

# Effectiveness of Serious Games for Visuospatial Abilities in Elderly Population with Cognitive Impairment: A Systematic Review and Meta-Analysis

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**Abstract.** We explore the effectiveness of serious games for visuospatial abilities among older adults with cognitive impairment by conducting a systematic review. Out of 548 identified publications, seven randomized controlled trials (RCTs) were included in this review. According to a meta-analysis of four RCTs, there is no statistically significant difference ( $p=0.28$ ) in visuospatial abilities between serious game and control groups. Further, the included RCTs noted no statistically significant difference in the visuospatial ability when comparing serious games to conventional exercise (one study) and other serious games (two studies). One RCT demonstrated a statistically significant effect of serious games on the visuospatial ability when compared with conventional cognitive training. This review could not prove the effectiveness of serious games in enhancing visuospatial abilities for older adults with cognitive impairment. Thus, serious games should not be offered or used for enhancing visuospatial abilities amongst the elderly population with cognitive impairment. More robust RCTs are needed to make firm conclusions on the efficacy of serious games.

**Keywords.** Serious games, Visuospatial abilities, Cognitive impairment, Older adults, Systematic reviews, Meta-analysis.

## 1. Introduction

According to the WHO, the percentage of the global population aging 60 and above will nearly double from 12% to 22% between 2015 and 2050 [1]. Meaning that the world is undergoing a difficult demographic shift, with an increasing proportion of elderly people. This number is expected to reach 2.1 billion [2]. To address the challenges experienced by the elderly that could arise in the near future, it is vital to acknowledge that as the

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older persons are aging, a decline in their cognitive functions is expected including challenges with visuospatial skills. Visuospatial skills refer to the capacity to cognitively recognize, picture, and manipulate two- and three-dimensional objects [3]. A vast number of interventions have been proposed in the literature to improve visuospatial skills with the elderly, and serious games appear to be one of these effective interventions. Serious games refer to video games that are designed for goals other than entertainment such as therapeutic rehabilitation, education, prevention, and training [4]. Previous systematic reviews have been carried out to derive conclusions about the effectiveness of serious games in enhancing visuospatial skills for seniors [5-9]. Yet, they (1) involved evidence from non-randomized controlled trials (RCTs) [5-7], (2) compared the effect of serious games to all comparators together instead of a specific comparator (e.g., control and conventional exercises) [5-9], (3) only targeted older persons who do not experience cognitive impairment [5, 8, 9], and (4) assessed only a specific type of serious games (e.g., exergames [5] and cognitive training games [6-9]). The objective of this review is to determine the efficacy of serious games for visuospatial skills in seniors with cognitive impairment.

## **2. Methods**

A systematic review and meta-analysis were performed to accomplish the study objective. seven electronic databases were searched plus the “Google Scholar” search engine. In addition, the authors checked the research that cited the included RCTs and screened the list of references in the included papers. The query used to search each database and Google Scholar is shown in Appendix 1. Only RCTs that assessed the effectiveness of serious games for visuospatial skills among the elderly with cognitive impairment were included in this study. To elaborate, we included the studies that assessed the serious games that were deployed on any digital platforms (e.g., computers, consoles, and mobile devices). The game has to be used solely for therapeutic purposes. Only older adults with any type of cognitive impairment were considered for the study population. The target outcome in this review is visuospatial function regardless of the outcome measures. We excluded all studies published before 2010 and written in a language other than English. The study selection procedure was divided into three stages: deleting duplicates, screening titles and abstracts, and reviewing entire texts. The Risk-of-Bias 2 (RoB 2) tool was used to appraise the risk of bias in the included studies. Two reviewers independently conducted the study selection, data extraction, and risk of bias assessment. The extracted data was then synthesized using narrative and statistical approaches. We used the software “RevMan” version 5.4 to carry out the meta-analysis.

