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Evaluation of ACE program: A Home-Based Aerobic Exercise and Cognitive Activities for Elderly to Delay Dementia Progression among Elderly with Mild Cognitive Impairment

Norlinda Abd Rashid[1]* & Zurratul Aina Mohd Zahidin[2]
[1]Department of Basic Medical Sciences *for* Nursing, Kulliyyah of Nursing, International Islamic University, Pahang, Malaysia
[2]Pusat Jagaan Rumah Sejahtera (OKU Mental), Pahang, Malaysia

ABSTRACT

Background: Dementia is a growing public health concern, particularly among elderly individuals with Mild Cognitive Impairment (MCI), a transitional stage between normal aging and dementia. Non-pharmacological interventions such as physical exercise and cognitive activities have shown potential in delaying cognitive decline. This study investigates the effectiveness of a home-based Aerobic Exercise and Cognitive Activities for Elderly (ACE) program in improving cognitive performance among elderly individuals with MCI.
Methods: A quasi-experimental study was conducted involving 100 elderly participants diagnosed MCI. Participants were assigned to either a control group or an intervention group, which underwent a structured 12-week ACE program. Cognitive performance was evaluated at baseline, week 4 and week 12. Data analysis utilised the Mini-Cog assessment, comprising two components, a memory recall task and the Clock Drawing Test (CDT).
Results: There were no experimental–control differences, confirming group homogeneity before the intervention. In the intervention group, 55.8% improved in memory by week 4, rising to 90.7% by week 12. CDT gains increased from 18.6% at week 4 to 39.5% at week 12 (p<0.001), whereas the control group showed slower memory improvement, with 50.0% at week 4 to 59.1% at week 12 (p< 0.001). By week 12, the intervention group had significantly higher Mini-Cog than controls (p<0.001).
Conclusion: The findings support the effectiveness of structured physical and cognitive activity programs in mitigating cognitive decline among elderly individuals with MCI. Integrating such interventions into community-based healthcare initiatives may serve as a viable strategy to delay dementia onset and promote cognitive resilience.

Keywords: Dementia; Mild cognitive impairment; Physical exercise; Cognitive activities; Elderly health

***Corresponding author**
Norlinda Abd Rashid
Department of Basic Medical Sciences *for* Nursing,
Kulliyyah of Nursing,
International Islamic University Malaysia,
Pahang, Malaysia
E-mail: anatomi@iium.edu.my

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INTRODUCTION

Research Background

Aging is a global phenomenon, with an increasing proportion of the elderly population worldwide. In 2019, The United Nations Department of Economic and Social Affairs reported that the number of elderly individuals reached 703 million in 2019 and is projected to double by 2050, reaching 1.5 billion (1). The Department of Statistics Malaysia (2021) estimated that 11.1% of the population were elderly in 2022, with projections indicating Malaysia will become an aging nation by 2030 (2). With the rise in elderly individuals, age-related diseases such as dementia have become a significant concern.

Dementia is a clinical syndrome characterized by progressive cognitive decline, affecting memory, thinking, and the ability to perform daily activities. According to the World Health Organization (2023), 55 million people globally suffer from dementia, with approximately 10 million new cases diagnosed annually (3). In Malaysia, dementia is the third leading cause of disability among men and the second among women aged 80 and above (4). As dementia progresses, affected individuals increasingly rely on caregivers, which leads to significant financial, physical, and emotional burdens. The global economic cost of dementia was estimated at $1.3 trillion in 2019 (3).

Given the absence of a cure for dementia, preventive strategies are essential. Research suggests that physical exercise and cognitive activities can play a crucial role in reducing dementia risk and delaying cognitive decline among elderly individuals with Mild Cognitive Impairment (MCI), a transitional stage between normal aging and dementia (4). This study evaluates the combined effects of physical exercise and cognitive activities in mitigating dementia risk among elderly individuals diagnosed with MCI. Specifically, the objectives were to compare the memory and cognitive domain (executive function) of elderly individuals with and without participation in the ACE programme and to assess the overall effectiveness of the ACE programme in improving cognitive function compared to no intervention.

