Netherlands (n = 1), Italy (n = 1), United Kingdom (n = 1), and Taiwan (n = 1). Only one study indicated participant recruitment in two countries, Sweden, and the United States (Simon et al., 2018).

Most of studies were of the Randomized Clinical Study type (n = 13), with the others being: Controlled Pilot Study (n = 2), Pre and Post Study (n = 3) and Quasi Experimental Clinical Trial type Study (n = 2). Regarding to the used method, in most studies (n = 13) there was a random classification of participants into two groups, intervention and control. Five studies used only one group and there were two studies that used three groups of elderly people.

Considering RQ1 (*Effects of CCT on the attention and memory functions of older people*), it was identified that, with the application of the intervention, all studies that aimed to improve the cognitive function of attention showed positive results (n = 13). Some studies did not investigate the function of attention, which is why they did not indicate any results (n = 7). When considering the cognitive function of memory, most studies indicated that there was an improvement in this function on the part of the intervention participants (n = 18). In turn, studies that did not aim to evaluate this function did not indicate information about memory (n = 2). In short, all studies showed some cognitive gain through the intervention. Although it was not the main object of this investigation, gains were reported in other functions, such as: processing speed (n = 3), executive functions (n = 2), improved mood (n = 1), decreased levels of depression (n = 1), improved quality of life (n = 1), increased mobility (n = 1), increased self-confidence (n = 1), and decreased anxiety levels (n = 1).

In response to RQ2 (*Types, characteristics, and frequencies of use*), it was found that the technologies used in the studies were quite different from each other, with commercial software and software adapted by researchers for the proposed intervention of CCT having been identified. It was verified that, apart from COGMED (Hyer et al., 2016, Simon et al., 2018, and Vermeiji et al., 2016), there was no repetition of the used technology. However, the significant number of studies that used virtual reality in intervention activities drew attention (n = 6).

Regarding the frequency of use of CCT, it was found that the duration of the session that appeared the most was 60 minutes (n = 11), occurring two to three times a week (n = 9). The studies analyzed lasted from 4 to 24 weeks. According to Silva and collaborators (2022), a study, to be classified as long-term, must have been conducted for six months or more. In this sense, only the investigations by Eggenberger and collaborators (2015), Hsieh and collaborators (2018), and Hughes and collaborators (2014), all lasting 6 months, are classified as a long-term study.

For the RQ3 (*Eligibility criteria, data sources, assessment instruments, analysis methods, and clinical outcomes*), the sample presented in the studies included the participation of elderly people, with some studies presenting information indicating the age range (n = 13), while others presented the average age (n = 7). Most investigations indicated the participation of elderly people who had mild cognitive impairment (n = 12). In interventions that included some type of movement (video game, virtual reality), good vision, good hearing, and no motor problems were requested (n = 8). Eligibility criteria were also not having a history of neurological or psychiatric diseases (n = 9), have an appropriate IQ and/or speak a specific language (n = 5), and no use of medications that affect the central nervous system (n = 3).

The data sources were quite varied, with emphasis on the results of neuropsychological assessments (n = 8), self-report questionnaires (n = 7), cognitive tests (n = 6), assessments before and after training (n = 6), and interviews (n = 3). Other sources cited were electroencephalogram, functional magnetic resonance imaging, and physical tests.

As for the assessment instruments, the ones that appeared most in the studies were memory tests (n = 11), followed by MMSE (n = 7), GDS (n = 6), cognitive tests (n = 6), attention test (n = 4), trail-making test A and B (n = 3), processing speed test (n = 2), verbal fluency test (n = 8), Stroop test (n = 3), and letter test (n = 2).

The analysis methods that appeared most in the studies were: analysis of variance – ANOVA (n = 13), analysis of covariance – ANCOVA (n = 4), Student's t test (n = 9), Mann Whitney-U (n = 3), and Chi-Square (n = 4). The methods that

appeared only once were Shapiro-Wilk, D'Agostino-Pearson, Greenhouse-Geisser correction, Cohen, Wilcoxon Test, Fischer's Exact Test, and Pearson Correlation.

