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The Effect of Computerized Cognitive Training Programs on Cognition, Depression, and Language Function in Older Adults with Mild Dementia: A Meta-Analysis

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Abstract

Computerized cognitive training utilized to enhance cognitive function in dementia patients enables them to autonomously execute and acquire tasks while obtaining prompt and precise feedback on their performance. We are designed to highlight the efficacy and clinical relevance of computerized cognitive training programs as therapies for elderly adults with mild dementia. In accordance with the Cochrane Handbook for Systematic Reviews of Interventions, we conducted a review of pertinent literature across various databases, including the Korean Information Service System, Research Information Sharing Service, National Assembly Digital Library, DBpia, and PubMed, encompassing research from 2003 to 2023. Utilizing rigorous inclusion and exclusion criteria, we examined a final sample of 12 research. The data indicated that following computerized cognitive training interventions for senior adults with mild dementia, ADAS-Cog exhibited the most substantial effect size (g=-1.400), succeeded by MMSE (g=0.631), DRS (g=0.522), BNT (g=0.335), and GDS (g=-0.304), ranked by intervention efficacy. The findings allow us to assert that computerized cognitive training programs significantly enhance cognitive function, alleviate depressive symptoms, and improve language abilities in elderly individuals with mild dementia.

Keywords: *Mild dementia, Computerized cognitive training, Cognitive rehabilitation, Meta-analysis*

1. INTRODUCTION

Dementia is a chronic degenerative disease that is becoming a significant health concern, particularly among the elderly[1]. It is characterized by memory and cognitive impairment. At present, dementia affects approximately 50 million individuals worldwide, and the World Health Organization anticipates that this figure will quadruple by 2050[2]. Patients with dementia exhibit deficiencies in executive function, visuospatial ability, problem-solving ability, and attention[3]. These deficiencies result in challenges in social participation and daily activities, thereby diminishing the quality of life [4,5]. Early detection and intervention are crucial because they can mitigate cognitive decline and enhance the likelihood of symptom relief [6,7]. Cognitive

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interventions that concentrate on the improvement of cognitive function and the alleviation of symptoms are particularly significant [8]. Non-pharmacological treatments include cognitive therapy, occupational therapy, physical activity, and multisensory stimulation.

Computer-based cognitive training is frequently implemented in clinical environments due to its capacity to generate objective outcomes and data documentation. This training is primarily employed for preventive purposes, and its efficacy in enhancing cognitive function in patients with moderate dementia remains uncertain [9]. However, it enables patients to learn independently and provides immediate feedback. Research on the efficacy of computerized cognitive training programs for elderly individuals with mild dementia is currently underway; however, there is a general paucity of comprehensive research. The objective of this investigation is to confirm the clinical practicality and domestic and international efficacy of these programs.

2. METHODS

2.1 Literature Selection

The effect size of the computerized cognitive training program intervention for elderly individuals with moderate dementia was determined through an exhaustive literature review of papers published in domestic and international journals up to 2023. The Cochrane Handbook for Systematic Reviews of Intervention was employed to search and collect papers from databases such as the Korea Research Information Service (KISS), the Korea Education and Research Information Service (RISS), the National Assembly Electronic Library (NAEL), the Academic Information Integration Service Site (DBpia), and the United States National Library of Medicine (PubMED). Following the application of the inclusion and exclusion criteria, a total of 12 studies were selected as the analysis subjects. Table 1 shows the key keywords such as patients, interventions, comparisons, and outcomes for literature search.

Table 1. Literature Search Word

Item	Explanation
Patient	65+, Alzheimer and Mild dementia
Intervention	Computerized cognitive training
Comparison	Traditional cognitive therapy, etc.
Outcomes	MMSE, DRS, ADAS-cog, GDS, BNT
Timing	No specific follow-up
Setting	Hospitals, Public health centers, etc. without restrictions
Study Desgin	Randomized Controlled Trial

ADAS-cog=Alzheimer`s Disease Assessment Scale-Cognition; BNT=Boston Naming Test; DRS=Dementia Rating Scale; GDS=Geriatric Depression Scale; MMSE=Mini Mental State Examination

2.2 Literature Selection Criteria

The following are the selection criteria for the studies included in this meta-analysis: experimental research that utilized computerized cognitive rehabilitation therapy on both domestic and international subjects, as well as research with original texts available after 2003. The following are the exclusion criteria: studies that lack pre-testing, studies that do not include patients with moderate dementia, and studies for which effect sizes could not be calculated.

