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THE IMPACT OF AEROBIC EXERCISE AND COGNITIVE STIMULATION ON COGNITIVE FUNCTION IN THE ELDERLY

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ABSTRACT

The world's population, including Indonesia, is currently undergoing an aging process, characterized by an increase in the number and proportion of elderly individuals. The aging process leads to changes in physical health, sleep patterns, psychosocial well-being, and cognitive function in the elderly. Cognitive impairment poses a serious problem for older adults due to its physical, psychological, social, and economic impacts. Effective interventions can provide holistic support to elderly individuals with cognitive impairment, helping them to live better and more meaningful lives. This research aims to analyze the influence of aerobic exercise and cognitive stimulation on the improvement of cognitive function in the elderly. The research method used was an experimental study with a one-group pretest-posttest design. The sample was selected using a purposive sampling technique. The study sample consisted of 34 elderly individuals who met the inclusion criteria. The research instrument used the Mini Mental State Examination (MMSE) to measure the cognitive level of the elderly participant. Data were processed using SPSS and analyzed using the Wilcoxon Signed Rank Test.The results of the Wilcoxon signed-rank test showed that the average score of cognitive function experienced a significant increase between before and after the intervention, with a p-value of 0.000. Based on the findings of this study, aerobic exercise and cognitive stimulation have a positive influence on the improvement of cognitive function in the elderly.

Keywords: cognitive function; elderly; exercise; puzzle

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INTRODUCTION

The current rate of global population growth, including in Indonesia, is progressing towards an aging process, characterized by an increase in the number and proportion of elderly individuals. By 2030, it's estimated that at least 1 in 6 people worldwide will be aged 60 or older (WHO, 2024). Older adults undergo an aging process that leads to changes in physical health, sleep patterns, psychosocial well-being, and cognitive function. Cognitive impairment is a serious issue that causes a decline in performance on crucial cognitive tasks essential for decision-making (Juniarti et al., 2021). One of the most common cognitive impairments among the elderly is dementia (Hillalia Nurseha & Ritanti, 2024). The number of people with dementia continues to rise; a WHO report estimates that over 55 million people (8.1% of women and 5.4% of men aged over 65) have dementia (WHO, 2021). In Indonesia, it was estimated that there were about 1.2 million people with dementia in 2016, a number projected to increase to 2 million by 2030 and 4 million by 2050 (Alzhaimer's Indonesia, 2019).

Dementia has physical, psychological, social, and economic impacts, not only on those with the condition but also on caregivers, families, and society at large (WHO, 2021). For family members and caregivers, dementia can be a challenging condition to manage, both emotionally and practically (Wang et al., 2022). At the community level, dementia can significantly affect the economy due to the typically high cost of care for individuals with the condition (Alzhaimer's Research, 2023).

Dementia has often been overlooked in public health interventions. A lack of awareness and understanding contributes to the stigmatization of the disease, making people reluctant to seek treatment (PAHO, 2019). While there is no definitive cure for dementia, several approaches can help manage symptoms and slow the progression of the condition (Tresno Saras, 2023). Physical exercise interventions and cognitive stimulation are effective strategies to enhance cognitive health in older adults, thus aiding in dementia prevention (Ben Ayed et al., 2024).

One suitable form of physical exercise for the elderly is low-impact aerobic exercise. This type of aerobic exercise involves movements that do not require excessive force or harshness and are relatively slower (Faridah, 2022). In addition to physical exercise, an effort to prevent dementia in older adults is cognitive stimulation. Recommended cognitive stimulation activities for seniors include engaging in brain-training activities like solving crossword puzzles (Valentinus Besin & Gaspar Besin, 2023).

