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Effectiveness of culture-based game exercises on cognitive function in older adults participating in gymnastics

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ABSTRACT

The aim of this study was to examine the effectiveness of culture-based game exercise training on the cognitive function of older adults. This study was a quasi-experimental research with a pre-test and post-test control design. The research subjects were 40 elderly individuals who are members of the Teratai elderly gymnastics group in the Nogotirto Gamping housing area, Sleman, Special Region of Yogyakarta, Indonesia. The research instruments included the Mini Mental State Examination (MMSE) to measure cognitive function, along with video recordings of physical exercise activities, recordings of culture-based game songs, and exercise props. After being given the intervention of culture-based game exercise training in the intervention group (IG), there was a significant improvement in cognitive function scores from pre-test to post-test (MMSE score: Fh;df=19; α=3.622; p=.003 < .05), and there was a significant difference in the change in MMSE scores between the intervention group (IG) and the control group (CG) (Fh;df=19; α=0.280; p = .004 < .05) with a large effect size (d=2.363). In the control group (CG), which engaged in daily activities such as singing culture-based game songs, cognitive function also improved, but the change was not statistically significant (p>.05). In conclusion, culture-based game exercise is effective in improving cognitive function in older adults.

KEYWORDS

Culture-Based Game Exercises; Cognitive Function; Older Adults; Gymnastics

1. INTRODUCTION

The elderly population will continue to increase along with the rise in life expectancy and the decline in birth and death rates in Indonesia. The 2023 Indonesian Health Profile recorded a population of 280,275,428 people, with 11.2% of them being elderly (Kementrian Kesehatan, 2024). The elderly experience functional decline due to biological, physical, psychological, and social changes, which can lead to a deterioration in cognitive function. Cognitive dysfunction can eventually develop into dementia (Tz-Han et al., 2023).

Dementia is a cognitive dysfunction disorder and has become a rapidly growing global public health issue. The WHO reported that in 2019, the estimated prevalence of dementia among the elderly aged 60 and above varied greatly depending on the location, ranging from 2.9% in Southeast Asia to 6.5% in Europe. Meanwhile, the global prevalence is rapidly increasing with age, from 1.1% in those aged 60-64 years to 35.9% in those aged 90 years or older (WHO, 2024). Jia et al. (2020) A cross-sectional study conducted in China involving 46,011 elderly individuals aged 60 and above aimed at identifying the prevalence and risk factors of dementia and Mild Cognitive Impairment (MCI) showed that the prevalence of dementia was 6%, Alzheimer's disease 3.9%, vascular dementia 1.6%, other types of dementia 0.5%, and MCI 15.5%.

Cognitive dysfunction is often accompanied by mood disorders, emotional control issues, behavioral disturbances, and motivational problems, which affect physical, psychological, social, and economic well-being. To prevent cognitive dysfunction, it is recommended that the elderly manage cardiovascular disease risk factors (as cardiovascular diseases are the main risk factor for cognitive dysfunction), engage in cognitive-stimulating activities such as playing games, listening to music, and actively socializing within the community (WHO, 2024). A descriptive correlational study with a cross-sectional design conducted on the elderly Malay population in Pekanbaru City, involving 98 samples, revealed that factors related to the cognitive function of the elderly include education level, type of occupation, and a history of hypertension, including the condition of hypertension, classification, and duration of hypertension. Additionally, family support that influences cognitive function includes emotional support, appreciation, instrumental support, and informational support (Shiddieqy et al., 2022)