2.3 Effect Size Calculation

In the meta-analysis, the effect size was analyzed using the corrected standardized mean difference (Hedges'g), and 0.20 or less was set as a small effect size, 0.30-0.70 was set as a medium effect size, and 0.80 or more was set as a large effect size [10].

3. RESULTS

A total of 12 studies analyzed in this study are as follows. The selected studies were published from 2003 to 2023, and 660 papers were identified through database search. After removing duplicates, 212 papers were reviewed, and 195 papers were excluded after reviewing the titles and abstracts. The remaining 17 papers were reviewed in their entirety to assess suitability, and a total of 12 RCT studies were ultimately meta-analyzed. Figure 1 shows a flow diagram of the literature selection process.

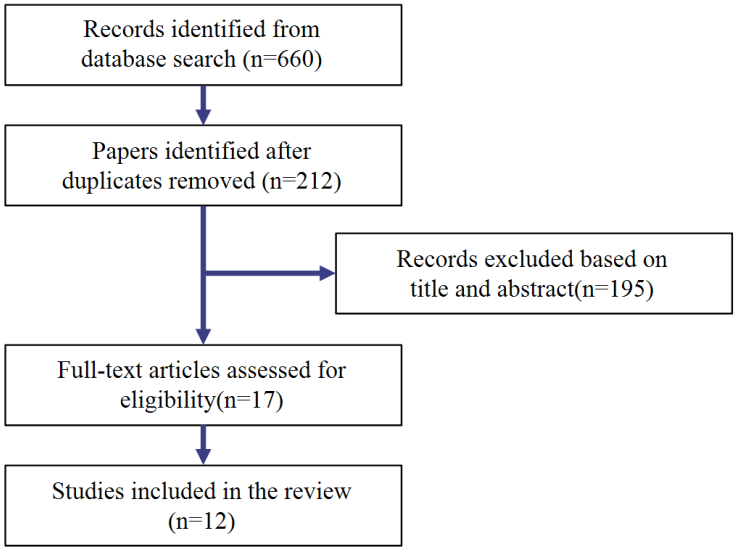

Figure 1. Flow Diagram of the Literature Selection Process

3.1 Included Research Characteristics

The subjects were patients with Alzheimer's disease and mild dementia aged 65 years or older, and the experimental group that received the intervention was compared with the experimental group that did not receive the intervention.The intervention program mostly used a computerized cognitive training program as a traditional cognitive therapy. Table 2 shows the study design, diagnosis name, participants, intervention, and assessment tools for 12 studies.

Table 2. Characteristics of Included Studies

Study (Year)	Design	Dx.	Participants		Intervention		Measure Tool
			EG	CG	EG	CG	
			Sample size		Program name		

Fernandez-Calvo et al.(2011)	RCT	AD	15	15	Nintendo Wii	Nonintervention	ADAS-cog, NPI-Q, EDC, RDRS-2
Terraga et al.(2006)	RCT	AD	15	12	CCT	Cognitive stimulation	MMSE, ADAS-cog, BNT, RDRS-2, GDS, et al.
Lee et al.(2013)	RCT	AD	7	6	CCT	Nonintervention	MMSE, GDS, DRS, HKLLT, MBI, et al.
Galante et al.(2007)	RCT	AD	7	4	CCT	semi-structure interview	MMSE, MODA, CPM, NPI, GDS, et al.
Eckroth-Bucher et al.(2009)	RCT	MCI	15	17	CCT	Nonintervention	DRS, LMI, LMI2-TRS, MMSE, LNS
Yang et al.(2017)	RCT	AD	10	10	CCT	Nonintervention	K-BNT, SVLT, K-MMSE, CDR, GDS, SOB, et al.
Shyu et al.(2021)	RCT	AD	15	15	CCT	Nonintervention	MMSE, CASI, PRMQ
Oh et al.(2018)	RCT	AD	15	15	CCT	Music therapy	MMSE-K, K-DRS
Kim et al.(2019)	RCT	AD	16	16	CCT	Nonintervention	MMSE-K, SGDS-K, ELS, BI
Jelcic et al.(2014)	RCT	AD	7	10	Telerehabilitation	Cognitive stimulation	MMSE, RAVL, ROCF, Verbal Naming Test
Kwon et al.(2021)	RCT	AD, MCI	30	29	Smart device application	paper-based workbook	SVLT-E, DST, S-K-BNT, K-CWST, et al.
Baquero et al.(2022)	RCT	AD	14	9	CCT	Usual care	MMSE, ADAS-cog, GDS, TMT, CAMCOG, et al.