The clinical outcomes presented in the studies were the improvement of selective attention (n = 9), sustained attention (n = 5), working memory (n = 12), episodic memory (n = 4), long-term memory (n = 2), and executive functions (n = 2). Some studies also reported improvements in logical memory, processing speed, mood, decreased levels of depression and anxiety, mobility, quality of life, and self-confidence.

Regarding the description of the intervention sample, some presented information indicating the age range of the participants (n = 13), while others presented the average age (n = 7). The samples used in the interventions of the evaluated studies included the participation of elderly people. Most investigations indicated the participation of elderly people who had mild cognitive impairment (n = 12). Some studies also indicated the participation of young adults: Anguera and collaborators (2013) indicated that the sample of their study was composed of participants between 20 and 79 years old; the investigation sample by Ballesteros and collaborators (2017) comprised participants between 55 and 84 years old, and Savulich and collaborators (2017) indicated that their sample was composed of participants aged 45 years and over.

Considering RQ4 (*Limitations, gaps, and clinical implications*), it was identified in most studies that more research is needed to determine long-term effectiveness (n = 18). It was also verified, in some studies, that the sample used was small (n = 10). Some studies identified that the intervention was considered short-lived (n = 5). The lack of a control group was identified as a limitation of the study (n = 5) and that individually adapted CCT can improve cognitive functions (n = 6). In the study by Han and collaborators (2014), a limitation was indicated involving the lack of uniformity in the type of cognitive impairment of the sample.

This study conducted a systematic review to identify the technology used in CCT and verify the effect on the neuropsychological functions of attention and memory in elderly people. Twenty studies (eight studies including only healthy people, nine studies including older people with mild cognitive decline, and three

studies with healthy older people and older people with mild cognitive impairment) met the established criteria. We identified that there was an improvement in the attention of elderly people participating in thirteen studies and an improvement in memory in eighteen studies.

It is important to highlight the number of studies involving interventions for people with mild cognitive impairment (Bahar-Fuchs et al., 2017, Chiu et al., 2022, Hagovská et al., 2017, Jirayucharoensak et al., 2019, Gonzales-Palau et al ., 2014, Han et al., 2014, Hyer et al., 2016, Hsieh et al., 2018, Hughes et al., 2014, Savulich et al., 2017, Mrakic-Sposta et al., 2018, Vermeiji et al., 2016). It is a condition characterized by subjective memory complaints, objective memory deficits, normal general cognitive performance and maintained activities of daily living (Flak et al., 2016, Petersen et al., 1999). Furthermore, mild cognitive impairment is an intermediate situation between normal cognition and dementia (Ge et al., 2018). In this sense, it is necessary to propose interventions that also serve these people with the aim of minimizing cognitive losses and preventing the situation from transforming into dementia (Bd-Alrazaq et al., 2023, Carcelén-Fraile et al., 2022, Hu et al., 2021, Li et al., 2020, Sakaki et al., 2021, Yeo et al., 2018).

Regarding the used technology, commercial software and software adapted by researchers for their interventions were identified (Bahar-Fuchs et al., 2017, Hagovská et al., 2017, Anguera et al., 2013, Jirayucharoensak et al., 2019, Ballesteros et al., 2017, Belchior et al., 2019, Eggenberger et al., 2015, Gonzales-Palau et al., 2014, Han et al., 2014, Hyer et al., 2016, Hsieh et al., 2018, Hughes et al., 2014, Rute-Pérez et al., 2023, Simon et al., 2018, Savulich et al., 2017, Wais et al., 2021, Vermeiji et al., 2016). It is interesting to highlight the fact that only one of the softwares was used in more than one study, with each study presenting a different technological approach to CCT. According to Ge and colleagues (2018), since 2014, technologies that are more interactive and immersive (virtual reality, game console, exergaming platform) have been introduced in cognitive intervention studies. Compared to traditional therapy, with cognitive interventions conducted with pen and paper, technologies are “smarter” in monitoring participants' performance and adjusting any intervention difficulties (Bekrater-Bodmann et al., 2019, Perrot et al., 2019). With the use of more

interactive and immersive technologies, researchers have the possibility of recording participants' performance throughout the intervention process in a more automated way (Bacha et al., 2018, Anderson-Hanley et al. 2012, Ge et al., 2018, Wang et al., 2023).

