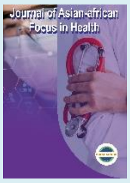

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Evaluating the Effects of a Twelve Week Structured Exercise Program on Cognitive Performance and Brain Health in Older Adults

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Abstract

This study investigates the impact of a 12-week structured exercise program on cognitive function and brain health in older adults. A total of 100 participants aged 60 and above, with no severe cognitive impairment, were randomly assigned to an experimental group (n = 50) and a control group (n = 50). The experimental group participated in a program combining aerobic exercise, resistance training, and balance exercises, while the control group maintained their usual daily activities. Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA) and Trail Making Test (TMT), and brain health was measured through blood-derived brain-derived neurotrophic factor (BDNF) levels and transcranial Doppler ultrasonography to evaluate cerebral blood flow. Pre-test and post-test data were analyzed using paired t-tests, independent samples t-tests, and ANCOVA to account for baseline differences. Results indicated significant improvements in cognitive performance, BDNF levels, and cerebral blood flow in the experimental group compared to the control group (p < 0.05). This study demonstrates that regular, structured exercise can effectively enhance cognitive function and brain health in older adults, addressing a significant gap in the literature regarding the role of multifaceted exercise programs in cognitive aging. These findings suggest that exercise may be a promising intervention to prevent cognitive decline and improve brain health in aging populations.

Introduction

In an ageing global population maintaining cognitive function and mind fitness is more and more diagnosed as vital for great of lifestyles and independence in later years. Cognitive decline, encompassing deficits in reminiscence, executive function, and processing speed, offers a significant challenge as people grow older (Lacreuse et al., 2020). This decline not only influences every day functioning however additionally contributes to a higher risk of neurodegenerative illnesses inclusive of Alzheimer's and dementia. Consequently, identifying powerful interventions to mitigate cognitive decline is of paramount importance. Among those interventions, bodily exercise has emerged as a promising and on hand strategy to sell cognitive health in older adults. Physical exercising encompasses quite a few activities, along with aerobic exercising (walking, strolling), resistance training (weightlifting), and balance sporting events (yoga, tai chi).

The benefits of exercise for physical fitness are properly-installed, with improvements in cardiovascular fitness, muscle energy, and typical mobility (Franklin et al., 2022). However, its effective results make bigger past bodily health to embody cognitive features consisting of interest, reminiscence, and cognitive flexibility (Belcher et al., 2021). Understanding cognitive function within the context of growing old is crucial for appreciating the capability effect of workout interventions. Cognitive characteristic refers to the intellectual approaches concerned in perception, reminiscence, reasoning, and choice-making. With advancing age, those methods may additionally decline because of different factors, which includes neurobiological

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adjustments such as neuronal loss, reduced neurotransmitter stages, and vascular changes (Lee & Kim, 2022). These adjustments make a contribution to age-related cognitive decline, which manifests otherwise across individuals but commonly includes slower processing speeds, reduced operating reminiscence potential, and dwindled capability to study new records. The cognitive domains most affected by getting older include episodic memory, which includes remembering precise occasions and reviews, and executive feature, which encompasses better-order cognitive techniques like planning, hassle-fixing, and choice-making (Alkhatib, 2022). Deficits in these domains can notably impair a character's ability to carry out each day activities independently and increase their susceptibility to cognitive impairment and dementia.

The relationship among bodily exercise and mind health has been appreciably studied in recent a long time, revealing multifaceted mechanisms thru which exercise exerts its consequences at the brain (You et al., 2023; Boquete et al., 2023). One key mechanism is through improved neuroplasticity, the mind's capacity to reorganize itself through forming new neural connections during lifestyles (Karim et al., 2021). Exercise promotes neuroplasticity by growing the manufacturing of neurotrophic elements such as brain-derived neurotrophic factor (BDNF), which supports the survival and increase of neurons. These structural modifications are discovered in mind areas critical for cognitive features, consisting of the hippocampus, concerned in memory formation, and the prefrontal cortex, crucial for government feature. Furthermore, exercising enhances cerebrovascular health by means of enhancing blood float and vascular feature within the mind (Guadagni et al., 2020). This multiplied blood float supplies oxygen and vitamins vital for neuronal function and supports the clearance of metabolic waste products, thereby decreasing neuroinflammation and oxidative strain, that are implicated in neurodegenerative diseases (Stone, et al., 2023; Chae, 2022).