Low-impact aerobic exercise has a positive effect on improving cognitive function in older adults. Low-impact aerobic exercise can stimulate brain activity, improve blood circulation, and contribute to mood enhancement, all of which play a role in improving cognitive function in the elderly (Aulia, 2021). Research has shown that engaging in aerobic exercise provides a protective effect against cognitive decline and can inhibit the progression of dementia. Aerobic exercise can stimulate the release of neurotransmitters such as dopamine and norepinephrine, as well as growth factors like Brain-Derived Neurotrophic Factor (BDNF), which contribute to neuronal growth and survival. The physical activity performed during aerobic exercise can stimulate neurogenesis, the process of forming new neurons, especially in brain areas associated with memory, such as the hippocampus (Triyulianti et al., 2024;Tanzila et al., 2020).

Furthermore, crossword puzzles can stimulate various brain regions, including the occipital-temporal lobe, parietal lobe, midfrontal lobe, frontal lobe, hippocampus, and entorhinal cortex (Isnaini & Komsin, 2020). Crossword puzzle therapy works on the brain through processes such as reading (perception), understanding clues (comprehension), analyzing clues (analysis), stimulating the brain to try possible answers again (retrieval), and deciding on the correct answer (execution). Crossword puzzle therapy then activates brain regions like the hippocampus and entorhinal cortex by producing the neurotransmitter acetylcholine, which can improve cognition and prevent the onset of dementia (Astuti et al., 2023). A study conducted by (Damayanti et al., 2023) on crossword puzzle therapy proved its effectiveness in improving memory in older adults with cognitive impairment.

Interventions combining these two types of exercises provide broader stimulation for the brain. During physical activity, the brain receives more oxygen and nutrients, which can improve cognitive performance. Physical exercise can enhance neuroplasticity, the brain's ability to form and strengthen neural connections. When implemented alongside cognitive tasks, this effect can become even more significant (Ben Ayed et al., 2024). This is supported by research analyzing the impact of physical exercise programs and cognitive stimulation. This research proves that such combined programs have a positive impact on the cognitive function of older adults with dementia (Juniarti et al., 2021). Therefore, the purpose of this study is to determine the effect of low-impact aerobic exercise and crossword puzzle therapy on cognitive function in the elderly.

METHOD

This study is a quantitative research with a one-group pretest-posttest design. The research population consists of elderly individuals within the working area of the UPT Puskesmas Babeko in Bungo Regency. Sampling for this study utilized a non-probability sampling technique, specifically purposive sampling, resulting in a sample size of 34 elderly

participants. Inclusion criteria for participants were elderly individuals aged 60–79 years, having a Mini Mental State Examination (MMSE) score of 21–26 (indicating mild cognitive impairment). Exclusion criteria were elderly individuals unable to read and/or write, having a history of medical conditions that pose a risk if they participate in the research activities

The study began with a pretest to assess the participants' cognitive function status using the Mini Mental State Examination (MMSE) instrument. The intervention was conducted over 4 weeks, from May 5th to May 28th, 2025. The intervention consisted of 12 sessions (3 sessions per week), with each session lasting 60 minutes. Each intervention session began with low-impact aerobic exercise led by a certified aerobics instructor for 30 minutes. After this, participants were given a 15-minute break. This was followed by the second intervention, crossword puzzle therapy, for 30 minutes. During the crossword puzzle therapy, participants were divided into 6 groups, with each group consisting of 5-6 elderly individuals. Each group was accompanied by 1 research assistant, comprising 3 elderly cadres, 2 health workers, and 1 village midwife. After the 4-week intervention program concluded, a posttest was conducted using the Mini Mental State Examination (MMSE) instrument. The Mini-Mental State Examination (MMSE) instrument used in this study has been tested for validity and reliability, with results indicating it is valid and reliable for research purposes.

Data Analysis for univariate analysis, the frequency distribution of respondent characteristics was presented. For bivariate analysis, the Wilcoxon signed-rank test was used because the data were not normally distributed. This test was performed to analyze the difference in cognitive function before and after the intervention. This study was approved by the Research Ethics Committee, Andalas University, Padang (ethics number: 494.layaketik/KEPKFKEPUNAND).