Seven studies used software with virtual reality (Wais et al., 2021, Rute-Pérez et al., 2023, Monteiro-Junior et al., 2017, Mrakic-Sposta et al., 2018, Chiu et al., 2022, Eggenberger et al., 2015, Hsieh et al., 2018). Evidence suggests that CCT using virtual reality improves global cognitive performance, addressing specific cognitive domains, with a direct impact on the psychosocial functions of people with some type of cognitive disability (Htut et al., 2018, De Luca et al., 2023, Hill et al., 2017, Livingston et al., 2020, Zhong et al., 2021, Zhu et al., 2022).

Several researchers have indicated the need to have studies with larger samples of elderly people, so that it is possible to have more information about cognitive gain through the application of activities using CCT (Mrakic-Sposta et al., 2018; Hughes et al. 2014, Savulich et al. 2017, Vermeiji et al. 2016, Han et al. 2014, Monteiro-Junior et al. 2017).

An observation should also be made regarding the greater or lesser involvement of elderly people in participating in intervention activities. In this case, it was verified that the software program used must be engaging enough to improve the cognitive performance of the elderly participants (Hsieh et al., 2018). To achieve this objective, recommendations from experts on the potential use of technology involved in CCT must be followed, as there are problems that can affect elderly people and that could directly compromise the performance of these people in applying the proposed activities, such as reduced vision, and loss of speed of movement function. The software must anticipate these situations and provide mechanisms to reduce the impact of its use on older people (Gamberini et al., 2006, Zhang et al., 2021, Bonnechère et al., 2021, Tewthanom et al., 2023).

4 CONCLUSION

This research has demonstrated that the application of CCT results in significant improvements in the cognitive functions of attention and memory

among elderly people. The results reinforce the importance of cognitive training as an effective strategy for cognitive stimulation in the elderly people, contributing to the maintenance of mental health and quality of life as the population ages. Reinforces the need to integrate CCT programs into public health policies aimed at the elderly population, promoting a healthy and active lifestyle that favors the preservation of cognitive functions.

For the Academy, the results can serve as a basis for future investigations into the effectiveness of CCT, stimulating studies that explore different methods, populations, and contexts. Furthermore, this research contributes to the existing body of theory on aging and cognition, helping to better understand how specific interventions can impact cognitive functions in the elderly people. The findings could encourage collaborations between areas such as psychology, geriatrics, technology, and education, promoting a broader dialogue about effective interventions for healthy aging.

As limitations, the research highlighted the need for more studies to explore the long-term effectiveness of CCT, the personalization of interventions ,and the inclusion of control groups to validate the findings.

As future work, a longitudinal study will be carried out to evaluate the effectiveness of CCT over the time, allowing a better understanding of the long-term effects on the cognitive functions of the elderly people, with larger and more diverse samples to increase the robustness and generalization of the results.To carry out this study, specific search terms were used, which may not have been able to capture all the articles on the proposed subject.

ACKNOWLEDGEMENTS

This study was funded by the Federal Institute of Education, Science, and Technology of Rio Grande do Sul (IFRS, Brazil.

REFERENCES

ALVES, L. *et al*. Neuropsychological Predictors of Long-Term (10 Years) Mild Cognitive Impairment Stability. **J. Alzheimers Dis**., v. 62, p. 1703–1711, 2018. DOI: 10.3233/jad-171034

ANDERSON-HANLEY, C. *et al*. Exergaming and older adult cognition: A cluster randomized clinical trial. **Am. J. Prev. Med**, v. 42, p. 109–119, 2012. DOI: 10.1016/j.amepre.2011.10.016

ANGUERA, J. *et al*. Video game training enhances cognitive control in older adults. **Nature**, v. 501, n. 7465, p. 97-101, 2013. DOI: 10.1038/nature12486

BACHA, J. *et al*. Effects of Kinect Adventures Games Versus Conventional Physical Therapy on Postural Control in Elderly People: A Randomized Controlled Trial. **Games Health J.**, v. 7, p. 24–36, 2018. DOI: 10.1089/g4h.2017.0065