In general, the risk factors for cognitive dysfunction and dementia can be either modifiable or non-modifiable. Non-modifiable risk factors include gene polymorphism, age, gender, race/ethnicity, and family history. Age, as a primary risk factor, does not necessarily mean cognitive decline occurs

naturally with age, but rather due to unhealthy lifestyle factors and diseases experienced by the elderly. Recent studies have shown a connection between the development of cognitive impairment and dementia linked to unhealthy lifestyle risk factors, such as physical inactivity, smoking, unhealthy diets, alcohol consumption, social isolation, and cognitive inactivity. Additionally, certain health conditions like hypertension, diabetes mellitus, hypercholesterolemia, obesity, and depression can increase the risk of developing cognitive dysfunction and dementia (WHO, 2019; Jia et al., 2020). Physical inactivity in the elderly is a modifiable risk factor for cognitive dysfunction. Physical exercise is key to reducing the risk of cognitive impairment in older adults (Department of Health & Human Services, 2018). Several studies have reported that physical activity and the implementation of physical exercise interventions have been proven to prevent cognitive decline and dementia (Song & Yu, 2019; Yamasaki, 2023). Aerobic exercises involving dynamic movements that require skill (such as gymnastics with specific movement patterns) have been shown to be more effective than other aerobic exercises that do not require skills, such as running or cycling (Yamasaki, 2023). According to Tinôco et al. (2023) that in a systematic review revealed that the effects of physical exercise on cognitive function primarily occur in the executive domain, memory, and overall cognition.

The WHO recommends recreational or leisure-time physical activities, such as walking or cycling for transportation, work-related activities (for those who are still employed), daily tasks, and games, to be performed in a structured and regular manner every day, either individually or in groups. To be beneficial for the cardiovascular system, muscles, bones, functional health, and cognitive function decline, physical exercise should be performed for at least 150 minutes per week at moderate intensity or 75 minutes per week at vigorous intensity, or a combination of both. Aerobic exercise for the elderly should be done with a minimum duration of 10 minutes. The exercise should be progressive and tailored to the elderly's abilities (WHO, 2019).

Cultural-based exercise routines, accompanied by local traditional songs, can have additional positive impacts on the elderly. The inclusion of songs from cultural games, which are familiar to them from childhood, can serve as a form of reminiscence music therapy. Providing exercise and reminiscence therapy is one of the non-pharmacological intervention alternatives. The use of music with nostalgic songs related to local culture can evoke memories of past joys, leading to feelings of happiness, motivation, and laughter, which can ultimately enhance cognitive function in the elderly (Tz-Han et al., 2023; Liu et al., 2024). Sutin et al. (2024) is also recommended that efforts to improve elderly health should take into account local cultural wisdom. There are various screening tools

available for assessing cognitive dysfunction. An ideal cognitive dysfunction screening tool should have high sensitivity, be easy to administer by anyone without difficulty, and be completed in a short amount of time. One commonly used instrument is the Mini-Mental State Examination (MMSE). The MMSE has a sensitivity of 25-87% for detecting dementia and a specificity ranging from 46-82% (Kolegium Neurologi Indonesia, 2023). The aim of this study is to examine the effectiveness of culture-based game exercise training on the cognitive function of older adults.

2. METHODS

2.1. Design and Participants

This study used a quasi-experimental pre-test and post-test control design to assess the impact of cultural-based game gymnastics on cognitive function in elderly individuals. A total of 40 elderly participants from the "Teratai" elderly gymnastics group in Nogotirto Gamping Housing, Sleman, Indonesia, participated, with 20 individuals in each group. The subjects, aged 60 and above, were divided into two groups: the intervention group (IG), which engaged in physical exercise through cultural-based game gymnastics, and the control group (CG), which listened to cultural-based game songs while performing daily activities.

Approval from the ethics committee for this study was obtained from the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada - Dr. Sardjito General Hospital, Yogyakarta, Indonesia; with the approval letter number KE/FK/1098/EC/2024.

2.2. Instruments and Procedures

The independent variable was cultural-based game gymnastics, and the dependent variable was cognitive function, measured using the Mini-Mental State Examination (MMSE). Data collection occurred before and after the intervention, which lasted for one month (12 sessions, three times a week). The IG performed the gymnastics based on a pre-designed module and video, while the CG listened to the cultural songs during daily routines. Cognitive function was assessed by completing the MMSE independently, with enumerator assistance.

