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Comparative Effects of Aerobic and Breathing Exercises on Neurocognitive Domains Assessed by MoCA in Middle-Aged Adults: An Interventional Study

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ABSTRACT
Introduction: Neurocognitive decline during middle age has been found to affect the quality of life significantly and may lead to neurodegenerative diseases. Although conventional methods to improve neurocognition have already been explored, the role of aerobic and breathing exercises on specific components of neurocognition remains unexplored. **Aim:** The study focused on comparing the effect of aerobic and breathing exercises on all domains of neurocognitive function using MOCA as the primary assessment tool. **Methodology:** Eighty smokers, aged between thirty to fifty years, were randomly assigned to aerobic and breathing groups. **Group A**, an aerobic group consisting of forty smokers, received a structured aerobic exercise intervention, while Group B, a breathing group consisting of forty smokers, participated in a structured breathing exercise program. Both interventions were carried out over five weeks, with each group attending three sessions per week. **Results:** Both Aerobic and breathing groups have significantly improved MoCA scores ($p < 0.0001$). However, the aerobic group demonstrated greater executive and attention function improvement, while the breathing group exhibited more improvement in memory and orientation. This suggests a domain-specific impact of the two interventions. **Conclusion:** Aerobic and breathing exercises significantly improve neurocognitive functions in middle-aged adults, but each has improved neurocognition in different domains. These findings advocate for tailored or combined interventions for optimal cognitive enhancement.

INTRODUCTION:

Middle-aged smokers usually present with a common concern of cognitive decline, often presenting as subtle deficits in executive functioning, attention, orientation, and memory, and may progress to neurodegenerative conditions if unaddressed(Singh-Manoux et al., 2012). Mild cognitive impairment can affect various aspects of life, quality of living, personal productivity, and emotional health. Yet, it is often underdiagnosed and untreated during middle age (Petersen, 2011). The Montreal Cognitive Assessment (MoCA) has been established as a reliable and sensitive screening tool to identify early cognitive deficits across multiple domains (Nasreddine et al., 2005)

Various therapeutic interventions exist, but physical activity and breathing exercises have emerged as non-invasive and cost-effective strategies to improve cognition (Colcombe & Kramer, 2003). Aerobic exercises are known to improve executive functions, working memory, and processing speed. Primarily, this improvement is seen due to increased cerebral perfusion and release of brain-derived neurotrophic factor (BNDF). (Erickson et al., 2011). In the alternative group, more memory and emotional stability are linked to the modulation of the autonomic nervous system (Chetry et al., 2022).

Aerobic and breathing-based interventions activate neural circuits involved in cognitive control, learning, and memory, promoting structural and functional brain adaptations(Voss et al., 2011). Neuroplasticity, the brain's ability to reorganize and form new neural connections, is the basis for these cognitive benefits (Cotman & Berchtold, 2002). Despite these beneficial effects, a dearth of studies has directly compared the effects of these interventions on neurocognitive domains using MOCA in a middle-aged population.

Considering the increasing prevalence of neurocognitive decline in middle-aged smokers. This study was designed to evaluate and compare the effects of aerobic and breathing exercises on neurocognitive performance in middle-aged adults, as assessed by the Montreal Cognitive Assessment (MoCA). The objective is to identify domain-specific cognitive benefits associated with each intervention, thereby informing more tailored and effective cognitive rehabilitation approaches.

MATERIALS AND METHODS:

Study Design and Participants:

This randomized controlled trial was conducted at Manav Rachna International Institute of Research and Studies, Faridabad. 80 Smokers, aged 30–50, with MoCA scores between 18 and 26, were recruited. Exclusion criteria included diagnosed neurological disorders, psychiatric illness, and use of cognitive-enhancing medication.

Ethical Approval and Consent:

The study was prospectively registered with the Clinical Trial Registry of India (CTRI/2024/12/078331) and received ethical approval from the Institutional Ethics Committee (EC/2024-25/049). Each subject acquired written informed consent. Based on previous research, a medium effect size (Cohen's d = 0.5), 80% power, and a significance level of 0.05 were used to determine a sample size of 40 per group. A total of 80 participants were recruited, including 40 smokers in the aerobic group and 40 smokers, age- and gender-matched smokers in the breathing group, all between the ages of 30 and 50 years. Smokers were defined as individuals who had been consuming five or more cigarettes daily for a minimum of three years. Participants with known medical conditions that could affect cognitive function—such as hypertension, diabetes mellitus, cardiovascular diseases, neurological disorders—as well as those with a history of substance abuse (excluding nicotine) or those currently taking medications like beta-blockers or antidepressants, were excluded from the research.

