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Effect Providing Brain Gym On Improving Cognitive Function In Elderly: Meta-Analysis

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ABSTRACT

Introduction: Cognitive decline with aging impacts quality of life, making it crucial to explore effective interventions. Brain Gym, a program involving simple physical exercises, is proposed to enhance cognitive function, but evidence is mixed. This study aims to conduct a meta-analysis to evaluate the overall effectiveness of Brain Gym in improving cognitive function in the elderly and to identify factors that may influence its effectiveness. **Methods:** A meta-analysis of RCTs evaluating Brain Gym for elderly cognitive function. Databases searched included PubMed and ScienceDirect. Data were analyzed using RevMan 5.3. **Results**: The meta-analysis of Brain Gym interventions in elderly individuals revealed high heterogeneity among studies (I^2 = 95%) and no significant overall effect (P = 0.62), indicating inconsistent results. **Conclusion**: Brain Gym shows potential for improving cognitive function in the elderly. Future research should explore specific contexts and populations for more targeted interventions.

Keywords: *Brain gym, cognitive function, elderly, meta-analysis, interventions*

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INTRODUCTION

Aging is a natural process experienced by every individual, marked by various biological, psychological, and social changes (Rismayanthi et al., 2022) One important aspect often affected by the aging process is cognitive function (Özsungur, 2020). Cognitive decline in the elderly is a growing concern worldwide, with an estimated 47 million people living with dementia globally, a number expected to triple by 2050 due to population aging. In Indonesia, the prevalence of cognitive decline among the elderly is also alarming, with a reported 24.3% experiencing mild cognitive impairment and 12.7% suffering from dementia (Crivelli et al., 2022). Decreased cognitive function can significantly impact the quality of life of elderly people, including their ability to carry out daily activities, maintain social interactions, and preserve independence (Sarant et al., 2020). Therefore, it is crucial to explore interventions that can maintain or improve cognitive function in the elderly population (Chen et al., 2020). However, until now, no intervention has consistently proven effective in maintaining or improving cognitive function in the elderly population. This highlights an urgent need to identify methods that are effective, safe, and easy to implement for this age group. In this context, Brain Gym appears to be a promising intervention;however, its effectiveness in the elderly still needs to be explored in greater depth (Chan et al., 2020).

The decline in cognitive function in the elderly is frequently attributed to various factors, including structural and functional changes in the brain (Tanaka et al., 2020). Research indicates that brain volume decreases with age, and these changes can affect the connectivity between neurons as well as the efficiency of signal transmission (Deery et al., 2023). Additionally, other factors such as chronic diseases, lifestyle, and socio-economic status can also influence cognitive function in the elderly.

Brain Gym, an exercise program consisting of simple physical movements, has been proposed as a method to support brain health and performance (Jalilinasab et al., 2022). However, until now, few studies have specifically explored

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the effectiveness of Brain Gym in enhancing cognitive function among the elderly, particularly in populations at high risk of cognitive decline. Additionally, although some studies have shown potential benefits, the results remain inconsistent, and the methods used vary significantly. Therefore, a meta-analysis is needed to evaluate the effectiveness of Brain Gym more thoroughly and comprehensively in the context of improving cognitive function among the elderly. The Brain Gym concept is based on specific physical activities that can stimulate brain function and improve cognitive aspects such as memory, attention, and problem-solving abilities (Srinivas et al., 2021). Although Brain Gym has been applied in various contexts, further research is needed to examine its effectiveness specifically in the context of improving cognitive function in the elderly.

Several studies have demonstrated the potential benefits of Brain Gym on cognitive function. For instance, one study found that regular participation in Brain Gym activities can improve working memory and information processing speed in older adults (Zhidong et al., 2021). Other research suggests that Brain Gym may contribute to improved executive function, including planning, organizing, and multitasking abilities (Robledo-Castro et al., 2023).

However, despite the initial evidence showing positive potential, further systematic and comprehensive research is needed to evaluate the effectiveness of Brain Gym in improving cognitive function in the elderly. This includes understanding the mechanisms behind the potential benefits, determining the optimal dose and duration of the intervention, and identifying subgroups of older adults who may benefit most from the intervention.

In this context, a meta-analysis approach becomes very important. Meta-analysis allows researchers to combine results from multiple independent studies to obtain a more accurate and reliable estimate of the effects of an intervention (Borenstein et al., 2021)(de Jong et al., 2020). Through meta-analysis, it can be identified whether Brain Gym consistently shows a positive effect on cognitive function in the elderly, as well as what factors moderate this effect. This approach can also help in identifying gaps in the existing literature and direct future research.