RESULT

Table 1.
Respondent Characteristics (n=34)

Elderly Characteristics		f	%
Age			
	60-69 years old	21	61,8
	70-79 years old	13	38,2
Gender			
	Male	9	26,5
	Female	25	73,5
Education Level			
	Elementary School	25	73,5
	Junior High School	5	14,7
	Senior High School	3	8,8
	University	1	2,9
Employment History			
	Unemployed	20	58,8
	Employed	14	41,2
Medical History			
	Absent	13	38,2
	Present	21	61,8

Based on the table above, we can see the descriptive analysis of the elderly participants' characteristics. More than half of the total respondents (61.8%) were aged between 60 and 69 years old. The majority were female (73.5%), and most had an elementary school education level (73.5%). Furthermore, over half of the respondents (58.8%) were unemployed, and a significant portion (61.8%) had a history of disease.

Table 2.
Mean Cognitive Function Scores of Elderly Before and After Intervention

Cognitive function score	Mean	Median	Min-Max
Pretest	22,82	23,00	21-26
Posttest	25,32	23,00	22-28

Table 2 shows that the average pretest cognitive function score for the elderly was 22.82, and the average posttest cognitive function score was 25.32. These results indicate that there was an increase in the cognitive function scores of the elderly after the intervention.

Table 3.
Differences in cognitive function scores of the elderly before and after intervention

Cognitive function score	Mean	Median	Difference	p-value
Pretest	22,82	23,00	2	0,000
Posttest	25,32	25,00		

Table 3 shows that the median value before the intervention was 23.00, and after the intervention, it was 25.00. Analysis using the Wilcoxon Signed-Rank Test yielded a p-value of 0.000 ($p < 0.05$). This result indicates a significant difference between cognitive function scores before and after the intervention.

DISCUSSION

Mean cognitive function scores of elderly before and after intervention

Based on the research findings, the mean cognitive function score before the intervention was 22.82. A major issue that humans experience as they age is a decline in cognitive function (Birle et al., 2021). The pretest analysis, using the Mini Mental State Examination (MMSE) instrument, revealed that the cognitive function domains experiencing a decline were primarily time orientation, where 19 out of 34 respondents only scored 3 (out of a maximum of 5), with only 3 respondents achieving the maximum score. A decline was also observed in the attention and calculation domain, where 17 respondents scored 2 (out of a maximum of 5), and only 2 respondents achieved the maximum score. Additionally, a decrease was noted in the recall domain, with 16 respondents scoring 2 (out of a maximum of 3), and only 2 respondents reaching the maximum score.

One study found that the orientation domain (especially time orientation) and delayed recall are among the earliest MMSE domains to show decline in patients with cognitive impairment or Alzheimer's disease (Guerrero-berroa et al., 2010). One of the most frequently affected areas is memory, particularly episodic memory, which impacts the ability to recall recent events or acquire new information (Marselli G, Favieri F, 2023). In patients with cognitive impairment, especially Mild Cognitive Impairment (MCI) which is at risk of progressing to Alzheimer's disease (AD), the decline in MMSE scores most commonly occurs in the time orientation and recall domains. These domains are consistently among the most affected in patients with cognitive impairment. Difficulty recalling recently learned information is a hallmark of memory problems (Choe et al., 2020). The human brain naturally experiences volume shrinkage, particularly in crucial areas for cognition such as the prefrontal cortex and hippocampus. Concurrently, there is a loss of synapses, which are connections between nerve cells, disrupting the efficiency of neural communication. Decreased cerebral perfusion is also a significant underlying mechanism of cognitive decline (Thomas et al., 2024).

The mean cognitive function score for the elderly after receiving the intervention was 25.32. Analysis of the Mini Mental State Examination (MMSE) instrument showed an increase in the average cognitive function score after the intervention. This indicates that the intervention provided to the elderly was able to improve their cognitive function scores. The improved cognitive function scores in the elderly were influenced by the intervention provided by the researchers.