## **3. Results**

A total of 548 citations were found in the databases. We found and removed 98 duplicates from this list. 363 of the remaining 450 did not meet the eligibility criteria in the title and abstract screening step. After scrutinizing the entire texts of the remaining 87 articles, 80 publications were eliminated. This review covered a total of seven studies. Appendices 2, 3, and 4 contain a flowchart of the study selection process, features of the included studies, population, interventions, comparators, and outcome measures, as well as the results of the risk of bias assessment, respectively. The results of the included studies

were classified into four categories according to the comparator type: serious games versus control (no/passive intervention), serious games versus conventional exercises, serious games versus conventional cognitive training, and serious games versus other serious games. Four studies compared the effect of serious games with control on visuospatial abilities [10-13]. While two of these four studies found no statistically significant difference between the experimental and control groups [10, 11], the other two studies found a statistically significant difference in visuospatial ability between the groups, preferring the serious game over no intervention; ( $p=0.01$  and  $p<0.001$ ) [12, 13]. A meta-analysis was conducted on these four studies (6 comparisons as 1 study assessed the outcome using 3 measures). The meta-analysis showed no statistically significant difference ( $p=0.28$ ) in visuospatial abilities between serious games and control groups (Standardized mean difference (SMD) 32, 95% confidence interval (CI) -0.26 to 0.91). The heterogeneity of the meta-analyzed studies was significant ( $p<0.001$ ) and considerable ( $I^2=86\%$ ) (Appendix 5)<sup>2</sup>. One study compared the effect of serious games to conventional cognitive training on visuospatial abilities, and the result showed a statistically significant difference ( $p<0.001$ ), preferring serious games over conventional cognitive training [13]. One study compared the influence of serious games to conventional exercise (balance training), and no statistically significant difference was found between the groups ( $p=0.82$ ) [14]. Two studies compared the effect of serious games on visuospatial abilities to other serious games [15, 16]. The first study looked at the impact of a serious game that targeted certain cognitive functions. (i.e., memory and attention) and a serious game targeting cognitive abilities in general on visuospatial abilities [15]. The study demonstrated no statistical significance difference ( $p=0.86$ ) in visuospatial abilities between the groups [15]. The second study compared 2 different types of serious games (i.e., cognitive training game versus exergame) [16], and it did not detect a statistically significant difference in visuospatial abilities between groups as measured by the Seoul Neuropsychological Screening Battery 2nd edition ( $p=0.37$ ), and Rey-Osterreith Complex Figure Test-Copy ( $p=0.56$ ).

#### 4. Discussion

The RCTs included in this review showed that serious games are more effective than conventional cognitive training and as effective as conventional exercises in improving visuospatial abilities among older adults with cognitive impairment. Surprisingly, the meta-analysis demonstrated that serious games are not better than control (no/passive interventions) in enhancing visuospatial abilities. The inconsistency in our findings may be attributed to the fact that they are based on a few studies with small sample size. In line with our findings, a previous review found that serious games are more effective than active interventions and as effective as passive interventions in improving visuospatial abilities among older adults without cognitive impairment [8]. Other reviews showed no statistically significant difference between serious games and other interventions (both passive and active interventions) in enhancing visuospatial abilities among older adults with cognitive impairment [6, 7] or without cognitive impairment [9]. In our review, we found no difference between various types of serious games (exergames vs. computerized cognitive games, and memory and attention-targeted

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<sup>2</sup> Appendices are available at GitHub: <https://github.com/AHassan2/Visuospatial-Skills-Serious-game-paper.git>

games vs. cognitive abilities-targeted games). Previous reviews did not compare the effect of serious games with other types of serious games.

## 5. Conclusion

We were unable to draw solid conclusions about the impact of serious games on visuospatial abilities among older adults with cognitive impairment for the following reasons: (i) Our findings were contradictory, (ii) number of the included studies is small, (iii) the sample size was small in most included studies, (iv) only one study was judged to have a low risk of bias in the “overall bias” domain, and (v) there was considerable heterogeneity in the meta-analyzed studies. Therefore, until more robust research is available, serious games should not be offered or used for enhancing visuospatial abilities among older adults with cognitive impairment. Researchers should undertake more rigorous RCTs to determine the efficacy of serious games in improving visuospatial abilities in older persons with cognitive impairment.

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