Literature Review

Mild Cognitive Impairment (MCI)

Mild Cognitive Impairment (MCI) is an intermediate stage between normal cognitive aging and dementia, characterized by noticeable cognitive decline that does not significantly impact daily functioning (5). It is a critical intervention stage where strategies to delay or prevent dementia progression can be implemented. Study found that approximately 30% of patients with MCI progressed to dementia during a median follow-up of 33 months, and nearly 50% of cases progressed within 1–3 years (6). However, some research suggests that MCI can be reversible, with a 30%–50% recovery rate to normal cognitive functioning (7).

The Role of Physical Exercise

Physical exercise has been extensively studied as a non-pharmacological intervention for cognitive health. Regular physical activity improves cerebral perfusion, enhances neuroplasticity, and reduces the risk of vascular diseases (8). Exercise-induced neurobiological changes include increased levels of Brain-Derived Neurotrophic Factor (BDNF), Insulin-Like Growth Factor-1 (IGF-1), and Vascular Endothelial Growth Factor (VEGF), all of which support cognitive function (9,10).

A study in 2018 found out that elderly individuals who participated in aerobic dance training exhibited significant improvements in episodic memory and processing speed (10). Similarly, in 2020, it was reported that resistance training had neuroprotective effects on hippocampal subfields associated with Alzheimer's disease (11). These findings highlight the potential of structured physical exercise programs in preserving cognitive function and delaying MCI progression.

The Role of Cognitive Activities

Engagement in cognitive activities such as reading, puzzles, and memory training has been shown to enhance cognitive resilience. The "use it or lose it" hypothesis suggests that continuous mental stimulation preserves cognitive function by strengthening neural connections (12). Cognitive training has been associated with improvements in executive function, episodic memory, and attention (13,14).

Leisure-based cognitive activities also contribute to cognitive health. In 2019, a researcher defined "cognitive activities" as intellectually stimulating leisure pursuits that improve cognitive reserve (15). Studies have demonstrated that elderly individuals who engage in frequent cognitive activities have a lower risk of developing dementia (16).

The Need for Combined Interventions

Recent research suggests that combining physical exercise with cognitive activities may produce synergistic effects on cognitive function. It was reported that elderly individuals receiving both physical exercise and computerized cognitive training showed superior improvements in memory and attention compared to those receiving either intervention alone (17). A meta-analysis study further demonstrated that dual-task interventions yielded small-to-moderate improvements in global cognitive function in elderly individuals with MCI (18).

Despite these promising findings, few studies have investigated the feasibility of home-based physical and cognitive activity programs, particularly in rural populations with low literacy levels. Given the unique socioeconomic and cultural factors affecting Malaysia's aging population, there is a need for accessible, cost-effective interventions tailored to elderly individuals living in community settings. This study aims to bridge that gap by evaluating the effectiveness of a combined home-based physical exercise and cognitive activity program in improving cognitive performance among elderly individuals with MCI.

MATERIALS AND METHODS

Study Design

This study employed a quasi-experimental design to evaluate the effectiveness of a home-based Aerobic exercise and Cognitive Activities for Elderly (ACE) programme in improving cognitive performance among elderly individuals with Mild Cognitive Impairment (MCI). The study was conducted over a period of 12 weeks, with cognitive assessments performed at baseline, week 4, and week 12.

Study Setting and Population

The study was conducted among elderly individuals residing in the Federal Land Development Authority (FELDA) communities in Kuantan, Malaysia. FELDA was selected as the study site due to its high proportion of elderly residents and the increasing prevalence of cognitive impairment within this population.

Inclusion and Exclusion Criteria

Participants were required to meet specific inclusion criteria to ensure the study targeted individuals with MCI. The inclusion criteria consisted of individuals aged 60 years and above, those diagnosed with Mild Cognitive Impairment (MCI) based on the Mini-Cog test, individuals who were physically capable of engaging in light physical activity, and those willing to participate in the intervention for the full 12-week duration. Participants were excluded if they had been diagnosed with severe cognitive impairment or dementia, had a history of neurological disorders such as stroke or Parkinson's disease, or had any medical condition that prevented them from engaging in physical or cognitive activities.