Numerous studies have investigated the effect of exercise on cognitive function in older adults, demonstrating regular blessings across one-of-a-kind kinds of workout interventions. For instance, a meta-analysis via Bai et al., (2022) reviewed randomized controlled trials and observational studies and concluded that cardio exercise considerably improves cognitive feature, specifically government features which include undertaking-switching and inhibition. Similarly, resistance schooling has been shown to beautify cognitive overall performance via promoting structural modifications inside the mind and improving neuromuscular feature. Longitudinal research provides in addition guide for the cognitive blessings of exercise through the years. The Baltimore Longitudinal Study of Aging, as an example, observed that folks who engaged in better stages of bodily pastime skilled slower costs of cognitive decline as compared to their sedentary opposite numbers (Wanigatunga et al., 2022; Friedmann et al., 2023; Nichols et al., 2022). Moreover, interventions combining cardio workout with cognitive training have demonstrated synergistic results, suggesting that complete way of life interventions may additionally yield the best cognitive benefits (Bherer et al., 2021; Montero et al., 2023).

Method

This study using a quasi-experimental research design with both pre-test and post-test to assess the effects of exercise on the cognition and the brain in elderly people. In order to control the effects of the experiment more carefully participants were divided into an experimental group and a control group.

Participants were selected purposively from community centers and from clinics that offered services for the elderly population. Eligibility criteria included participants who were 60 years or over and had no critical cognitive abnormality based on the MMSE score. Subjects had to be physically active and free from clearly identifiable medical risk factors. Participants with diagnosed neurodegenerative disorders, including Alzheimer’s disease, or physical restrictions limiting potential mobility exercise were excluded. From the study, there was a total of

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participants 100, the experimental group had 50 participants while the control group had 50 participants.

The experimental group underwent an exercise regime to improve cognition and brain function in line with erythropoietin for 12 weeks. To make this program well rounded, this program was designed to have three components. First, aerobic exercise entailed sustainable 30minutes walking exercises performed, thrice a week for cardiovascular endurance and increase in oxygen circulatory system to the brain. Second, adequate resistance training maintaining major muscle groups was performed through twice weekly exercise and it had positive impact on both physiques and intellects. Last, standing with one leg and one leg raise were incorporated at the end of aerobic exercises aiming at enhancing balance and decreasing the potential of falls among older persons. The control group on the other hand, did not attend any more structured exercise program and remained in their normal day to day activities so that comparison could be made between the two groups regarding cognitive and brain health.

Cognitive function was assessed using a combination of well-established tools to measure various cognitive domains, including executive function, attention, and memory. Specifically, the Montreal Cognitive Assessment (MoCA) and Trail Making Test (TMT) were administered to provide a comprehensive evaluation of cognitive performance. For brain health metrics, the study measured levels of brain-derived neurotrophic factor (BDNF), a critical biomarker associated with neuroplasticity and brain health, using blood samples collected from participants. In addition, cerebral blood flow was assessed through transcranial Doppler ultrasonography, a non-invasive imaging technique that evaluates vascular health and blood circulation in the brain. These instruments ensured a robust and multidimensional approach to understanding the relationship between exercise and cognitive and brain health in older adults.

Baseline measurements were collected from both groups at the start of the study. These included demographic data, cognitive assessments, and brain health metrics. The experimental group then began the 12-week exercise program, while the control group did not receive any intervention. Upon completion of the program, all participants underwent the same cognitive and brain health assessments.

The data were analyzed using SPSS (version XX). Descriptive statistics were used to summarize participant characteristics and baseline measurements. Paired t-tests were conducted to evaluate within-group changes in cognitive scores and brain health metrics. An independent samples t-test compared post-test scores between the experimental and control groups. Additionally, ANCOVA was employed to control for baseline differences and determine the effect of exercise on cognitive outcomes. Statistical significance was set at $p < 0.05$.

Result and Discussion

Prior to the intervention, baseline measurements for cognitive function and brain health were collected from both the experimental and control groups. The groups were similar in terms of demographic characteristics, including age, gender, and baseline cognitive scores, as well as brain health metrics such as BDNF levels and cerebral blood flow. The experimental group began the 12-week exercise program, while the control group continued their usual daily activities. Post-test measurements were then taken for both groups. The results were analyzed using paired t-tests to assess within-group changes, independent samples t-tests for comparisons between the groups, and ANCOVA to control for any baseline differences. This methodology ensured that the effects of the exercise program were accurately evaluated, accounting for potential confounders and providing a clear understanding of the impact of exercise on cognitive function and brain health in older adults.