Intervention Protocol:

Here's a simple week-by-week progression table for aerobic exercise duration MHR = 220 – Age, Target HR = [(MHR − Resting HR) × %Intensity] + Resting HR.

The exercise program for the walking group is structured to gradually increase duration and maintain intensity using the Target Heart Rate (THR) formula: **THR = [(MHR − Resting HR) × % Intensity] + Resting HR**. In the first week, participants perform a 5-minute warm-up by walking at 20% of MHR, followed by 20 minutes of walking at 60% MHR, and end with a 5-minute cool-down at 20% MHR. In the second week, the main walking phase is extended to 25 minutes while maintaining the same warm-up and cool-down pattern. The third week increases the main activity to 30 minutes, the fourth week to 35 minutes, and the fifth week to 40 minutes, with warm-up and cool-down remaining at 5 minutes each at low intensity (20% MHR).

For Group B, the breathing protocol begins in the first week with 6 minutes of breathing control, 6 minutes of diaphragmatic breathing, and 6 minutes of combined diaphragmatic and pursed-lip breathing performed in a semi-Fowler’s position. In the second week, the same sequence is practiced in a supine position, while in the third week it is performed standing. The fourth week involves executing the sequence while walking, and in the fifth week, the exercises are done during stair climbing.

RESULTS:

Participant Demographics:

The study included a total of **80 smokers**, divided equally into two groups: **Group A (Aerobic Exercise, n = 40)** and **Group B (Breathing Exercises, n = 40)**. All participants were informed prior to inclusion that the study was interventional in nature. Participants ranged in age from 30 to 50 years. The average age of Group A participants was **36.1±4.3 years**, while Group B participants averaged **36.2±4.4 years**. Mean height was

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164.2±8.1 cm in Group A and **163.8±7.9 cm** in Group B. Average weight in Group A was **63.4±9.2 kg**, compared to **64.1±8.9 kg** in Group B. The mean BMI in Group A was **23.4±2.8 kg/m²,** while Group B had a mean BMI of **23.9±2.7 kg/m².** Detailed demographic data are presented in **Table 1.**

To evaluate the effects of aerobic and breathing exercises on **neurocognitive function, Repeated Measures ANOVA** was performed using the **Montreal Cognitive Assessment (MoCA)** scores. The **time effect** was found to be **highly significant** for all cognitive parameters, indicating improvement post-intervention. However, there were **no significant time × group interactions,** and **no significant differences** were observed between groups, suggesting both interventions were similarly effective.

- The **mean ± SD** of **total MoCA scores** pre-intervention for Group A and Group B were **22.4±1.9** and **22.6±2.1**, respectively. Post-intervention scores increased to **27.1±1.5** in Group A and **26.2±1.8** in Group B. The **time effect** was significant (**p = 0.000**), while **time × group interaction** (**p = 0.250**) and **between-group effect** (**p = 0.935**) were not significant.
- In the **Executive Function** domain, Group A showed a mean improvement from **3.4±1.1 to 4.8±1.0**, while Group B improved from **3.3±1.2 to 4.2±1.1**. Time effect was significant (**p = 0.000**), but both **interaction** (**p = 0.289**) and **group effect** (**p = 0.417**) were non-significant.
- For **Attention**, Group A improved from **4.5±0.9 to 5.7±0.8**, and Group B from **4.4±0.8 to 5.5±0.9**. Again, time effect was significant (**p = 0.000**), while time × group (**p = 0.413**) and between-group difference (**p = 0.692**) were not.
- In the **Memory** domain, pre-intervention scores were **3.1±0.8 (Group A)** and **3.0±0.9 (Group B)**; post-intervention values were **4.0±0.7 (Group A)** and **4.3±0.6 (Group B)**. Time effect was significant (**p = 0.000**), but **no significant difference** was observed for time × group (**p = 0.127**) or between groups (**p = 0.304**).
- The **Orientation** domain improved from **5.2±1.0 to 5.9±0.7** in Group A and **5.3±1.1 to 6.1±0.6** in Group B. Significant change over time (**p = 0.000**) was noted, but no significant differences in interaction (**p = 0.076**) or group comparison (**p = 0.369**).