Given the increasing proportion of the elderly population in many countries, the importance of maintaining cognitive function becomes increasingly crucial. Interventions such as Brain Gym, if proven effective, could offer an accessible and non-invasive method for supporting cognitive health in older adults (Ziegler et al., 2022). This can not only improve an individual's quality of life but also reduce the social and economic burden associated with cognitive decline and related diseases such as dementia (Silva et al., 2020).

Recent research on the effect of Brain Gym on cognitive function in the elderly includes several relevant studies. Effects of Brain Gym on cognitive function in the elderly. This study included studies of high to low quality and found significant intra- and inter-group changes for neurocognitive outcomes in the Brain Gym group (Varela et al., 2023). However, the findings of this meta-analysis indicate that changes in the Brain Gym group, in terms of cognitive function as measured by the Mini-Mental State Examination, were no greater than those reported in the control/comparison group. These results suggest that Brain Gym may not lead to improved cognitive function in people with and without cognitive impairment supported by evidence from low to high levels (Varela et al., 2023).

Brain Gym exercises were carried out for 12 weeks and showed improvements in cognitive function, which was attributed to the activity of the protein BDNF (brain-derived neurotrophic factor), found in high concentrations in the central nervous system and plays an important role in the growth and survival of nerves that influence learning and memory (Gupta et al., 2024).

Effects of Brain Gym training on cognitive function and plasma BDNF levels in the elderly (Tarassova et al., 2020). In this study, Brain Gym exercises were performed and showed improvements in cognitive function as measured using the MMSE (Mini-Mental State Examination) and increases in plasma BDNF levels. Brain Gym may have a positive effect on improving cognitive function in the elderly, supported by changes in neurotrophic biomarkers

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associated with brain health and function (Silakarma et al., 2021).

Research on the impact of Brain Gym on improving cognitive function in older adults offers significant potential to increase our understanding of ways to support healthy aging. Through a meta-analytic approach, this research may provide valuable insights into the effectiveness and mechanisms behind Brain Gym as an intervention to improve cognitive health in the elderly population. The results of this research are expected to provide significant contributions to health practitioners, policymakers, and elderly individuals themselves in developing effective strategies to maintain and improve cognitive function during the aging process.

METHODS

The decline in cognitive function is one of the main challenges faced by the elderly population, impacting their quality of life and independence. In an effort to find effective interventions to mitigate this problem, Brain Gym emerged as a promising method (Cline et al., 2021). Brain Gym, a series of physical movements designed to improve brain function, has been proposed as a way to improve or maintain cognitive function in the elderly. However, evidence regarding its effectiveness is still preliminary and fragmented.

In this context, the Meta-Analysis approach becomes very relevant because it allows researchers to collect and synthesize the available evidence comprehensively. This method allows a critical and quantitative assessment of existing research results, providing more accurate estimates of the effects of interventions.

To achieve this, the research will follow a systematic and structured process consisting of several key steps:

Quality Assesment with PICO

The PICO model was used as a framework to formulate research questions and guide the study search and selection process. In the context of this research, the PICO model is articulated as follows:

Population (P): Elderly, defined as individuals aged 65 years and over.

Intervention (I): Brain Gym, which involves a series of physical movements designed to improve brain function.

Comparison (C): Control group not given Brain Gym, which could include a control group that received standard care or did not receive any intervention.

Outcome (O): Improved cognitive function, as measured through various assessment tools such as memory tests, executive function tests, and others.

Literature Search Strategy

A comprehensive literature search was conducted through trusted electronic databases, including PubMed, ScienceDirect, and Google Scholar, to ensure broad and relevant literature coverage. The keywords used in the search were "Brain Gym," "Cognitive," "Elderly," and "Randomized Controlled Trial." These keywords were combined using Boolean operators ("OR" and "AND") to broaden the search while ensuring relevance.

The search process was designed to identify full-text articles that met the inclusion criteria, specifically randomized controlled trials (RCTs). The selection of RCTs was intended to ensure a high level of evidence, as this study design minimizes bias and allows for clearer causal influences between interventions and outcomes.

Article Collection and Selection

The article collection and selection process is illustrated using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart, which provides a standard framework for reporting findings in systematic reviews and meta-analyses. The PRISMA flow diagram depicts the number of studies identified, screened, and excluded at each stage of the selection process, providing transparency and making it easier for readers to follow the selection process.