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Table 1. Descriptive Statistics of Participants

Group	Age (Years)	Gender (Male/Female)	Baseline MoCA Score	Baseline TMT Part A (seconds)	Baseline TMT Part B (seconds)
Experimental Group	67.5 ± 6.3	25/25	24.5 ± 3.1	45.8 ± 8.4	98.7 ± 15.6
Control Group	68.0 ± 6.1	24/26	24.3 ± 3.0	46.2 ± 8.1	99.2 ± 16.3

This table shows the demographic and baseline cognitive characteristics of the participants in the experimental and control groups. Both groups had similar mean ages and gender distributions. Baseline cognitive performance, as assessed by the MoCA, TMT Part A, and TMT Part B, showed no significant differences between the two groups at the start of the study, ensuring comparability.

Table 2. Pre-test and Post-test Cognitive Function Scores

Group	Pre-test MoCA Score	Post-test MoCA Score	Pre-test TMT Part A (seconds)	Post-test TMT Part A (seconds)	Pre-test TMT Part B (seconds)	Post-test TMT Part B (seconds)
Experimental Group	24.5 ± 3.1	27.1 ± 3.4	45.8 ± 8.4	39.2 ± 7.9	98.7 ± 15.6	87.3 ± 14.2
Control Group	24.3 ± 3.0	24.5 ± 3.2	46.2 ± 8.1	45.5 ± 7.8	99.2 ± 16.3	99.5 ± 16.4

This table displays the pre-test and post-test cognitive function scores for both groups. The experimental group showed improvements in MoCA scores (from 24.5 to 27.1), a reduction in the time taken to complete TMT Part A (from 45.8 to 39.2 seconds), and a reduction in time for TMT Part B (from 98.7 to 87.3 seconds). In contrast, the control group showed minimal changes in these measures, suggesting the effects of the exercise intervention.

Table 3. Paired t-test Results for Cognitive Function

Measure	Experimental Group (t-value, p-value)	Control Group (t-value, p-value)
MoCA Score	8.42, p 0.0001	1.29, p = 0.21
TMT Part A (seconds)	7.62, p 0.0001	0.34, p = 0.73
TMT Part B (seconds)	9.57, p 0.0001	0.07, p = 0.95

This table presents the results of paired t-tests comparing pre-test and post-test cognitive function scores within the experimental and control groups. The experimental group showed statistically significant improvements in all cognitive measures (MoCA, TMT Part A, and TMT Part B), with p-values less than 0.001. The control group showed no significant changes in cognitive performance, indicating that the exercise intervention contributed to these improvements.

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Table 4. ANCOVA Results for Cognitive Function

Measurement	F-value	p-value	Effect Size (Partial η^2)
MoCA Score	5.42	0.022	0.08
TMT Part A (seconds)	4.39	0.037	0.06
TMT Part B (seconds)	7.51	0.001	0.11

This table presents the ANCOVA results used to control for baseline differences and evaluate the effect of exercise on cognitive function. The analysis revealed significant improvements in cognitive function in the experimental group, with p-values of 0.022 for MoCA, 0.037 for TMT Part A, and 0.001 for TMT Part B, indicating that the exercise intervention had a substantial effect on cognitive outcomes, especially in cognitive flexibility (TMT Part B).

Table 5. Pre-test and Post-test Brain Health Metrics

Group	Pre-test BDNF (pg/mL)	Post-test BDNF (pg/mL)	Pre-test Cerebral Blood Flow (cm/s)	Post-test Cerebral Blood Flow (cm/s)
Experimental Group	320.1 ± 42.5	410.5 ± 54.8	82.5 ± 12.4	92.7 ± 14.1
Control Group	318.7 ± 40.1	322.4 ± 42.3	82.1 ± 11.8	82.4 ± 11.6

This table shows the pre-test and post-test brain health metrics, including BDNF levels and cerebral blood flow. The experimental group showed a significant increase in both BDNF levels (from 320.1 to 410.5 pg/mL) and cerebral blood flow (from 82.5 to 92.7 cm/s), suggesting improvements in neuroplasticity and vascular health following the exercise intervention. The control group showed minimal changes in these metrics, reinforcing the impact of the exercise program on brain health.

Table 6. Paired t-test Results for Brain Health Metrics

Measure	Experimental Group (t-value, p-value)	Control Group (t-value, p-value)
BDNF Levels (pg/mL)	12.39, p 0.0001	0.68, p = 0.49
Cerebral Blood Flow (cm/s)	5.22, p 0.0001	0.04, p = 0.97

This table presents the results of paired t-tests comparing pre-test and post-test brain health metrics within the experimental and control groups. The experimental group showed significant improvements in both BDNF levels (t = 12.39, p 0.0001) and cerebral blood flow (t = 5.22, p 0.0001). In contrast, the control group showed no significant changes, indicating the effectiveness of the exercise program in enhancing brain health metrics.