Table 1: Depict Demographic data

Variable	Group A (Aerobic)	Group B (Breathing)
Age (years)	36.1 ± 4.3	36.2 ± 4.4
Height (cm)	164.2 ± 8.1	163.8 ± 7.9
Weight (kg)	63.4 ± 9.2	64.1 ± 8.9
BMI (kg/m²)	23.4 ± 2.8	23.9 ± 2.7

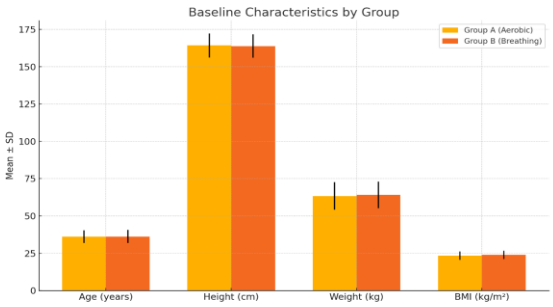

Figure 1:Reperesent Demographic data of Smokers in both groups

Table 2: Domain Wise Comparison Pre-post

Domain	Group A Pre	Group A Post	Group B Pre	Group B Post	Time p-value	Time × Group p	Group p-value
Total MoCA	22.4	27.1	22.6	26.2	0	0.25	0.935
Executive Function	3.4	4.8	3.3	4.2	0	0.289	0.417
Attention	4.5	5.7	4.4	5.5	0	0.413	0.692
Memory	3.1	4	3	4.3	0	0.127	0.304
Orientation	5.2	5.9	5.3	6.1	0	0.076	0.369

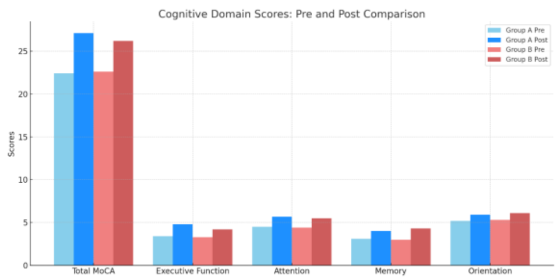

Figure 2: Represent Pre -Post Comparison in all domain

Table 3: Comparison Pre-post MOCA Score
Pre- and Post-Intervention MoCA Scores

Group	Pre (Mean ± SD)	Post (Mean ± SD)	p-value
A	22.4 ± 1.9	27.1 ± 1.5	<0.0001
B	22.6 ± 2.1	26.2 ± 1.8	<0.0001

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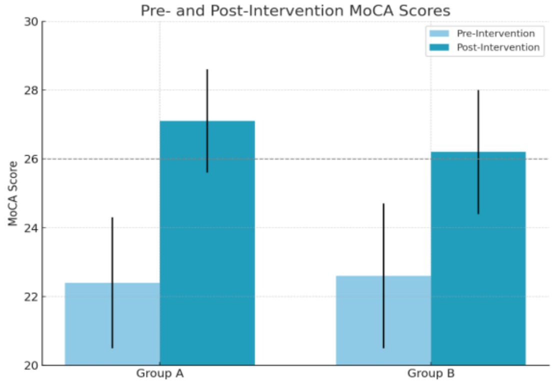

Figure 3: Represent Pre -Post Comparison of MOCA

Table 4: Comparison domain wise qualitative

Domain	Group A Improvement	Group B Improvement
Executive Function	↑↑	↑
Attention	↑↑	↑
Memory	↑	↑↑
Orientation	↑	↑↑

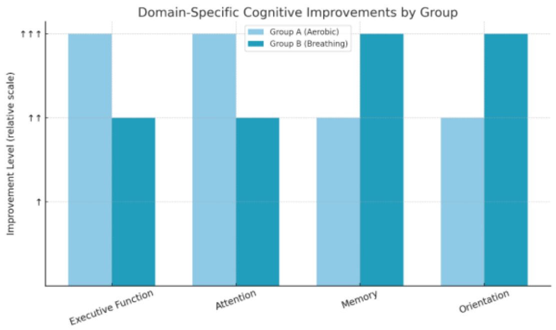

Figure 4: Comparison domain wise qualitative

DISCUSSION:

Both aerobic exercise and structured breathing exercises led to significant improvements across all cognitive domains as measured by MoCA scores, with no significant differences between the interventions. This suggests that both modalities are effective in enhancing cognitive function among smokers.

Aerobic Exercise and Cognitive Enhancement:

Aerobic exercise is widely recognized for its positive impact on brain health. Regular aerobic activity leads to increased levels of brain-derived neurotrophic factor (BDNF), which supports neuroplasticity, synaptic growth, and neurogenesis—particularly within regions such as the hippocampus and prefrontal cortex that are critical for memory and executive function (Oyovwi et al., 2025; Wikipedia, 2025). Additionally, consistent aerobic exercise has been associated with increased gray matter volume and improved cognitive control, attention, working memory, and processing speed (Wikipedia, 2025; Sports Medicine-Open, 2025). Further, aerobic activity enhances cerebral blood flow, delivering oxygen and nutrients to the brain, which supports neuronal health and function (Time, 2017).