2.3. Statistical Analyses

The statistical analyses were carried out with the statistical software SPSS, version 25. Descriptive statistics, including means, standard deviations, and percentages, were used, and inferential statistics, including Chi-square and F-tests, determined the effectiveness of the intervention. Ethical approval was granted by Gadjah Mada University's Ethics Commission. The

study aimed to evaluate the cognitive function changes in both groups, comparing pre- and post-intervention scores, with a significance level of $\alpha = 0.05$.

3. RESULTS

The research subjects involved in this study were 40 members of the elderly gymnastics group "Teratai" from Nogotirto Gamping Housing, Sleman, Special Region of Yogyakarta, Indonesia. These subjects were divided into two groups: 20 individuals in the intervention group (IG) and 20 individuals in the control group (CG). Table 1 shows the characteristics of the study subjects. Three-quarters (75%) of the subjects were female, while the remaining were male. The proportion of female subjects was 90% (18 individuals) in the IG and 60% (12 individuals) in the CG.

Table 1. Distribution of respondents based on socio-demographic characteristics

	IG		CG		IG + CG	
	f	**%**	**f**	**%**	**f**	**%**
Gender						
Male	2	10	8	40	10	25
Female	18	90	12	60	30	75
Education						
High School	9	45	10	50	19	47
Academy/University	11	55	10	50	21	52
Occupation						
Housewife	13	65	9	45	22	55
Retired	5	25	7	35	12	30
Private Sector	1	5	3	15	4	10
Civil Servant	1	5	1	5	2	5

Note. *IG; intervention group: CG; control group*

Based on the educational level, the study subjects generally had a good educational background. Subjects with an academic/college education numbered 11 (55%) in the intervention group (IG) and 10 (50%) in the control group (CG). The remaining subjects, 9 (45%) in the IG group and 10 (50%) in the CG group, had a high school education or lower. More than half of the subjects, 22 individuals (55%), were housewives. Among them, 13 (65%) in the IG group and 9 (45%) in the CG group were housewives. According to their age as elderly individuals, 12 (30%) were retirees. Only 4 individuals (10%) worked in the private sector, and 2 individuals (5%) were still active as civil servants.

A Chi-square test with $\alpha = 0.05$ comparing the proportion of the subject characteristics between the IG and CG groups resulted in $\chi 2$ df = 7; $\alpha = 11.6014$; $p = 0.210273 > 0.05$. This result indicates that there were no statistically significant differences in the distribution of subject

characteristics between the two groups. Table 2 shows the distribution of MMSE Scores in the IG and CG Groups before intervention

Table 2. Distribution of MMSE Scores in the IG and CG Groups before intervention

MMSE Score (Cognitive Function)	IG		CG		IG + CG	
	f	%	f	%	f	%
27-30 (Normal/Good)	6	30,0	9	45,0	15	37,5
21-26 (Mild Dementia)	14	70,0	11	55,0	25	62,5
10-20 (Moderate Dementia)	0	0,0	0	0,0	0	0,0
<10 (Severe Dementia)	0	0,0	0	0,0	0	0,0
Average MMSE Score	25,80		26,65		26,23	

Note. *MMSE; Mini-Mental State Examination*

From the entire study sample, 15 subjects (37.5%) exhibited normal cognitive function, while 25 subjects (62.5%) showed mild cognitive impairment. An F-test analysis using $\alpha = 0.05$, comparing the MMSE scores between the IG and CG groups at the start of the study (pre-test), resulted in Fh;df = 19; $\alpha = 0.506978$; $p = 0.073862 > \alpha$. This indicates that there were no statistically significant differences in the MMSE scores between the IG and CG groups before the intervention.

The results of the pre-test analysis, as shown in Table 3, reveal that there was an equal cognitive function status between the IG and CG groups at the beginning of the study.