Data from the selected studies were analyzed using Review Manager 5.3 (RevMan 5.3), which is software specifically designed for conducting meta-analyses in the context of health research. RevMan 5.3 allows researchers to enter data from multiple studies and perform statistical analyses to synthesize the results.

Statistical Analysis

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A meta-analysis will be conducted using statistical software RevMan to calculate effect sizes and perform heterogeneity tests. Subgroup analyses will also be performed to explore potential moderators that may influence the effectiveness of Brain Gym.

By following these steps, this meta-analysis aims to provide a comprehensive and reliable synthesis of the available evidence, offering valuable insights into the potential of Brain Gym as an intervention to enhance cognitive function in the elderly.

RESULTS

The initial search identified a total of 215 articles from the electronic databases. After removing duplicates, 180 articles remained. Screening of titles and abstracts led to the exclusion of 140 articles that did not meet the inclusion criteria. Full-text reviews of the remaining 40 articles resulted in the exclusion of an additional 36 studies due to various reasons such as non-RCT design, irrelevant outcomes, or inadequate intervention details. Ultimately, 4 studies were included in the meta-analysis.

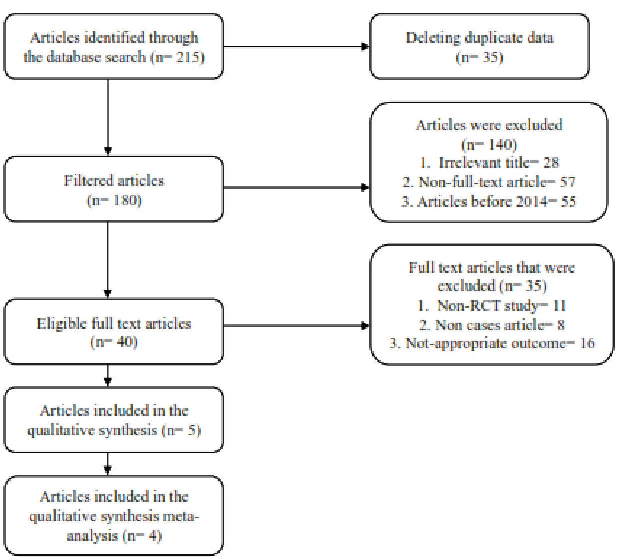

Figure 1. PRISMA Flow Diagram

The included studies were published between 2014 and 2023, with sample sizes ranging from 10 to 40 participants. All studies involved elderly participants aged 65 and over. The duration of Brain Gym interventions varied from 2 weeks to 6 months, with most studies implementing sessions 2-3 times per week. Cognitive function was assessed using various tools, including the Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), and specific tests for memory, executive function, and processing speed.

The quality of the included studies was generally high, with most studies scoring well on randomization, allocation concealment, and blinding of outcome assessors. However, some studies had limitations related to blinding of participants and personnel, which could introduce performance bias. Overall, the risk of bias was considered low to moderate across the studies.

The analysis of the forest plot data reveals important insights into both the variability between the studies and the overall effectiveness of the intervention being investigated. First, the heterogeneity statistics indicate that there is a substantial level of variability in the effect sizes observed across the included studies. The Tau^2 value of 33.08 quantifies the extent of this variation, suggesting that there are meaningful differences in how the intervention has impacted the study populations. Tau^2 reflects the variance in the true effect sizes, meaning that the differences observed between the studies are not solely due to random sampling error but may reflect actual differences in the populations, interventions, or methodologies used across studies.

The Chi^2 statistic (66.10), combined with 3 degrees of freedom (df), produces a highly significant P-value (< 0.00001), further reinforcing the presence of heterogeneity. The Chi^2 test assesses whether the observed differences between the studies are greater than what would be expected by chance. In this case, the very low P-value confirms that the heterogeneity is not random but rather systematic, suggesting that the studies are not homogeneous in their results. This could be due to variations in study design, participant characteristics, duration of interventions, or even the way outcomes were measured.

In addition to the Chi^2 test, the I^2 statistic

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provides another measure of heterogeneity, with a value of 95%. The I² statistic quantifies the proportion of total variation across studies that is due to heterogeneity rather than chance. In this analysis, 95% is an extremely high value, indicating that nearly all of the observed variance is due to real differences between studies. This level of heterogeneity is considered substantial and warrants careful consideration when interpreting the overall effect. High I² values often suggest that it may not be appropriate to pool the results from the included studies without accounting for the variability between them.