BAHAR-FUCHS, A. *et al.* Tailored and adaptive computerized cognitive training in older adults at risk for dementia: a randomized controlled trial. **J Alzheimers Dis**., v. 60, n. 3, p. 889-911, 2017. DOI: 10.3233/jad-170404

BALLESTEROS, S. *et al.* Effects of video game training on measures of selective attention and working memory in older adults: results from a randomized controlled trial. **Front Aging Neurosci**., v. 9, n. 354, 2017. DOI: 10.3389/fnagi.2017.00354

BD-ALRAZAQ, A. *et al*. The performance of serious games for enhancing attention in cognitively impaired older adults. **npj Digit. Med.**, v. 6, p. 122, 2023. DOI: 10.1038/s41746-023-00863-2

BEKRATER-BODMANN, R. *et al*. Tablet-based sensorimotor home-training system for amnestic mild cognitive impairments in the elderly: design of a randomised clinical trial. **BMJ Open**, v. 9, p. e028632, 2019. DOI: 10.1136/bmjopen-2018-028632

BELCHIOR, P. *et al*. Computer and Videogame Interventions for Older Adults' Cognitive and Everyday Functioning. **Games Health J**, v. 8, n. 2, p. 129–143, 2019. DOI: 10.1089/g4h.2017.0092

BONNECHÈRE, B. *et al.* Brain training using cognitive apps can improve cognitive performance and processing speed in older adults. **Sci Rep.**, v. 11, n. 12313, 2021. DOI: 10.1038/s41598-021-91867-z

CARCELÉN-FRAILE, M. *et al*. Cognitive Stimulation as Alternative Treatment to Improve Psychological Disorders in Patients with Mild Cognitive Impairment. **J. Clin. Med**., v. 11, p. 3947, 2022. DOI: 10.3390/jcm11143947

CHIU, H. *et al.* Effects of Incorporating Virtual Reality Training Intervention into Health Care on Cognitive Function and Wellbeing in Older Adults with Cognitive Impairment: A Randomized Controlled Trial. **International Journal of Human-Computer Studies**, v. 170 n. 102957, 2022. DOI:10.1016/j.ijhcs.2022.102957

DE LUCA, R. *et al*. Can Virtual Reality Cognitive Rehabilitation Improve Executive Functioning and Coping Strategies in Traumatic Brain Injury? A Pilot Study. **Brain Sci.**, v. 13, n. 578, 2023. DOI: 10.3390/brainsci13040578

EGGENBERGER, P. *et al.* Does multicomponent physical exercise with simultaneous cognitive training boost cognitive performance in older adults? A 6-month randomized controlled trial with a 1-year follow-up. **Clin. Interv. Aging**, v. 10, p. 1335–1349, 2015. DOI: 10.2147/cia.s87732

FLAK, M. *et al.* The Memory Aid study: protocol for a randomized controlled clinical trial evaluating the effect of computer-based working memory training in elderly patients with mild cognitive impairment (MCI). **Trials**, v. 15, p. 156, 2016. DOI: 10.1186/s13063-016-1180-0

GAMBERINI, L. *et al.* Cognition, technology, and games for the elderly: an introduction to ELDERGAMES project. **PsychNol J**. v. 4, n. 3, p. 285-308, 2006.

GAVELIN, H. *et al.* Cognition-Oriented Treatments for Older Adults: A Systematic Overview of Systematic Reviews. **Neuropsychol. Rev**. v. 30, p. 167–193, 2020. DOI: 10.1007/s11065-020-09434-8

GE, S. *et al.* Technology-based cognitive training and rehabilitation interventions for individuals with mild cognitive impairment: A systematic review. **BMC Geriatrics**, v. 18, n. 1, p. 213-232, 2018. DOI: 10.1186/s12877-018-0893-1

GONZALES-PALAU, F. *et al*. The effects of a computer-based cognitive and physical training program in a healthy and mildly cognitive impaired aging sample. **Aging Ment Health**. v. 18, n. 7, p. 838–46, 2014. DOI: 10.1080/13607863.2014.899972

HAGOVSKÁ, M. *et al.* Comparison of two cognitive training programs with effects on functional activities and quality of life. **Res Gerontol Nurs**., v. 10, p. 172–80, 2017. DOI: 10.3928/19404921-20170524-01