Table 3. Summary of pre-intervention MMSE and GDS Score data analysis between the KR-I and KR-K Groups ($\alpha = 0.05$)

Test/Measurement	$F_{h;df=19}$ / $t_{h;df=5}$	p value	Result
MMSE (Cognitive Function)	$F_h = 0,506978$	0,073862	No significant difference
GDS (Tendency for Depression)	$F_h = 0,686911$	0,210273	No significant difference

These findings provide assurance that any changes in cognitive function observed in both groups after the intervention can be attributed to the effects of the intervention, rather than differences in initial conditions at the start of the study.

The cognitive function measurement using the MMSE instrument on the IG and CG groups after the intervention yielded results as shown in Tables 4 and 5. Both the IG and CG groups showed an increase in MMSE scores, indicating that cognitive function improved in both groups following

the intervention, though the changes differed between the two groups. The average MMSE score for the IG group increased from 25.80 before the intervention to 29.35 after the intervention, reflecting an improvement of 3.55 points (13.8%).

Table 4. Changes in MMSE Scores (Cognitive Function) for the IG Group before and after intervention

MMSE Score (Cognitive Function)	Before Intervention		After Intervention		Change	
	f	%	f	%	f	%
27-30 (Normal/Good)	6	30,0	19	95,0	+13	+216,7
21-26 (Mild Dementia)	14	70,0	1	5,0	-13	-92,8
10-20 (Moderate Dementia)	0	0,0	0	0,0	0	0,0
<10 (Severe Dementia)	0	0,0	0	0,0	0	0,0
Average MMSE Score	25,80		29,35		+3,55 (+13,8%)	

The increase in the MMSE score in the IG group was statistically significant (Fh;df=19;α = 3.622642; p = 0.003655 < α). The IG group, which had mild dementia, experienced a significant decrease in the number of individuals with mild cognitive impairment, dropping from 14 individuals (70.0%) at the start of the study to only 1 individual (5.0%) after the intervention. On the other hand, the number of subjects with normal cognitive function increased from 6 individuals (30.0%) at the beginning of the study to 19 individuals (95.0%) after the intervention (see Table 4 above).

Table 5. Changes in MMSE Scores (Cognitive Function) in the CG group before and after intervention

MMSE Score (Cognitive Function)	Before Intervention		After Intervention		Change	
	f	%	f	%	f	%
27-30 (Normal/Good)	9	45,0	15	75,0	+6	+66,7
21-26 (Mild Dementia)	11	55,0	5	25,0	-6	-54,5
10-20 (Moderate Dementia)	0	0,0	0	0,0	0	0,0
<10 (Severe Dementia)	0	0,0	0	0,0	0	0,0
Average MMSE Score	26,65		27,80		+1,15 (4,3%)	

In the CG group, the average MMSE score increased from 26.65 at the beginning of the study to 27.80 after the intervention, with an increase of 1.15 points (4.3%). Subjects in the CG group with mild cognitive impairment decreased from 11 people (55.0%) at the beginning of the study to 5 people (25.0%) after the intervention. Meanwhile, subjects with normal cognitive function increased from 9 people (45.0%) at the beginning of the study to 15 people (75.0%) after the intervention (Table 5). The F-test analysis yielded Fh; df=19; $\alpha = 0.822270$; $p = 0.337029 > \alpha$, indicating that there was no significant difference between the MMSE scores of the CG group before and after the intervention. The analysis of pre-test to post-test score changes between the IG and CG groups resulted in Fh; df=19; $\alpha = 0.280435$; $p = 0.004009 < 0.05$ with a large effect size (d=2.363215). This result shows that the intervention of cultural-based exercise games in the IG group was effective in improving cognitive function, whereas daily physical activity while singing cultural-based game songs in the CG group showed an improvement in cognitive function, but this improvement was not statistically significant.