Sample Size and Sampling Technique

The sample size calculation was performed using G-Power software (G-Power, V3.0). According to the calculation, each group required at least 42 subjects as shown in **Figure 1**. Based on previous research (19), this study considered the inclusion of at least 50 participants in each group to allow for a 20% dropout rate.

In this study, total of 100 participants was recruited using purposive sampling. Participants were randomly assigned into two groups: the intervention group (n=50), which received the ACE programme involving both aerobic exercise and cognitive activities, and the control group (n=50), which did not receive any structured intervention.

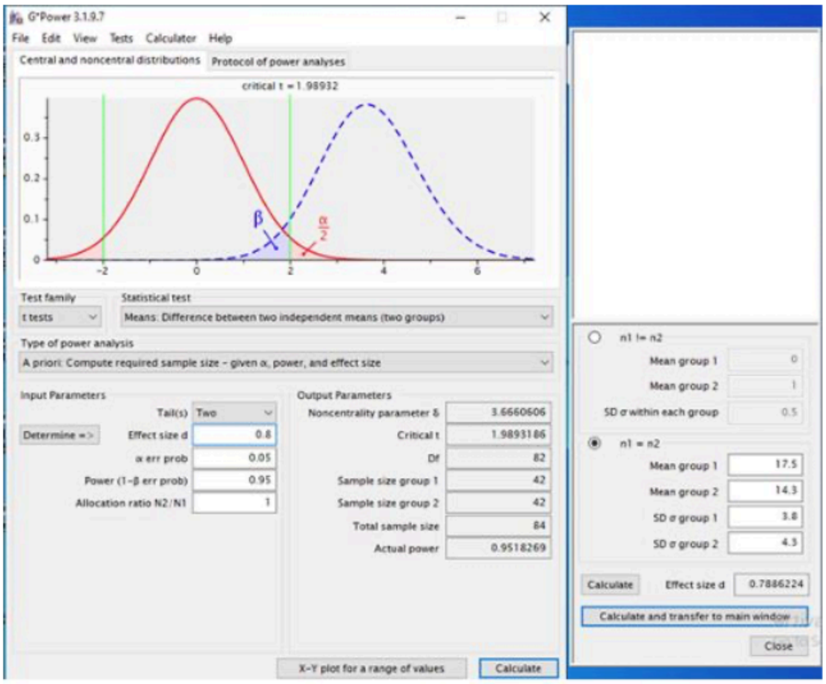
Intervention: The ACE Programme

The ACE programme was designed as a home-based intervention combining aerobic exercises and cognitive activities to enhance cognitive performance among elderly individuals with MCI as in **Figure 2**.

a) Physical Exercise Component

The physical exercise component included chair aerobic exercises, which were performed for 20 to 30 minutes per session, three times per week. The exercises involved rhythmic movements such as marching in place, seated leg raises, and upper body movements aimed at improving cardiovascular function and enhancing blood flow to the brain.