ADAS-cog=Alzheimer`s Disease Assessment Scale-Cognition; BNT=Boston Naming Test; CAMCOG=Cambridge Cognition examination; CASI=Cognitive Abilities Screening; CCT=Computerized Cognitive Training; CDR=Clinical Dementia Rating Scale; CPM=Raven's Coloured Progressive Matrices; CWST=Korean-Color Word Stroop Test; DST=Digit Span Test; EDC=Escala Depression Cornell; DRS=Dementia Rating Scale; ELS=Elderly Life Satisfaction; GDS=Geriatric Depression Scale; HKLLT=Hong Kong List Learning Test; LMI=Logical Memory I; LMI2-TRS=Logical Memory II-Total Recall Score; LNS=Letter-Number Sequencing; MBI=Modified Barthel Index; MMSE=Mini Mental State Examination; MODA=Milan Overall Dementia Assessment; NPI-Q=Neuropsychiatric Inventory-Questionary, PRMQ=Prospective and Retrospective Memory Questionnaire Instrument; RAVL=Rey Auditory Verbal Learning Tests; ROCF=Rey-Osterrieth Complex Figure Tests; SOB=Sum of Box; SVLT=Seoul Verbal Learning Test; TMT=Trail Making Test

3.2 Statistical Effect Size

Figure 2 shows the results and plots, showing an overall effect size value of 0.631 with a 95% confidence interval of 0.249 to 1.012. This is statistically significant because the effect size is greater than 0.5 excluding 0 in the confidence interval, meaning the mmse effect size for the computerized cognitive training program is a medium effec.

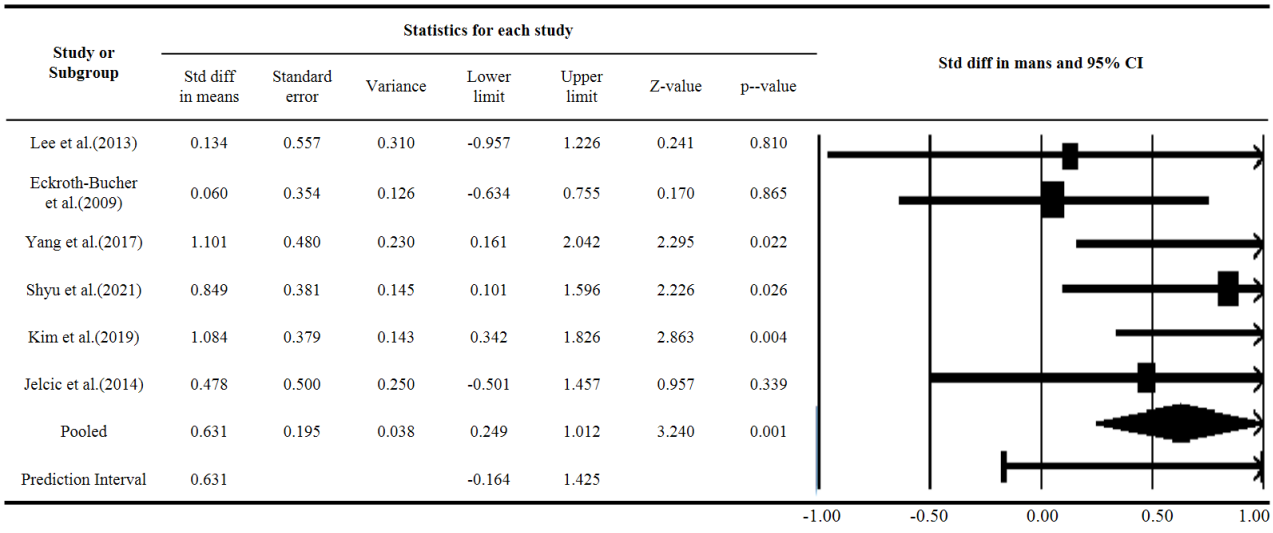

Figure 2. Effect Size of MMSE

Figure 3 shows the results and plots, showing an overall effect size value of 0.522 with a 95% confidence interval of -1.287 to 2.330. This is statistically significant because the effect size is close to 0.5 excluding 0 in the confidence interval, meaning that the DRS effect size for the computerized cognitive training program is a medium effect.