4. DISCUSSION

The results of this study show that the education level of the research subjects is good, as they are high school graduates or higher, meaning that all subjects meet the requirements for cognitive function assessment using the MMSE. The Indonesian Neurology Collegium (2023) stated that in the MMSE examination, to obtain accurate results, individuals must have the ability to read and write. The majority of the research subjects were female, accounting for 75%, which is consistent with previous literature indicating that older adults are predominantly female (Dinas Kesehatan Sleman, 2020; BPS, 2021; Kementrian Kesehatan, 2024).

Globally, it is predicted that the number of older adults will continue to increase. Therefore, strategies and policies are needed to ensure that older adults are healthy, fit, and prosperous with good functional capacity. Physical independence and preserved cognitive abilities are crucial components of the lives of older adults (Liu et al., 2024). Physical inactivity is one of the risk factors for cognitive dysfunction in older adults (Yamasaki, 2023), Therefore, efforts are needed to ensure sufficient physical activity for older adults by providing physical exercise, such as senior gymnastics. In order to achieve positive adaptations from the exercise to address the aging process, the exercise must meet the required frequency, duration, and intensity. It should include multi-component training that focuses on muscle strength and endurance, flexibility, balance, as well as aerobic exercises, with an emphasis on games (WHO, 2019; Yamasaki, 2023). Cultural-based game gymnastics

accompanied by nostalgic songs rooted in local culture, which have been previously familiar to most older adults, is a form of physical exercise that is well-suited for implementation with seniors. This nostalgic music accompaniment is a form of reminiscence music therapy, which triggers past memories, activating the memory and evoking feelings of joy, enthusiasm, and laughter. These positive emotional responses can, in turn, enhance cognitive function in older adults (Tz-Han et al., 2023; Liu et al., 2024). A similar statement was also expressed by Sutin et al. (2024) a similar statement was also expressed by those who recommend that efforts to improve the health of the elderly should consider the local cultural wisdom. According to the World Federation of Music Therapy (WFMT), music therapy is the use of music and its elements (harmony, rhythm, and melody) as an intervention to optimize the quality of life, and enhance physical, social, communicative, emotional, intellectual, and spiritual well-being (Jiménez-Palomares et al., 2024).

The systematic review conducted Jiménez-Palomares et al. (2024) a systematic review conducted revealed that music therapy can improve cognitive function in Alzheimer's patients, particularly in memory, language, and orientation, as well as improve behavioral issues, mood, emotions, and psychological well-being. This is because music therapy activates the limbic and paralimbic areas in the brain. The use of reminiscence music helps improve cognitive function by evoking past memories. Some literature mentions that plasticity processes can occur in older adults, even in those with neurodegenerative diseases, making music therapy intervention recommended for early dementia, mild cognitive impairment, and as a preventive measure for cognitively healthy older adults. Several studies have shown improvements or, at the very least, the ability to maintain global cognitive function (Raglio et al., 2024).

Exercises conducted in groups can enhance social activity and interpersonal relationships among older adults, which helps alleviate feelings of isolation, provides a sense of calm and satisfaction, and ultimately reduces the incidence of depression in the elderly (Wardhani et al., 2024). Joy and spontaneous laughter physiologically increase the secretion of endorphins, which can enhance mood, induce positive affect, and reduce stress, mental instability, and depression. Additionally, it can lower blood cortisol levels, which are released when the sympathetic nervous system is dominant. A decrease in cortisol levels indicates dominance of the parasympathetic nervous system, which lowers stress hormone levels, induces relaxation, and reduces stress. Psychologically, spontaneous laughter enhances positive emotional responses and facial expressions, leading the brain to experience positive emotions and improve mood, fostering happiness and relieving stress. Laughter or smiling can also improve interpersonal relationships and communication with others,

preventing and alleviating depression in older adults. Spontaneous laughter has more significant physiological effects compared to smiling, especially in terms of improving cardiorespiratory function and relieving muscle tension (Takeda et al., 2024).