HAN, J. *et al*. Development of the ubiquitous spaced retrieval-based memory advancement and rehabilitation training program. **Psychiatry investigation**, v. 11, n. 1, p. 52–58, 2014. DOI: 10.4306/pi.2014.11.1.52

HILL, N. *et al.* Computerized cognitive training in older adults with mild cognitive impairment or dementia: a systematic review and meta-analysis. **Am. J. Psychiatry**, v. 174, n. 4, p. 329–340, 2017. DOI: 10.1176/appi.ajp.2016.16030360

HSIEH, C. *et al*. The Effectiveness of a Virtual Reality-Based Tai Chi Exercise on Cognitive and Physical Function in Older Adults with Cognitive Impairment. **Dement. Geriatr. Cogn. Disord.**, v. 46, p. 358–370, 2018. DOI: 10.1159/000494659

HTUT, T. *et al.* Effects of physical, virtual reality-based, and brain exercise on physical, cognition, and preference in older persons: A randomized controlled

trial. **Eur. Rev. Aging Phys. Act**., v. 15, p. 1–12, 2018. DOI: 10.1186/s11556-018-0199-5

HU, M. *et al.* Effects of computerised cognitive training on cognitive impairment: a meta-analysis. **J Neurol**., 2021 v. 268, n. 5, p. 1680-1688, 2021. DOI: 10.1007/s00415-019-09522-7

HUGHES, T. *et al.* Interactive video gaming compared with health education in older adults with mild cognitive impairment: a feasibility study. **Int J Geriatr Psychiatry**., v. 29, n. 9, p. 890-898, 2014. DOI: 10.1002/gps.4075

HYER, L. *et al*. Cognitive training program to improve working memory in older adults with MCI. **Clinical Gerontologist: The Journal of Aging and Mental Health**. v. 39, n. 5, p. 410–27, 2016. DOI: 10.1080/07317115.2015.1120257

JIRAYUCHAROENSAK, S. *et al*. A game-based neurofeedback training system to enhance cognitive performance in healthy elderly subjects and in patients with amnestic mild cognitive impairment. **Clin Interv Aging**., v. 14, p. 347-360, 2019. DOI: 10.2147/CIA.S189047

KITCHENHAM, B.; CHARTERS, S. **Guidelines for performing Systematic Literature Reviews in Software Engeneering**. Keele University and Durham University. 2007.

KLIMOVA, B.; MARESOVA, P. Computer-Based Training Programs for Older People with Mild Cognitive Impairment and/or Dementia. **Front. Hum. Neurosci**., v. 11, 2017. DOI: 10.3389/fnhum.2017.00262

LI, S. *et al*. Effect of virtual reality on cognitive impairment and clinical symptoms among patients with schizophrenia in the remission stage : a randomized controlled trial. **Brain Sci.**, v. 12, p. 1572, 2020. DOI: 10.21203/rs.3.rs-49234/v2

LIVINGSTON, G. *et al*. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. **Lancet**, v. 396, n. 10248, p. 413–446, 2020. DOI:10.1016/S0140-6736(20)30367-6

MOHER, D. *et al.* Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. **PLoS Medicine**, v. 6, n. 7, 2009. DOI: 10.1136/bmj.b2535

MONTEIRO-JUNIOR, R. *et al*. Virtual Reality-Based Physical Exercise with Exergames (PhysEx) Improves Mental and Physical Health of Institutionalized Older Adults. **J. Am. Med. Dir. Assoc**. v. 18, n. 5, 2017. DOI: 10.1016/j.jamda.2017.01.001

MRAKIC-SPOSTA, S. *et al*. Effects of Combined Physical and Cognitive Virtual Reality-Based Training on Cognitive Impairment and Oxidative Stress in MCI Patients: A Pilot Study. **Front. Aging Neurosci**. v. 10, n. 282, 2018. DOI: 10.3389/fnagi.2018.00282

PERROT, A. *et al.* Cognitive training game versus action videogame: effects on cognitive functions in older adults. **Games Health J**, v. 8, p. 35-40, 2019. DOI: 10.1089/g4h.2018.0010

PETERSEN, R. *et al.* Mild cognitive impairment: Clinical characterization and outcome. **Arch Neurol**, v. 56, n. 3, p. 303-308, 1999. DOI: 10.1001/archneur.56.3.303

