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**Original Research**

# Exergame: Exercise With Matching Memory Game On Cognitive Function And Physical Fitness Of The Elderly

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**ABSTRACT**

***Background:*** *Cognitive decline and physical deterioration are common issues among the elderly, significantly impacting their quality of life. The unanticipated cognitive impairments will result in dementia. Effective approaches to simultaneously improving both aspects remain to be further developed and evaluated. Exercise with a matching memory game overcomes the issues. This study aimed to examine the effectiveness of an exergame, combining memory-stimulating games and physical exercise in improving cognitive function and physical fitness among the elderly.*

***Methods:*** *The study was a quick experiment with two groups in a pre-post test design. A number of 119 participants were recruited using purposive sampling and randomly divided into the experimental group (n=60) or the control group (n=59). Cognitive function was assessed using the Mini-Mental State Examination (MMSE), while physical fitness was measured with the 2-minute step test score.*

***Results:*** *The data was analyzed using a paired t-test, which revealed a significant improvement in MMSE and 2-minute scores in the experimental group before and after the intervention ($p < 0.05$). Additionally, the independent t-test analysis demonstrated a significant difference between the experimental and control groups in both cognitive and physical fitness measures after the intervention ($p < 0.05$).*

***Conclusion:*** *Implementing exercise has a significant positive influence on cognitive function and physical fitness among the elderly. Incorporating an exergame into community health programs for the elderly could provide substantial benefits to their overall well-being.*

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## INTRODUCTION

Old age is a stage of human growth and development that occurs continuously, and the cycle is inevitable for every individual. A person is considered to be entering old age when they reach an age greater than 60 (Kemenkes RI, 2017; Undang-Undang Republik Indonesia No 13, 1998). Globally, the proportion of the population aged 60 years and older has increased in recent years (Huang et al., 2019; Nayak et al., 2019).

By 2020, the number of elderly individuals will reach 1 billion and is predicted to double by 2050 (World Health Organization, 2022).

Physical function in the elderly is a critical component of life that typically declines with age (Navarrete-Villanueva et al., 2021). The risk of disability and physical limitations increases by two to four times upon entering old age (Milanović et al., 2013). This condition can make it difficult for the elderly to meet their basic needs and increase their vulnerability to various diseases (Yen & Lin, 2018). Furthermore, decreased functional capacity is associated with declining quality of life and well-being and an increased risk of mortality among seniors (Angulo et al., 2020; Santos et al., 2021).

Declining physical health and function contribute to a sedentary lifestyle among older adults, where individuals have a lack of enthusiasm for physical activity (Lins-Filho et al., 2020). Previous studies revealed low activity levels among seniors, ranging from 45% to 56% (Effendi et al., 2014; Fitri, 2018; Sipayung & Siregar, 2018). Considering the impact, both regular exercise and spontaneous/unplanned physical activity can be helpful as mediators in raising physical fitness and reducing stress (Navarrete-Villanueva et al., 2021; Silverman & Deuster, 2014).

Exercise is described as structured, planned, and repeated physical exercise performed with consciousness (Di Lorito et al., 2021). Numerous studies have demonstrated that traditional exercises, such as aerobics, muscle endurance training, or combined exercise, can enhance the physical functionality and mental well-being of the elderly (Da Silva et al., 2022; Lucya et al., 2024; Mahmoudi et al., 2022; Pratiwi et al., 2024). Aside from physical function, cognitive function among elders also declines with age (Hu et al., 2021; Huang et al., 2019).

The prevalence of impaired cognitive function in the elderly reaches almost half of this population (Pais et al., 2020; Rini et al., 2018). Cognitive function impairment is a significant predictor of dementia incidence and, therefore, requires attention (Pais et al., 2020). Elderly persons with cognitive impairment are fourfold more likely to develop dementia (Gómez-Soria et al., 2023). However, cognitive impairment is frequently misconstrued as a natural aging aspect and thus often disregarded.

Cognitive stimulation is crucial in the elderly as it positively influences thinking and memory functions (Mather, 2020). It can also reduce the risk of dementia and maintain cognitive function (Collins et al., 2021). A systematic review explains that cognitive stimulation significantly improves cognitive function among seniors (Gómez-Soria et al., 2023). However, traditional cognitive stimulation conducted through individual sessions is considered less effective in providing benefits for cognitive function and quality of life for elderly people experiencing functional decline (Orrell et al., 2017).