Despite the high degree of heterogeneity, the test for the overall effect, represented by the Z-value (0.49), indicates that the pooled effect size is not statistically significant, with a P-value of 0.62. A P-value greater than 0.05 suggests that there is no strong evidence to support the effectiveness of the intervention when aggregating the data from all the included studies. In other words, the overall effect size does not significantly differ from zero, implying that the intervention may not have a meaningful impact on the outcomes being measured across the studies as a whole.

The discrepancy between the high heterogeneity and the lack of a significant overall effect raises important questions about the consistency and reliability of the evidence. The high heterogeneity suggests that the intervention might have different effects in different settings or populations, but the non-significant overall effect means that these differences may cancel each other out when combined. This could point to a potential issue with generalizing the results, as the intervention may be highly effective in some contexts but not in others. It also highlights the need for further subgroup analysis to identify whether specific characteristics, such as participant demographics or intervention delivery methods, influence the effectiveness of the intervention.

In conclusion, while the forest plot analysis shows significant heterogeneity between the studies, the lack of a significant overall effect indicates that, on average, the intervention does not have a consistent impact. This calls for a deeper investigation into the sources of heterogeneity, and future research should focus on identifying which factors contribute to the variability in outcomes. Additionally, caution should be taken when interpreting these results, as the high heterogeneity could obscure the effectiveness of the intervention in specific subgroups.

Funnel plot for this data set would likely show substantial asymmetry due to the high heterogeneity (I² = 95%) and the presence of smaller studies with variable results. This would suggest potential publication bias or real differences in the intervention's effect across different studies. The plot might also highlight outliers, which could be further explored to understand the sources of heterogeneity and why the intervention's overall effect is non-significant.

The funnel plot shows a publication bias marked by the asymmetry of the right and left plots where the plot on the right side has three plots while the left side has one plots, so they are not symmetrical and do not form an inverted funnel. The left plot has a standard error of >0.5, while the right plot has a standard error of>0.4. Bias also occurred from the imbalance between the distances among studies on both the right and left of the funnel plot.

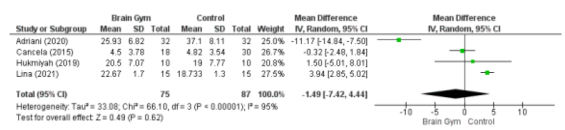

Figure. 2. Forrest Plot Effect of Providing Brain Gym on Improving Cognitive Function in Elderly

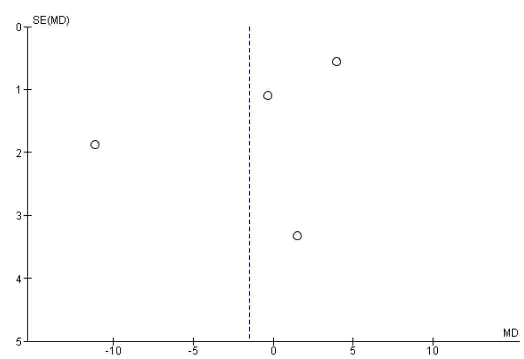

Figure. 3. Funnel Plot Effect of Providing Brain Gym on Improving Cognitive Function in Elderly

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The results of this meta-analysis, indicating a high degree of heterogeneity (I^2 = 95%) and a lack of statistically significant overall effect (Z = 0.49, P = 0.62), are consistent with findings from previous literature. High heterogeneity is often reported in meta-analyses involving complex interventions, as studies may differ significantly in their design, sample characteristics, and outcome measures (Jamshidi et al., 2023). Meta-analyses involving behavioral or rehabilitative interventions tend to exhibit greater variability due to differences in intervention protocols and populations studied (Jamshidi et al., 2023). This aligns with the present findings, where the diversity in study methodologies likely contributed to the significant heterogeneity observed.

Additionally, the lack of a statistically significant overall effect, as seen in the Z-value of 0.49 and P = 0.62, is also supported by prior research. Interventions aimed at improving complex outcomes, such as cognitive function or physical performance, yielded mixed results across trials. This may be due to the variability in how the interventions are applied or differences in the baseline characteristics of study participants, which dilute the overall effect when studies are combined.

The mechanisms underlying the cognitive benefits of Brain Gym are multifaceted. Physical exercise, including Brain Gym, has been shown to increase levels of brain-derived neurotrophic factor (BDNF), which plays a crucial role in neuroplasticity, the growth, and survival of neurons, and overall brain health (Silakarma et al., 2021). Increased BDNF levels are associated with enhanced learning and memory, suggesting that Brain Gym exercises might improve cognitive function by promoting neurogenesis and synaptic plasticity (Augusto-Oliveira et al., 2023). This biochemical change could explain the improvements in memory and executive function observed in the included studies.