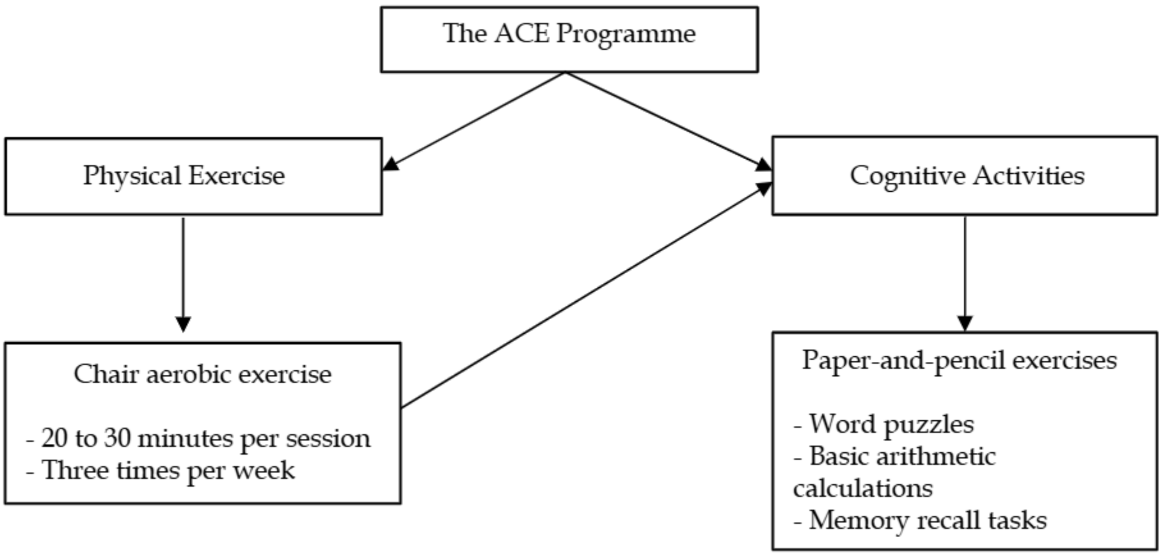
Figure 1: Sample Size Calculation Using G-Power Software



b) Cognitive Activities Component

The cognitive activities component comprised paper-and-pencil exercises, including word puzzles, basic arithmetic calculations, and memory recall tasks. Additionally, participants engaged in storytelling and discussion activities, where they were encouraged to recall past events and narrate short stories. These activities were intended to stimulate executive function and reinforce memory retention. The intervention was self-administered at home, with initial face-to-face guidance provided by trained facilitators. Participants received periodic follow-ups via WhatsApp messages and phone calls to monitor adherence and provide encouragement.

Figure 2: The ACE Programme



Outcome Measures

Cognitive performance was assessed using the Mini-Cog test, a widely used screening tool for cognitive impairment. The Mini-Cog test evaluates two key cognitive domains: memory recall and executive function. The assessment consisted of two tasks: the three-word recall test, in which participants were asked to remember and repeat three unrelated words after a brief delay, and the clock drawing test (CDT), where participants were required to draw a clock with a specified time. The validity and reliability of the Mini-Cog in elderly people is high, and it could identify MCI early (20). Scores ranged from 0 to 5, with higher scores indicating better cognitive function.

Data Collection Procedure

Data collection was conducted at three time points: baseline (pre-intervention), mid-intervention (week 4), and post-intervention (week 12). At each time point, participants underwent cognitive assessments using the Mini-Cog test. The same trained facilitators administered all assessments to ensure consistency and reliability of data collection.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics were used to summarize demographic characteristics. Categorical variables underwent analysis using the chi-square test, while numerical data were assessed using independent t-tests. Participant scores were categorized as improved, static, or decreased. Statistical significance was set at $p<0.05$.

Ethical Considerations

Ethical approval for the study was obtained from the Kulliyyah of Nursing Postgraduate and Research Committee (KNPGRC), IIUM Kuantan Campus and International Islamic University Malaysia Research Ethics Committee (Approval No. IREC 2022-066). All participants provided written informed consent before enrolment in the study. Confidentiality and anonymity were maintained throughout the research process, and participants were informed that they could withdraw from the study at any time without consequences.

RESULTS

Participant Characteristics

A total of 100 elderly individuals diagnosed with Mild Cognitive Impairment (MCI) were recruited, with 50 participants allocated to the experimental group and 50 to the control group. However, due to attrition, 87 participants (experimental group: n=43, control group: n=44) completed the study, yielding a completion rate of 87% as stated in **Table 1**. The mean age of participants was 70.46 ± 6.8 years. The majority had at least a primary education level (n=61, 70.1%), and a large proportion were married (n=47, 54.0%). Approximately 71.3% of participants had comorbidities such as hypertension, diabetes, or hypercholesterolemia.