As human beings, the elderly appreciate engagement and enjoy interaction, communication, and social cohesion, which can stimulate language capability, attention, and responsiveness (Orfanos et al., 2021). For this reason, it is suggested that cognitive stimulation should be provided in groups through fun and exciting activity components (Devita et al., 2021). Games with memory stimulation, for example, can be an alternative therapy to improve cognitive function and psychological wellness among elderly populations (Moreira et al., 2020; Tu et al., 2022).

Combining physical exercise and stimulating games is still uncommon in Indonesia. Several studies separately applied physical exercise or cognitive stimulation (Gómez-Soria et al., 2023; Makawekes et al., 2020). However, providing

single therapy offers advantages in only one domain of life function and does not provide optimal benefits for the elders (Orrell et al., 2017). The current study combined stimulation to build a comprehensive physical and cognitive therapy model. This research yields a model for concurrently executing therapy that integrates physical exercise with memory games to enhance seniors' physical function and cognitive capacities.

The current study explores the integration of cognitive stimulation (memory games) with physical exercise activities as an alternative for the elderly to achieve cognitive engagement while attaining physical benefits through group interactions. Physical movement serves as a stimulus for the aged, improving sensory and motor integration, therefore improving their physical and cognitive function (Raichlen et al., 2020; Upate & Marasabessy, 2023). Engaging in memory games incorporating physical movement and social interaction will simultaneously enhance cognitive performance and physical capabilities (Biazus-Sehn et al., 2020). Activities that include a social component provide better therapeutically beneficial (Devita et al., 2021; Orfanos et al., 2021).

## MATERIALS AND METHOD

The present study was quantitative research using a two-group pretest-posttest design conducted from May to July 2024. The control and intervention groups were included in this study and selected using a purposive sampling technique from three public health centres in Bandung, Indonesia. Using g-power calculation, the study involved 120 participants of both genders. The participants were recruited using purposive sampling and then divided randomly into intervention and control groups of 60 participants each. However, during the data collection process, one participant from the control group withdrew, resulting in a total of 119 participants for data analysis (60 participants in the intervention group and 59 in the control group).

Data was processed using the SPSS-21 program. Demographic characteristics, MMSE score, and physical fitness score were analyzed using descriptive analysis as univariate. The *paired t-test* was used to identify the mean difference of variables between the pretest and post-test. The *independent t-test* was used to analyze the post-test difference between the intervention and control groups. The bivariate analysis was run after the normality data test was performed.

Ethical permission was obtained from the STIKEP PPNI Ethical Board under the number III/071/KEPK-SLE/STIKEP/PPNI/JABAR/VII/2024. Eligible participants were asked to follow the research process, and consent was collected after explaining the research procedure and risk. Data collection was conducted twice, before and after the intervention (Table 1), using the Mini-Mental Scale Examination (MMSE) and 2-minute step test. The MMSE was used to measure general cognitive function with scoring ranging from 0–30 (Folstein et al., 1975), and a 2-minute step test was used to evaluate physical fitness (Poncumhak et al., 2023; Rikli & Jones, 2004).

After developing the module and protocol, the intervention group followed the intervention sessions according to the protocol. It was performed within six meeting sessions over four weeks, each with a different activity (Table 4), while the control group received a leaflet to take home. Pretest data collection was performed at the beginning of the session, and the post-test data was collected at the last session.

**Table 1.** Exergame Activities Series

| Session | Activity |
|---|---|
| **I (week- 1)** | Explanation of research procedure and pretest data collection. |
| **II (week- 1)** | Health education about physical exercise and the aging process |
| **III (week -2)** | The participants are divided into small groups of 6. Each group is assigned to match pairs of identical pictures. The pictures are placed 3 meters apart, requiring the seniors to walk to match them. Each participant within the group takes turns matching the pictures. The group with the fastest and the most pictures matches attains the highest score. |
| **IV (week -3)** | During this session, group activities are conducted under the facilitator's guidance. The facilitator shows a card containing instructions for specific movements to one of the group members to demonstrate. The other members imitate the movement and guess the name of the movement activity. This activity continued until each group member got the chance. Examples of the movements are playing basketball, dancing, stepping, etc. Once the member imitates and guesses the movement correctly, they get the score. |
| **V (week -4)** | The facilitator conducted a modified creative exercise with various movements, and all the members followed the movements. Points are awarded to the groups that demonstrate precise movements. |
| **VI (week -4)** | Post-test data collection |

## RESULTS

A total of 119 subjects were included in the analysis. According to the characteristics of the subjects, the experimental group mainly consisted of females (86.7%) who were mostly married (60%), had attained a primary school education (61.7%), and were housewives/not engaged in formal employment (78.3%). The average age of participants was 66.5 years, with a standard deviation of 4.8. Meanwhile, in the control group, a majority of participants were female (81.4%), married (54.2%), had completed elementary school education (47.5%), and were housewives/not working (78.3%) with an average age of 68 ± 5.9 years. The characteristics of the subjects are seen in Table 2.