Neuropsychiatric symptoms can be used to predict the progression from mild cognitive impairment (MCI) to dementia or from mild dementia to severe dementia. An exploratory study in Cache County, USA, among the elderly population showed that the total Neuropsychiatric Inventory (NPI) score was associated with rapid decline in verbal memory, verbal fluency, and constructional praxis. This study also found that NPI-depression was not associated with cognitive decline, while NPI-anxiety was associated with Symbol Digit Modality performance. The study concluded that neuropsychiatric symptoms (NPS) are related to the likelihood of cognitive decline, making NPS scores a risk factor or clinical indicator of preclinical dementia symptoms (Burhanullah et al., 2020). Song & Yu (2019) also state that cognitive function improvement is significantly mediated by the reduction of depressive symptoms and improvement in sleep quality. A cross-sectional study shows that physical activity is protective against anxiety and depression in the elderly and can improve their quality of life. Older adults should always be kept in an active state because physical activity helps maintain good health and improves functional abilities, vitality, and psychological status in the elderly (de Oliveira et al., 2019)**.**

The results of the study indicate that the intervention of cultural-based game exercises in the IG group significantly improved the MMSE scores, which means there was an improvement in cognitive function in the IG group. These results are consistent with the research conducted by Yamasaki (2023) which states that increased physical activity and physical exercise interventions have been proven effective in preventing cognitive decline and dementia. Physical exercise effectively reduces the adverse effects of the aging process on brain health, although the progression of neurodegeneration in dementia is difficult to reverse with physical exercise interventions alone. Therefore, the importance of early physical exercise interventions should be emphasized in efforts to delay cognitive decline in healthy older adults, patients with MCI, and those in the early stages of dementia. A systematic review indicates that physical exercise has a positive effect on cognitive function in older adults, especially in the domains of executive function, memory function, and global cognition (Tinôco et al., 2023). The effects of physical exercise on cognitive function improvement are primarily mediated by the improvement of the cardiovascular system, through mechanisms such as preventing vascular diseases and enhancing blood flow to the brain. This includes the increased expression of neurotrophic factors such as brain-derived neurotrophic factor

(BDNF), insulin-like growth factor 1 (IGF-1), and vascular endothelial growth factor (VEGF), as well as the reduction of β-amyloid and inflammatory responses. BDNF is essential for neuroplasticity, neurogenesis, synaptogenesis, as well as energy homeostasis regulation, and the increase in the size of the anterior hippocampus. Meanwhile, IGF-I and VEGF are crucial in neurogenesis, angiogenesis, and enhancing BDNF expression in the hippocampus, which can improve cognitive function. The reduction of neuroinflammation factors such as C-reactive protein, IL-6 (interleukin-6), and TNF-α (tumor necrosis factor-alpha) improves cognitive performance in both healthy older adults and those with mild cognitive impairment (Yamasaki, 2023). Individuals with mild cognitive impairment (MCI) are at a high risk of developing dementia. Physical exercise, particularly moderate-intensity aerobic exercise, is a promising lifestyle intervention to improve the cognitive function of MCI patients (Song and Yu, 2019).

5. CONCLUSIONS

This study showed that culture-based gymnastic exercises have a significant impact on improving cognitive function in older adults. The analysis results indicate that the intervention group (IG), which participated in culture-based gymnastic exercises, showed a significant increase in the MMSE scores, with an average increase of 3.55 points (13.8%) after the intervention. In contrast, the control group (CG), which only listened to cultural songs while engaging in daily activities, also experienced improvement, but the change was not statistically significant, with an average increase of 1.15 points (4.3%). The culture-based gymnastic exercises not only enhanced cognitive function but also contributed to emotional well-being, as they involved local cultural elements that triggered positive memories and improved mood. Group exercises like this are also beneficial in reducing feelings of loneliness, enhancing social relationships, and alleviating depressive symptoms in the elderly. This study supports the importance of structured physical activities that combine exercise with local cultural elements to promote both cognitive and psychological health in the elderly. Therefore, culture-based gymnastic programs can be an effective non-pharmacological intervention for maintaining cognitive function and preventing further cognitive decline in older adults.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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