Baseline Cognitive Performance

In the Mini-Cog test, the maximum scores that participants could achieve for each task are 3 for Memory and 2 for Clock Drawing Test (CDT). **Table 2** showed, at baseline, the mean Mini-Cog memory score for all participants was 1.55 ± 0.89, and the mean clock drawing test (CDT) score was 0.34±0.76. No significant differences were observed between the experimental and control groups in terms of baseline cognitive scores ($p>0.05$), confirming the homogeneity of the study sample before the intervention.

Intervention Group Performance

Table 3 showed the intervention group performance. In the experimental group, 24 of 43 participants (55.8%) exhibited an improvement in memory scores from baseline to week 4. By week 12, the number of participants with improved memory scores increased to 39 (90.7%), while only one participant (2.3%) experienced a decline. This difference was statistically significant ($p=0.043$). Similarly, CDT scores improved in 8 participants (18.6%) by week 4, increasing to 17 participants (39.5%) by week 12 ($p<0.001$).

Control Group Performance

In contrast, the control group as stated in **Table 4**, demonstrated a slower rate of cognitive improvement. At week 4, 22 of 44 participants (50.0%) exhibited improved memory scores, which increased to 26 participants (59.1%) by week 12. However, 4 participants (9.1%) showed a decline at week 12. The improvement in memory scores was statistically significant ($p < 0.001$). For CDT, 7 participants (15.9%) improved at week 4, with no further improvement observed by week 12 ($p=0.505$), suggesting that the control group did not benefit from significant CDT improvements over time.

Table 1: Sociodemographic Characteristics and Comorbidities Status of Participants (N=87)

Sociodemographic characteristics	All (N=87)	Experimental group (n=43)	Control group (n=44)
Age (Mean±SD)	70.46 (6.8)	71.0 ± 6.0	69.9 ± 7.6
Gender (n, %)			
• Male	22 (25.3%)	12 (54.5%)	10 (45.5%)
• Female	65 (74.7%)	31 (47.7%)	34 (52.3%)
Education level (n, %)			
• Primary school	61 (70.1%)	32 (52.5%)	29 (47.5%)
• Secondary school	26 (29.9%)	11 (42.3%)	15 (57.7%)
Marital status (n, %)			
• Single	1 (1.1%)	0 (0.0%)	1 (100.0%)
• Married	47 (54.0%)	23 (48.9%)	24 (51.1%)
• Widower	39 (44.8%)	20 (51.3%)	19 (48.7%)
Employment status:			
• Working	22 (25.3%)	8 (36.4%)	14 (63.6%)
• Not working	65 (74.75%)	35 (53.8%)	30 (46.2%)
Comorbidity:			
• Has comorbid	62 (71.3%)	32 (51.6%)	30 (48.4%)
• No comorbid	25 (28.7%)	11 (44.0%)	14 (56.0%)

Table 2: Cognitive Performance Score of Participants at Baseline (N=87)

Variable	All (N=87)	Experimental Group (n=43)	Control Group (n=44)	*p*- value
Mini-Cog Test Score				
Memory	1.55 ± 0.89	1.6 ± 0.8	1.5 ± 1.0	0.585
Clock Drawing Test	0.34 ± 0.76	0.3 ± 0.7	0.4 ± 0.8	0.817

*Chi square test, *p*-value<0.05

Table 3: Participants' Memory Score and CDT Score in Experimental Group (n = 43)

Outcome	From baseline to week 4				From baseline to week 12			
	Improved	Static	Decrease	*p*-value†	Im-proved	Static	Decrease	*p*-value†
Memory score	24 (55.8%)	15 (34.9%)	4 (9.3%)	0.00018	39 (90.7%)	3 (7.0%)	1 (2.3%)	<0.0001
CDT score	8 (18.6%)	34 (79.1%)	1 (2.3%)	0.03906	17 (39.5%)	25 (58.1%)	1 (2.3%)	0.00014958