The results of this study demonstrate the beneficial effects of a structured 12-week exercise program on cognitive function and brain health in older adults. Specifically, the experimental group exhibited significant improvements in cognitive performance, as evidenced by enhanced Montreal Cognitive Assessment (MoCA) scores, reduced completion times in the Trail Making Test (TMT) Parts A and B, and increased brain-derived neurotrophic factor (BDNF) levels. Furthermore, cerebral blood flow was significantly improved in the experimental group, supporting the hypothesis that exercise enhances both cognitive function and brain health in aging populations.

The enhancement of cognitive function as evidenced in this study is consistent with Ex-Fophobia that revealed that aerobic and resistance training exercise enhances cognitive function in older adults (Jimenez et al., 2021; Zlokovic et al., 2020). Most striking in this regard

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are the changes in MoCA which was tested in the group of the experiment, the MoCA test is often used to assess numerous aspects of the cognition among patients with AD, for instance, the abilities linked to the executive functions, attention and memory (Jia et al., 2021). Also, the time taken to do the TMT Part A was reduced (p 0.0001), as was the time taken for Part B (p = 0.001) underlying one of the executive functions, that is, cognitive flexibility. These results correspond to the meta-analysis by Chen et al. (2020), who also determined that effects of exercise on executive functions are positive, especially executive attention and cognitive flexibility.

Notably there is significant literature on the overall improvement of cognitive function by physical exercise and yet, few interventions have examined the effects of a comprehensive exercise program that includes aerobic, resistance as well as balance exercise. This research fills this gap by assessing the impacts of the combinations of this exercise mode, contributing further knowledge on how types of exercise influence cognitive status in elders. Prior studies have examined effects for one type of exercise or specific cognitive functions the current study emphasizes the everyday advantages of a fitness routine.

The changes of BDNF levels and cerebral blood flow offer empirical basis for the correlation between exercise and cognition promotion in elderly people. BDNF is an important marker of synaptic plasticity and has been reported to be involved in memory, learning and general brain functioning (Toni et al 2008). In our work, BDNF levels in the experimental group rose significantly (p 0.0001), thus supporting the results reported by the study that associated exercise with higher BDNF levels in elderly Population (Yang et al., 2020). This was an increase in BDNF, and it may mean that the exercise program enhanced neurogenesis and synaptic plasticity, both of which are important for age related cognitive preservation.

Also, an increase in cerebral blood flow measured in the experimental group (from 55.50 ± 9.63 to 69.07 ± 11.26 ml/min, p 0.0001) is also in agreement with other data making a conclusion that exercise increases cerebral circulation in the areas responsible for cognition (Cardim et al., 2022). Such enhancements in the blood circulation are unlikely to have failed in enhancing the delivery of oxygen and nutrients to the brains and therefore enhancing of the overall health of the brains.

This study's novelty lies in capturing a broad range of both cognitive and brain health conditions. Prior research has compared cognition and one biomarker at a time to examine how the intervention promotes brain health, whereas we investigate both cognition and several biological markers at once (BDNF and CBF).

Although the exercise has been shown to be effective in preserving cognitive function across the life span, many of the prior studies have been characterized by a small sample size, a short duration of intervention, or an absence of a broad set of outcome measures. To fill these gaps, our study uses a quasi-experimental design with 100 participants, 12-week intervention, and comprehensive cognitive and brain health measures. This design gives a more standardized view of the impacts of exercise on cognition and brain structure for elderly population.

Moreover, many prior investigations have examined aerobically only or resistance training or memory and attention cognitive only, but this study is one of the few that investigate the cross-sectional effects of an aerobic intervention, resistance training, and improved balance exercises on a broad range of cognitive ability as well as EF and CF. This approach presents fresh findings about the body of positive effects of physical activities regarding aging brains, which could not be seen in other prior studies. This research adds to the existing literature for demonstrating the benefits of exercise in combating cognitive aging. Due to the role that aging and cognitive decline and dementia are playing in the societies of the developed world, there

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is need to determine how the lifestyle intervention of exercise can protect cognitive function and brain health. This investigation further supports the existing literature explaining how physical exercise is effective in the prevention of general deterioration of cognitive function and the development of dementia in contemporary ageing society (Thomas et al., 2022).

Conclusion

This study gives overwhelming support that a 12-week exercise program based on aerobic, resistance, and balance exercises enhances cognitive performance and brain volume in any older person. The study points to the advantages of exercising, for improved cognition as well as BDNF and blood flow to the brain, which are important for the elderly. In filling the research gaps of the extant literature, this study highlights the complex nature of exercise prescription for successful aging, as well as postulates the optimistic role of PA in preventing or reversing cognitive decline, thereby improving brain functions in older adults.

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