These research findings are supported by a study on the combination of physical exercise and cognitive stimulation, which demonstrated better outcomes in cognitive function (Tan et al., 2023). Based on the posttest analysis using the Mini Mental State Examination (MMSE instrument), the cognitive function assessment domains that showed improvement were time orientation, with 20 respondents achieving a score of 5, and recall, with 14 respondents achieving a score of 3. The research findings indicate that the cognitive function scores increased due to the intervention, which consisted of low-impact aerobic exercise combined with crossword puzzle cognitive stimulation.

Differences in cognitive function scores of the elderly before and after intervention

The research findings indicate an increase in the cognitive function scores of the elderly. The median pretest score was 23.00, and after the intervention of low-impact aerobic exercise and crossword puzzle therapy, the median score increased to 25.00. This 2-point increase in cognitive function scores demonstrates an improvement in the cognitive condition of the elderly. Statistical analysis using the Wilcoxon Signed-Rank Test yielded a p-value of 0.000 ($p < 0.05$). Consequently, the null hypothesis (Ho) is rejected. This result confirms that aerobic exercise and cognitive stimulation intervention has a significant positive effect on improving cognitive function in the elderly.

These findings are supported by a study that aimed to evaluate the effectiveness of a cognitive stimulation program and strength training in older adults with Mild Cognitive Impairment (MCI). That study concluded that both cognitive stimulation and strength training were effective in improving cognitive function (Muñoz-perete et al., 2025). Furthermore, another study investigating the effect of physical exercise and learning therapy on elderly cognitive function scores before and after intervention found a significant increase in the mean cognitive function scores from pre- to post-intervention (Juniarti et al., 2021).

The combination of aerobic exercise and cognitive stimulation can enhance cognitive function. Physical exercise and cognitive stimulation interventions are effective strategies for improving cognitive health in older adults, thereby aiding in the prevention of cognitive impairment or dementia (Ben Ayed et al., 2024). These two types of interventions provide broader stimulation for the brain. Aerobic exercise causes vasodilation of blood vessels and an increased heart rate, leading to improved blood circulation throughout the body, including the brain. With enhanced blood circulation, the supply of nutrients and oxygen also becomes more efficient, optimizing brain function and ultimately improving short-term memory (Asrizal & Fitra, 2020).

Aerobic exercise can stimulate the release of neurotransmitters like dopamine and norepinephrine, as well as growth factors such as Brain-Derived Neurotrophic Factor (BDNF), all of which contribute to the growth and survival of neurons. The physical activity involved in aerobic exercise can stimulate neurogenesis, the process of forming new neurons, especially in brain areas related to memory, like the hippocampus (Triyulianti et al., 2024;Tanzila et al., 2020). The hippocampus is a complex structure located in the inner part of the temporal lobe and plays a crucial role in various cognitive functions, particularly those related to learning and memory (Anand & Dhikav, 2012).

Meanwhile, crossword puzzle therapy can stimulate brain regions including the occipital-temporal lobe, parietal lobe, midfrontal lobe, frontal lobe, hippocampus, and entorhinal cortex (Isnaini & Komsin, 2020). Crossword puzzle therapy engages the brain through processes such as reading (perception), understanding clues (comprehension), analyzing clues (analysis), stimulating the brain to re-attempt possible answers (retrieval), and deciding on the correct answer (execution). This therapy then activates brain areas like the hippocampus and entorhinal cortex by producing the neurotransmitter acetylcholine, which can enhance

cognitive function and prevent cognitive impairment (Astuti et al., 2023). Based on the discussion above, this study demonstrates that low-impact aerobic exercise and crossword puzzle therapy are significantly effective in improving cognitive function scores in elderly individuals with cognitive impairment. Therefore, this intervention can be considered an effective strategy for preventing cognitive impairment in older adults.

CONCLUSION

This study concludes that the combined intervention of low-impact aerobic exercise and crossword puzzle therapy leads to a significant improvement in cognitive function among elderly individuals with mild cognitive impairment.

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