†Exact binomial sign test comparing the number of participants with **Improved** vs **Decrease** from baseline to the indicated timepoint; **Static** (ties) are excluded from the test. Two-sided *p*-values, *p*-value<0.05

Table 4: Participants' Memory Score and CDT Score in Control Group (n = 44)

Outcome	From baseline to week 4				From baseline to week 12			
	Improved	Static	Decrease	*p*-value†	Improved	Static	Decrease	*p*-value†
Memory score	22 (50.0%)	16 (36.4%)	6 (13.6%)	0.003719	26 (59.1%)	14 (31.8%)	4 (9.1%)	<0.0001
CDT score	7 (15.9%)	33 (75.0%)	4 (9.1%)	0.548828	7 (15.9%)	35 (79.5%)	2 (4.5%)	0.505

†Exact binomial sign test comparing the number of participants with **Improved** vs **Decrease** from baseline to the indicated timepoint; **Static** (ties) are excluded from the test. Two-sided *p*-values, *p*-value<0.05

Comparison of Proportion Improved of Experimental vs Control groups

By week 12 as stated in **Table 5**, participants in the experimental group had significantly higher Mini-Cog memory and CDT scores compared to those in the control group ($p<0.001$). This indicated a moderate to large effect of the intervention, further confirming the efficacy of the structured Aerobic Exercise and Cognitive Activities for Elderly (ACE) program in improving cognitive performance among elderly individuals with MCI.

Table 5: Comparison of Proportion Improved (Experimental vs Control)

Outcome/Time	Experimental Improved	Control Improved	Risk Difference (pp)	Relative Risk	*p*-value (Fisher)
Memory at week 4	24/43 (55.8%)	22/44 (50.0%)	5.8 (-23.1, 33.7)	1.12 (0.75, 1.66)	0.669362
Memory at week 12	39/43 (90.7%)	26/44 (59.1%)	31.6 (6.1, 51.9)	1.53 (1.18, 2.00)	0.00105673
CDT at week 4	8/43 (18.6%)	7/44 (15.9%)	2.7 (-19.6, 24.7)	1.17 (0.46, 2.94)	0.78303
CDT at week 12	17/43 (39.5%)	7/44 (15.9%)	23.6 (-3.0, 46.5)	2.49 (1.15, 5.39)	0.0171146

Notes: "Improved" = improved from baseline; "Not improved" pools Static and Decrease. Fisher's exact test two-sided. RD: absolute percentage-point difference with Newcombe-Wilson 95% CI. RR: Katz 95% CI. *p*-value<0.05

DISCUSSION

The findings of this study provide strong evidence that the Aerobic Exercise and Cognitive Activities for Elderly (ACE) program is effective in enhancing cognitive function among elderly individuals with Mild Cognitive Impairment (MCI). The significant improvements observed in Mini-Cog test includes memory and Clock Drawing Test (CDT) scores within the intervention group suggest that the integration of structured physical exercise and cognitive activities can lead to measurable cognitive benefits. These findings align with previous research that highlights the role of physical and cognitive interventions in promoting neuroplasticity and delaying cognitive decline in elderly populations (17,21).

The control group, on the other hand, exhibited only modest improvements in memory scores, with no significant changes in executive function, reinforcing the necessity of structured intervention programs for cognitive enhancement. The observed between-group differences at week 12 further support the efficacy of the ACE program, as participants in the intervention group demonstrated superior cognitive gains compared to their counterparts in the control group ($p<0.001$).

These findings are consistent with existing literature demonstrating that combined physical and cognitive interventions yield superior cognitive benefits compared to single-modality interventions (18,22). Studies have shown that aerobic exercise improves cerebral perfusion, promotes neurogenesis, and enhances brain-derived neurotrophic factor (BDNF) levels, all of which contribute to improved cognitive function (23,24). Similarly, cognitive activities have been found to reinforce neural pathways and stimulate executive function, particularly in aging populations at risk of dementia (25).