Study or Subgroup	Statistics for each study							Std diff in mans and 95% CI
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-value	p--value	
Fernandez-Calvo et al.(2011)	-1.551	0.416	0.173	-2.367	-0.735	-3.724	0.000	
Lee et al.(2013)	0.410	0.562	0.316	-0.692	1.512	0.729	0.466	
Eckroth-Bucher et al.(2009)	0.058	0.354	0.126	-0.637	0.752	0.163	0.870	
Oh et al.(2018)	3.282	0.559	0.313	2.186	4.379	5.868	0.000	
Pooled	0.522	0.923	0.851	-1.287	2.330	0.565	0.572	
Prediction Interval	0.522			-8.112	9.155			

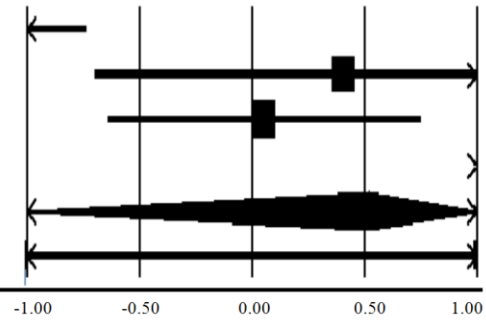

Figure 3. Effect Size of DRS

Figure 4 shows the results and plot showing that the overall effect size value amounts to -1.400 with a 95% confidence interval of -3.448 to 0.648. This is statistically significant because the effect size is over 0.8 excluding 0 in the confidence interval, meaning that the effect size of ADAS-cog for the computerized cognitive training program is a large effect size.

Study or Subgroup	Statistics for each study							Std diff in mans and 95% CI
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-value	p--value	
Fernandez-Calvo et al.(2011)	-3.966	0.629	0.395	-5.199	-2.733	-6.306	0.000	
Terraga et al.(2006)	-0.157	0.388	0.150	-0.917	0.603	-0.405	0.685	
Baquero et al.(2022)	-0.247	0.429	0.184	-1.087	0.593	-0.576	0.564	
Pooled	-1.400	1.045	1.092	-3.448	0.648	-1.339	0.180	
Prediction Interval	-1.400			-27.216	24.416			

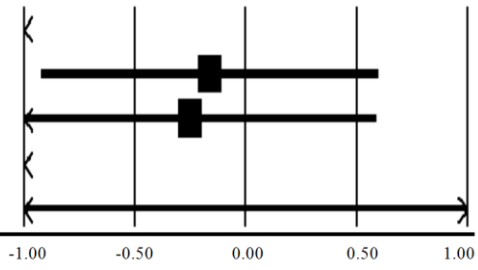

Figure 4. Effect Size of ADAS-cog

Figure 5 shows the results and plots, showing an overall effect size value of -0.304 with a 95% confidence interval of -0.711 to 0.102. This is statistically significant because the effect size is greater than 0.3 excluding 0 in the confidence interval, meaning that the GDS effect size for the computerized cognitive training program is a medium effect size.

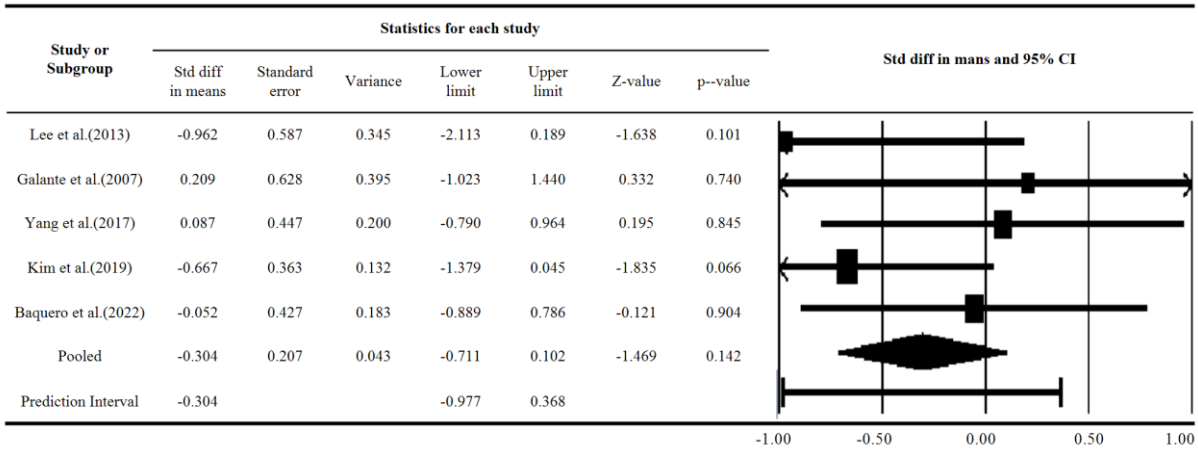

Figure 5. Effect Size of GDS

Figure 6 shows the results and graphical representation of an overall effect size value of 0.335 with a 95% confidence interval of -0.050 to 0.720. This is statistically significant because the effect size is greater than 0.3 excluding 0 in the confidence interval, meaning that the BNT effect size for the computerized cognitive training program is a medium effect size.