**Table 2.** Characteristics of Respondents

| Variables | Experimental (n=60) | | Control (n=59) | | Total (n=119) | |
|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % |
| **Sex** | | | | | | |
| Male | 8 | 13.3 | 11 | 18.6 | 19 | 16 |
| Female | 52 | 86.7 | 48 | 81.4 | 100 | 84.0 |
| **Education level** | | | | | | |
| Not attending school | 5 | 3.4 | 10 | 3.4 | 15 | 5.26 |
| Primary school | 37 | 61.7 | 28 | 47.5 | 65 | 54.6 |
| High school | 17 | 28.3 | 17 | 28.8 | 34 | 28.6 |

| Variables | Experimental (n=60) | | Control (n=59) | | Total (n=119) | |
|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % |
| College | 1 | 1.7 | 4 | 6.8 | 5 | 4.2 |
| **Working status/ working experience** | | | | | | |
| Civil servant/ military service/ police | 2 | 3.3 | 5 | 8.5 | 7 | 5.9 |
| Employee | 1 | 1.7 | 2 | 3.4 | 3 | 2.5 |
| Self-employed | 6 | 10 | 8 | 13.6 | 14 | 11.8 |
| Farmer/laborer | 4 | 6.7 | 7 | 11.9 | 11 | 9.2 |
| Housewives/ not working | 47 | 78.3 | 37 | 62.7 | 84 | 70.6 |
| **Marital status** | | | | | | |
| Single | 0 | 0 | 3 | 5.1 | 3 | 2.6 |
| Married | 36 | 60 | 32 | 54.2 | 68 | 57.1 |
| Widowed/widower | 24 | 40 | 24 | 40.7 | 48 | 40.3 |
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Age** | 66.5 | 4.8 | 68 | 5.9 | 67.2 | 5.4 |

Table 3 provides data on physical activity levels in experimental and control groups. Most participants reported engaging in physical exercise in the experimental and control groups, with 75% and 78%, respectively. Physical training was predominantly done once a week in both the experimental and control groups, with rates of 43.3% and 66.1%, respectively. According to the disease description, the experimental group reported experiencing one type of disease (75%), whereas the control group mainly reported that they did not perceive any disease (44.1%).

**Table 3.** The Physical Aspect of Respondents

| Variables | Experimental (n-60) | | Control (n=59) | | Total (n=119) | |
|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % |
| **Physical exercise** | | | | | | |
| Yes | 45 | 75 | 46 | 78 | 91 | 76.5 |
| No | 15 | 23.5 | 13 | 22 | 28 | 23.5 |
| **Physical exercise occurrence** | | | | | | |
| Never | 15 | 25 | 13 | 22 | 28 | 23.5 |
| 1x / week | 26 | 43.3 | 39 | 66.1 | 65 | 54.6 |
| 2x / week | 11 | 18.3 | 6 | 10.2 | 17 | 14.3 |
| >2x/ week | 8 | 39.5 | 1 | 1.7 | 9 | 7.6 |
| **Presence of disease** | | | | | | |
| None | 10 | 16.7 | 26 | 44.1 | 36 | 30.3 |
| 1 disease | 45 | 75 | 24 | 40.7 | 69 | 58.0 |
| 2 disease | 3 | 5 | 7 | 11.9 | 10 | 8.4 |
| >2 disease | 2 | 3.3 | 2 | 3.4 | 4 | 3.4 |

In this study, all participants were assessed using MMSE and 2-minute scores. According to Table 4, the experimental group reported an average pretest MMSE score of 26.9±2.1, slightly higher than the control group's score of 26.5±4.2. The average 2-minute score for the experimental group was 75.9±26.3, while the control group scored 73.2±24.7.

**Table 4.** MMSE and 2-Minute Step Test Score

| Variable | Experimental (n=60) | | Control (n=59) | | Total (n=119) | |
|---|---|---|---|---|---|---|
| | Pretest | Postest | Pretest | Postest | Pretest | Postest |
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| MMSE score | 26.9 (2.1) | 29.2 (1.2) | 26.5 (4.2) | 27.1 (2.2) | 26.74 (3.3) | 27.03 (4.3) |
| 2-minute score | 75.9 (26.3) | 89.5 (33.9) | 73.2 (24.7) | 71.7 (17.8) | 74.5 (25.5) | 80.7 (28.5) |

The evaluation of variables in the experimental group indicated significant differences in the MMSE and 2-min score compared to pre- and post-intervention ($p < 0.05$). Meanwhile, the control group reported contrasting outcomes (Table 5). The analysis of post-test scores between the experimental and control groups revealed significant outcomes ($p < 0.05$) across all variables (Table 6).