Breathing Exercises and Cognitive Function:

Structured breathing techniques, such as diaphragmatic and pursed-lip breathing, help activate the parasympathetic nervous system, reducing stress and enhancing mental clarity and attention (Verywell Health, 2024). Empirical studies show diaphragmatic breathing significantly improves sustained attention while reducing cortisol levels and negative affect (Saón et al., 2017). Improved respiratory function and autonomic balance through deep breathing may underpin these cognitive gains (Verywell Health, 2024).

Similar Efficacy via Different Mechanisms:

Although both aerobic and breathing interventions yielded comparable cognitive improvements over time, their mechanisms likely differ. Aerobic exercise primarily facilitates neurocognitive enhancement through increased neurotrophin expression and structural brain changes, whereas breathing exercises appear to leverage autonomic modulation and stress reduction to enhance cognitive performance. This finding aligns with literature suggesting multiple physiologically distinct pathways can support cognitive improvement (Verywell Health, 2024; Oyovwi et al., 2025).

LIMITATIONS:

- Limited sample size restricts broader generalizability.
- Lack of a long-term follow-up means sustained effects remain unknown.
- Cognitive domain scores were not independently subscored in MoCA.

RECOMMENDATIONS:

- Future studies should examine combined aerobic-breathing protocols.
- Use of neuroimaging (e.g., fMRI, EEG) may clarify mechanisms.
- A longer intervention and follow-up period would provide deeper insights.

CONCLUSION:

Both aerobic and breathing exercises independently improve neurocognitive function in middle-aged adults. Aerobic training is particularly effective for executive function and attention, while breathing techniques enhance memory and orientation. A holistic program incorporating both may maximize cognitive health.

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REFERENCES

1. Chetry D., Telles S., Mahadevan J., Prasoon K., Gandharva K., Agrawal M., Balkrishna A., et al. A comparison of practice guidelines for yoga breathing from the traditional texts and pubmed-indexed research. *International Journal of Yoga Therapy*. *2022;32*:17.
2. Colcombe S., Kramer A. F. Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological science*. 2003;*14*(2):125-130.
3. Cotman C. W., Berchtold N. C. Exercise: a behavioral intervention to enhance brain health and plasticity. *Trends in neurosciences*. 2002;*25*(6):295-301.
4. Erickson K. I., Voss M. W., Prakash R. S., Basak C., Szabo A., Chaddock L., Kim J. S., Heo S., Alves H., White S. M., et al. Exercise training increases size of hippocampus and improves memory. *Proceedings of the national academy of sciences*. 2011;*108*(7): 3017-3022.
5. Nasreddine Z. S., Phillips N. A., Bédirian V., Charbonneau S., Whitehead V., Collin I., Cummings J. L., Chertkow H., et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*. 2005;*53*(4):695-699.
6. Petersen R. C. Mild cognitive impairment. *New England journal of medicine*. 2011;3*64*(23): 2227-2234.
7. Singh-Manoux A., Kivimaki M., Glymour M. M., Elbaz A., Berr C., Ebmeier K. P., Ferrie J. E., Dugravot A., et al. Timing of onset of cognitive decline: results from Whitehall II prospective cohort study. *Bmj*. 2012;*344*.
8. Voss M. W., Nagamatsu L. S., Liu-Ambrose T., Kramer A. F. Exercise, brain, and cognition across the life span. *Journal of applied physiology*. 2011;*111*(5):1505-1513.
9. Oyovwi D. 2025. *Aerobic exercise, an effective intervention for cognitive impairment* [Review]. *Frontiers in Aging Neuroscience*. (Mechanistic insights into BDNF-mediated neuroplasticity).
10. Wikipedia. 2025. *Neurobiological effects of physical exercise*. Retrieved from Wikimedia. (Effects of aerobic exercise on BDNF, neuroplasticity, brain structure).
11. Sports Medicine-Open. 2025. *Physical activity to counter age-related cognitive decline: Benefits*. (Effects of moderate-intensity aerobic exercise on executive function and memory)
12. Time. (2017, April 26). The simple reason exercise enhances your brain. *Time Magazine*. (Aerobic exercise increases cerebral blood flow and BDNF.
13. Saón S. The effect of diaphragmatic breathing on attention, negative affect, and cortisol responses to stress. *Frontiers in Psychology*. 2017;*8*:874. (Diaphragmatic breathing improves sustained attention and reduces cortisol.
14. Verywell Health. 2024. 8 health benefits of deep breathing (diaphragmatic breathing). *Verywell Health*. Breathing techniques improve concentration via parasympathetic activation.