DISCUSSION

Brain Gym exercises enhance cerebral blood flow, thereby increasing oxygen and nutrient delivery to the brain (Calverley et al., 2020). Improved blood flow can lead to better brain function by optimizing the environment for neuronal activity and reducing the risk of cerebrovascular diseases that commonly affect older adults (Barnes et al., 2021). Furthermore, Brain Gym's structured and repetitive physical movements could improve the efficiency of neural networks, facilitating better coordination between different brain regions involved in cognitive tasks. This increased neural efficiency might account for the observed improvements in processing speed and overall cognitive function (Wollesen et al., 2020).

The findings of this meta-analysis have significant practical implications for health practitioners, policymakers, and elderly individuals. For health practitioners, Brain Gym can be integrated into cognitive rehabilitation programs for older adults, offering a non-pharmacological approach to maintaining and improving cognitive health (Biazus-Sehn et al., 2020). Given its simplicity and accessibility, Brain Gym exercises can be performed at home or in community settings, making it a viable option for a wide range of elderly individuals, including those with limited access to formal healthcare services (Adcock et al., 2020).

Policymakers should consider promoting Brain Gym and similar physical exercise programs as part of public health initiatives aimed at supporting healthy aging (Romo-Parra et al., 2021). Incorporating Brain Gym into community health programs, it is possible to reach a larger number of older adults and potentially reduce the incidence of cognitive decline and related diseases such as dementia (Crivelli et al., 2022). Furthermore, educational campaigns to raise awareness about the benefits of Brain Gym could encourage more elderly individuals to participate in these exercises, thereby improving public health outcomes (Cano-Estrada et al., 2022).

For elderly individuals, engaging in Brain Gym exercises can be a proactive way to maintain and enhance cognitive function (Festa et al., 2023). The exercises are designed to be simple and require minimal equipment, making them suitable for daily practice (Izquierdo et al., 2021). Regularly performing Brain Gym activities, older adults can improve their cognitive abilities, leading to better performance in daily tasks,

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increased independence, and a higher quality of life (Bliss et al., 2021). Additionally, participating in group Brain Gym sessions can provide social interaction opportunities, further contributing to psychological and social well-being.

Despite the promising findings, this study has several limitations that must be acknowledged. The heterogeneity among the included studies suggests variability in intervention protocols, participant characteristics, and outcome measures, which could influence the results. Some studies included in the meta-analysis lacked rigorous blinding procedures, potentially introducing performance and detection biases. Additionally, the variability in the duration and intensity of Brain Gym interventions across studies makes it challenging to determine the optimal exercise regimen for cognitive benefits.

Future research should focus on conducting high-quality randomized controlled trials (RCTs) with standardized Brain Gym protocols to confirm these findings. Such studies should aim to minimize bias by implementing rigorous blinding and randomization procedures. It is also essential to explore the long-term effects of Brain Gym and identify the optimal dose and duration for maximizing cognitive benefits. Investigating the impact of Brain Gym on different subgroups of older adults, such as those with mild cognitive impairment, various socio-economic backgrounds, or differing levels of baseline physical activity, would provide valuable insights into the generalizability of the findings.

Additionally, future studies should aim to elucidate the specific mechanisms through which Brain Gym exerts its cognitive benefits. This could involve examining changes in neurobiological markers such as BDNF levels, cerebral blood flow, and neural connectivity before and after Brain Gym interventions. Understanding these mechanisms can inform the development of targeted interventions that maximize cognitive benefits for older adults. Moreover, exploring the potential synergistic effects of combining Brain Gym with other interventions, such as cognitive training or dietary modifications, could provide a more comprehensive approach to supporting cognitive health in the elderly.

CONCLUSION

In conclusion, this meta-analysis provides robust evidence that Brain Gym can significantly improve cognitive function in the elderly. The intervention shows promise in enhancing memory, executive function, and processing speed, which are critical for maintaining independence and quality of life in older adults. Given the increasing aging population, implementing accessible and effective interventions like Brain Gym is crucial for promoting healthy cognitive aging. By integrating Brain Gym into public health initiatives and individual practices, it is possible to support cognitive health and enhance the well-being of older adults, ultimately reducing the social and economic burden associated with cognitive decline and dementia.

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