**Table 5.** MMSE and 2-Minute Step Test Score Pre and Post-Intervention

| Variables | Group | test | *x* | SD | Δ | Statistic | *p-value* |
|---|---|---|---|---|---|---|---|
| MMSE score | Experimental[a] | Pretest | 26.9 | 2.1 | 2.3 | -5.691 | 0.000* |
| | | Posttest | 29.2 | 1.2 | | | |
| | Control[a] | Pretest | 26.5 | 4.2 | 0.6 | -.024 | 0.981 |
| | | Posttest | 27.1 | 2.2 | | | |
| 2-min score | Experimental[a] | Pretest | 75.9 | 26.3 | 13.6 | -4.028 | 0.000* |
| | | Posttest | 89.5 | 33.9 | | | |
| | Control[b] | Pretest | 73.2 | 24.7 | 1.5 | 0.828 | 0.411 |
| | | Posttest | 71.7 | 17.8 | | | |

[a] *Wilcoxon*
[b] *paired t-test*
** $p<0.05$

**Table 6.** MMSE and 2-Minute Step Test Score Between Experimental and Control Group

| Variables | Group | test | *x* | SD | Δ | Statistic | Sig. |
|---|---|---|---|---|---|---|---|
| MMSE score | Pre-test[a] | Experimental | 26.9 | 2.1 | 0.4 | -.697 | 0.486 |
| | | Control | 26.5 | 4.2 | | | |
| | Post-test[a] | Experimental | 29.2 | 1.2 | 2.1 | -6.936 | 0.000* |
| | | Control | 27.1 | 2.2 | | | |
| 2-min score | Pre-test[b] | Experimental | 75.9 | 26.3 | 1.6 | -.567 | 0.572 |
| | | Control | 73.2 | 24.7 | | | |
| | Post-test[a] | Experimental | 89.5 | 33.9 | 17.8 | -2.850 | 0.004* |
| | | Control | 71.7 | 17.8 | | | |

[a] *Mann-Whitney U test*
[b] *Independent t-test*
* $p<0.05$

## DISCUSSION

*Cognitive function*

The study reported a significant increase in cognitive function, as measured by the MMSE score before and after the exergame intervention. The MMSE score showed a significant difference compared to the control group. This suggests that cognitive stimulation via memory games, in conjunction with physical exercise, has significant advantages for the elderly.

Before the intervention, the mean cognitive score of respondents was low since cognitive scores decline with increasing years of age (Feng et al., 2023). Older individuals showed poor cognitive function compared to younger age groups (Qin et al., 2022). This occurs due to the normal aging process experienced by each individual. The study's findings aligned with the frequency of cognitive decline among the elderly in Indonesia, which was 35% in 2018 (Kementrian Kesehatan RI, 2018).

Cognitive function is well-known as an important aspect that plays a significant role in autonomous functioning among the elderly. The cognitive status of an individual significantly influences decision-making and the ability to manage behavior within the framework of executive function (Guarino et al., 2020). Impaired cognitive function in the elderly ultimately impacts physical performance and psychosocial well-being (Lee et al., 2023). Cognitive function also influences walking balance, a significant risk factor for falls in the elderly (Adam et al., 2023). Understanding the cognitive status of the elderly can serve as a prediction for future falls within this population (Guo et al., 2023).

The decline in cognitive function among seniors is closely related to the aging process. Individuals' cognitive abilities are predominantly controlled by the frontal lobes of the brain, which undergo change and aging throughout time as they become older (Li et al., 2020; Smith et al., 2020). Furthermore, cellular neurodegenerative mechanisms such as diminished metabolism and neurotransmitters, as well as increased inflammatory markers, also affect cognitive function (Feng et al., 2023; Sargent et al., 2020).

However, cognitive decline is not something inevitable as part of the aging rocess. However, cognitive decline is not something that inevitably occurs as part of the aging process (Ruan et al., 2020; Sugimoto et al., 2018); thus, individuals may retain cognitive ability without deterioration in their elderly years (Liu et al., 2023). Implementing proper treatments in vulnerable populations such as older adults can mitigate and prevent those functional deteriorations.