RUTE-PÉREZ, S. *et al.* Effectiveness of Computerized Cognitive Training by VIRTRAEL on Memory and Executive Function in Older People: A Pilot Study. **Brain Sci**. v. 13, n. 684, 2023. DOI: 10.3390/brainsci13040684

SAKAKI, K. *et al.* Benefits of VR Physical Exercise on Cognition in Older Adults with and without Mild Cognitive Decline: A Systematic Review of Randomized Controlled Trials. **Healthcare (Basel)**, v. 9, n. 883, 2021. DOI: 10.3390/healthcare9070883

SAVULICH, G. *et al*. Cognitive training using a novel memory game on an iPad in patients with amnestic mild cognitive impairment (aMCI). **Int J Neuropsychopharmacol**., v. 20, p. 624–633, 2017. DOI: 10.1093/ijnp/pyx040

SILVA, T. *et al*. Long-term studies in cognitive training for older adults: a systematic review. **Dement Neuropsychol**., v. 16, n. 2, p. 135-152, 2022. DOI: 10.1590/1980-764-DN-2021-0064

SIMON, S. *et al.* Is Computerized Working Memory Training Effective in Healthy Older Adults? Evidence from a Multi-Site, Randomized Controlled Trial. **Journal of Alzheimer's Disease**, v. 65, n. 3, p. 931–949, 2018. DOI: 10.3233/jad-180455

SMART, C. *et al*. Non-Pharmacologic Interventions for Older Adults with Subjective Cognitive Decline: Systematic Review, Meta-Analysis, and Preliminary Recommendations. **Neuropsychol. Rev**. v. 27, p. 245–257, 2017. DOI: 10.1007/s11065-017-9342-8

TEWTHANOM, K. *et al.* The potential competency outcome of vigorous brain training game in the elderly: A systematic review. **Health Sci Rep**. v. 6, n. 7, e1406, 2023. DOI: 10.1002/hsr2.1406

UNITED NATIONS. **World Population Prospects Highlights, 2019** Revision Highlights, 2019 Revision; Department of Economic and Social Affairs: New York, NY, USA. 2019.

VERMEIJI, A. *et al.* Transfer and maintenance effects of online working-memory training in normal ageing and mild cognitive impairment. **Neuropsychol Rehabil**., v. 26, n. 5, p. 783-809, 2016. DOI: 10.1080/09602011.2015.1048694

WAIS, P. *et al.* Virtual reality video game improves high-fidelity memory in older adults. **Sci Rep**., v. 11, n. 2552, 2021. DOI: 10.1038/s41598-021-82109-3

WANG, D. *et al.* Exergames improves cognitive functions in adolescents with depression: study protocol of a prospective, assessor-blind, randomized

controlled trial. **BMC Psychiatry**, v. 23, n. 507, 2023. DOI: 10.1186/s12888-023-04967-7

WORLD HEALTH ORGANIZATION. **Decade of healthy ageing: baseline report**. 2021. WHO.

ZHANG, N. *et al*. The effects of age on brain cortical activation and functional connectivity during video game-based finger-to-thumb opposition movement: a functional near-infrared spectroscopy study. **Neurosci Lett**., v. 746, n. 135668, 2021. DOI: 10.1016/j.neulet.2021.135668

ZHONG, D. *et al.* Effects of virtual reality cognitive training in individuals with mild cognitive impairment: a systematic review and meta-analysis. **Int. J. Geriatr. Psychiatry**, v. 36, n. 12, p. 1829–1847, 2021. DOI: 10.1002/gps.5603

ZHU, K. *et al.* Immersive virtual reality–based cognitive intervention for the improvement of cognitive function, depression, and perceived stress in older adults with mild cognitive impairment and mild dementia: pilot pre-post study. J**. Med. Internet Res**., v. 10, n. 1, p. e32117, 2022. DOI: 10.2196/32117

YEO, S. *et al*. Effectiveness of a personalized brain- computer interface system for cognitive training in healthy elderly: a randomized controlled trial. **J Alzheimer's Dis**, v. 66, p. 127-138, 2018. DOI: 10.3233/JAD-180450