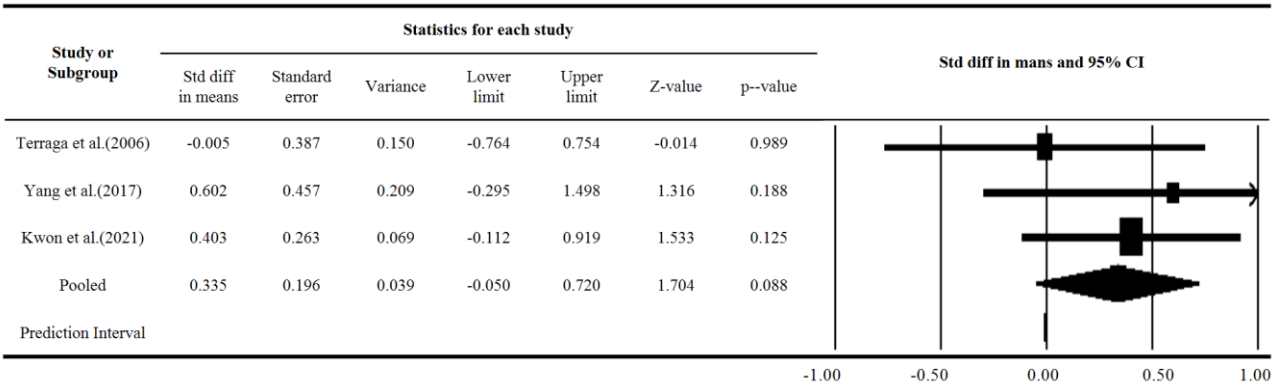

Figure 6. Effect Size of BNT

4. DISCUSSION

The effect size for each dependent variable of the computerized cognitive training program indicated the highest effect size for ADAS-Cog, followed by MMSE, DRS, BNT, and GDS, which exhibited an intermediate effect size. The results suggest that a computerized cognitive training program may positively affect cognitive function, depressive symptoms, and language abilities in elderly adults with mild dementia. A 12-week home-based computerized cognitive training (CCT) program, incorporating adjustable difficulty and individualized elements, was conducted for 25 elderly individuals demonstrating mild cognitive impairment (MCI) or neuropsychiatric symptoms, as detailed in the study in [11]. The results demonstrated improvements in memory, learning ability, and general cognitive performance compared to conventional CCT. The study referenced in [12] involved 50 healthy older individuals and patients with Mild Cognitive Impairment (MCI) who engaged in 12 weeks of physical exercise (three sessions per week, each lasting one hour) in conjunction with 35 minutes of computer-based cognitive training. This intervention led to significant improvements in

overall cognitive function, verbal memory, attention, episodic memory, and depressive symptoms. Computerized cognitive rehabilitation offers advantages over traditional paper-and-pencil or tabletop methods by enabling a systematic approach tailored to the patient's capabilities [13]. The amount of stimuli, complexity, and speed can be easily adjusted based on the patient's response. Furthermore, the incorporation of multimedia elements, such as graphics, music, and virtual reality, enhances content delivery in a dynamic and engaging fashion, hence increasing patient interest [14].

The study's limitations encompass the limited number of examined trials and the inability to entirely eliminate the influence of other interventions. Further research is necessary to gather more data and perform comparison analyses across different cognitive domains, as this may limit the generalizability of the study findings. Specifically, novel therapies employing virtual reality or digital technologies may yield a deeper level of immersion and prove more efficacious than existing CCTs. Therefore, additional research is necessary.

5. CONCLUSION

This investigation verified that a computerized cognitive training program (CCT) that concentrated on elderly individuals with moderate dementia had a substantial impact on the enhancement of language function, depression, and cognition. CCT is an intervention method that can complement traditional cognitive rehabilitation, as evidenced by the moderate or higher effects of a variety of measurement instruments, including ADAS-Cog, MMSE, DRS, BNT, and GDS. In particular, it demonstrated a significant impact on memory and language function, potentially delaying the progression of dementia. Nevertheless, this investigation is restricted by the limited number of selected studies and the difficulty of excluding the influence of other interventions. Consequently, additional research data and comparative studies should be conducted. Consequently, it is imperative to further elucidate the clinical utility of CCT and investigate the potential of a variety of digital-based interventions.

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