In the current study, exergame therapy significantly improved the MMSE score ($p < 0.05$) compared to baseline. This indicates that elderly people experience enhancements in cognitive abilities, including attention, memory, orientation, and logical reasoning. Previous studies demonstrated that combined physical exercise and cognitive stimulation, such as exergames, can improve cognitive performance (Adcock et al., 2020; Eggenberger et al., 2015; Gschwind et al., 2015).

This combination exercise promotes interaction between cognitive and motor activities, hence improving communication among various brain parts. Additionally, Kraft's research stated that combination training yields more success in improving executive function and extending benefits to other functions compared to singular training (Kraft, 2012; Pellegrini-Laplagne et al., 2023). However, the evidence is inconclusive, as certain research indicates no significant cognitive benefits from

exercise alone (Young et al., 2015). Therefore, while the overall trend supports the cognitive benefits of exercise, further research needs to be investigated.

*Physical Function*

The physical impact in the current study was evaluated by measuring physical fitness using a 2-min test calculation. The results revealed a significant gain in physical function by the increase in the 2-minute step test score after the exergame among the experimental group. Furthermore, the post-test measurement results reported significant differences between the control and experimental groups. These current results suggested that exergame interventions improved the physical fitness of the elderly.

In the current study, physical fitness levels were assessed using the 2-minute step test to provide an overview of the seniors' physical capacity. The average score before the intervention among the experimental group was 75.9, whereas the control group had an average score of 73.2, resulting in an overall average of 74.5. However, the mean difference between the experimental and control groups was not statistically significant at the baseline. On the other hand, different results were obtained after the intervention.

The mean score among the experimental group climbed to 89.5 relative to the baseline ($p < 0.05$), showing a 17.9% increase. These findings were relatively similar to studies assessing the effectiveness of training using kinetic games in improving physical fitness by 15% (Yu et al., 2020) and 23% (Choi et al., 2020). The 2-minute step test evaluates the physical fitness of the elderly by assessing their capacity to perform activities that require muscle strength, balance control, and cardiovascular endurance (Poncumhak et al., 2023).

Engaging in active physical exercise elevates heart rate and increases cardiorespiratory oxygenation and muscle metabolism, all of which improve total physical fitness (Adcock et al., 2020; Dewa Ayu Putri Hartaningrum et al., 2022). Previous studies found that older adults engaged in physical activity combined with memory games had enhancement in their physical condition and function (Gallou-Guyot et al., 2020; Schättin et al., 2016; Yu et al., 2020). Physical exercise has an impact on muscle strength and balance, depending on the type of exercise and physical components involved. This current study involved physical exercise combined with games, encouraging elderly individuals to engage by running and competing with other participants.

Additionally, participants were instructed to imitate various motions that required lower extremity muscle strength. This strategy pertains to dual-task training, which consists of exercises that integrate the sensory and motoric functions of the nervous system (Gallou-Guyot et al., 2020; Norouzi et al., 2019). The integration of sensory and motor nerves can mitigate postural instability and enhance balance (Ghai et al., 2017).

Concurrent exercise can enhance nerve function and has been proven to improve balance control, hence decreasing the incidence of falls in the elderly (Hofheinz et al., 2016; Nugraha et al., 2023). Uysal et al., found that dual-task training, including exergames, can enhance balance, lower body strength, and aerobic capacity, all associated with improved physical fitness (Uysal et al., 2023). However, some studies demonstrated the opposite, that there were no significant training effects on physical function (Adcock et al., 2020).

Maintaining lower body muscle strength in the elderly is vital not just for fulfilling everyday activities but also for preventing functional decline, weakness, disability, and the risk of falls (Bernabei et al., 2022). Muscular endurance, particularly

in walking, is a predictor of disability among the elderly (Wickramarachchi et al., 2023). Exergame in the current study promises an alternative approach to promoting physical fitness by improving body muscle endurance while simultaneously stimulating cognitive function among the elderly. Despite the varied outcomes, exercise with matching memory games presents an effective method for promoting physical activity, especially for groups that encounter obstacles to conventional exercise.

## CONCLUSION

Cognitive and physical deterioration in the elderly due to the aging process is common. However, it can be prevented by implementing exercises that improve lower-body muscle endurance while simultaneously preserving cognitive function in the elderly. Exergames, which combine physical exercise and memory games, are an alternative therapy that can help the elderly enhance their cognitive function and fitness.

This study has proven that exergame training effectively enhances cognitive function and physical fitness in the elderly. Nevertheless, further large-scale investigations are needed. Physical-cognitive training should also be adapted to individual interests and preferences, considering sociocultural factors. The efficacy of exergames in groups with specific health issues requires investigation to ascertain additional benefits.

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