Interestingly, the level of improvement in Mini-Cog memory and CDT scores observed in this study aligns with research conducted in non-Malaysian settings, suggesting that the ACE program could be a universally applicable intervention. However, the study uniquely contributes to the literature by demonstrating the effectiveness of a home-based intervention, which offers a cost-effective and accessible alternative to clinic-based cognitive training programs, particularly for elderly individuals in rural settings.

The observed cognitive benefits in the intervention group can be attributed to several neurophysiological mechanisms. Regular aerobic exercise is known to enhance hippocampal volume and synaptic plasticity, which are critical for memory and learning (26). Additionally, cognitive training has been shown to improve working memory and executive function by activating the prefrontal cortex and reinforcing cognitive reserves (13). The combination of these interventions likely produced synergistic effects, resulting in significant cognitive gains over the 12-week period.

Another plausible explanation for the findings is the engagement hypothesis, which posits that sustained cognitive engagement through structured activities promotes adaptive brain function and reduces the risk of neurodegeneration (12). The ACE program, by incorporating both aerobic exercise and cognitive tasks, effectively provided a multimodal stimulus for cognitive resilience.

Implications for Clinical Practice and Public Health

The results of this study have important implications for clinical practice and community-based dementia prevention strategies. Given that cognitive decline is a major public health concern, particularly in aging populations, scalable interventions like the ACE program can play a crucial role in mitigating the burden of dementia.

From a healthcare perspective, incorporating structured physical and cognitive activities into routine elder care could enhance cognitive resilience and delay the progression of MCI to dementia. The home-based nature of the ACE program also suggests that such interventions can be feasibly implemented in rural and resource-limited settings, where access to specialized cognitive training facilities is often restricted.

Moreover, the study highlights the importance of adherence and compliance in achieving cognitive benefits. Participants with higher adherence rates demonstrated greater cognitive improvements, reinforcing the necessity of sustained engagement in brain-stimulating activities. Future interventions should explore strategies to enhance adherence, such as social support mechanisms and digital reminders, to maximize the impact of cognitive training programs.

CONCLUSION

This study suggests that the Aerobic Exercise and Cognitive Activities for Elderly (ACE) program can be effective in improving cognitive function among elderly individuals with Mild Cognitive Impairment (MCI). The program significantly enhanced memory recall and executive function, emphasizing its potential to delay cognitive decline and reduce dementia risk.

The study highlights the synergistic effects of physical exercise and cognitive training, which promote neuroplasticity and cerebral perfusion. Given the high adherence rate among participants, the home-based intervention is feasible and accessible, especially in rural and resource-limited settings.

From a public health perspective, integrating structured physical and cognitive activities into community-based programs can enhance cognitive resilience and promote brain health. Future research should explore long-term effects, broader implementation, and additional neuropsychological assessments.

Overall, the study supports non-pharmacological interventions as sustainable strategies for maintaining cognitive function and preventing dementia in aging populations.

LIMITATIONS AND FUTURE DIRECTIONS

Despite the promising findings, this study has several limitations. First, the relatively short intervention period (12 weeks) limits the ability to assess long-term cognitive benefits and adherence sustainability. Future research should consider extending the duration of follow-up to determine whether cognitive gains are maintained over time.

Second, while the Mini-Cog and CDT are widely used cognitive assessment tools, they may not capture subtle cognitive changes. The inclusion of more comprehensive neuropsychological assessments, such as the Montreal Cognitive Assessment (MoCA) or functional MRI studies, could provide deeper insights into the neural mechanisms underlying cognitive improvements.

Third, the study primarily focused on a rural elderly population, which may limit the generalizability of findings to urban settings or diverse demographic groups. Future studies should investigate the effectiveness of the ACE program across different cultural and socioeconomic backgrounds.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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AUTHOR CONTRIBUTIONS

ZAMZ: Data collection, data analysis and drafting the manuscript.
NAR: Revised the manuscript critically with intellectual contents and approved the final version of the manuscript.

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