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Aerobics: an effective exercise to improve cognition in adults with mild cognitive impairment

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Abstract

Introduction. Mild cognitive impairment (MCI) is a transitional stage between normal ageing and dementia, associated with an increased risk of Alzheimer's disease. Research has shown a decreased risk of cognitive impairment with moderate-intensity exercise. Dance aerobics has a positive effect on cognition in old age. A limited body of evidence suggests a link between aerobics and cognitive function in middle-aged adults. To test the effect of 12 weeks of dance aerobics on neurocognitive function in 40–60-year-old adults with MCI.

Methods. A single-blinded randomized controlled trial was conducted on fifty middle-aged individuals from the community in Pune, India, after institutional ethical approval. The participants aged 40–60 was screened for the inclusion and exclusion criteria. They were randomly allocated into group A – aerobics (intervention) and group B – routine care only (control). A structured aerobics protocol was given to group A for 12 weeks with 3 sessions/week. Neurocognitive domains like attention, memory, and executive function were assessed using a Neuropsychological Assessment Battery (NAB) at baseline and 12 weeks of intervention for both groups.

Results. Statistical analysis was done on 50 participants, 25 in each group, with a mean age of 49.6 ± 4.03. The intervention group showed greater improvement in NAB scores where the mean difference in the attention domain (15.5; 95% CI = 12.93 to 18.02; $p < 0.0001$), memory domain (7.24; 95% CI = 5.99 to 8.48; $p < 0.0001$), and executive function (4.7; 95% CI = 3.6 to 5.94; $p < 0.0001$) was significant compared to the control group.

Conclusions. Dance aerobics is a potent way to improve neurocognitive function in middle-aged adults with MCI.

Key words: dance aerobic, neuropsychological assessment battery, mild cognitive impairment

Introduction

Higher brain processes like decision-making, memory, learning, language, attention, processing speed, and executive functions are referred to as cognition [1]. The essential aspect that should be preserved or improved to ensure a healthy and disease-free life are the components of cognition i.e., the capacity for recognizing, conceptualizing, and processing inputs [2].

A longitudinal study confirms that cognitive decline begins in the fourth or fifth decade of age [3]. Due to neuroanatomical changes, the overall brain volume regresses by around 5% every decade after the age of 40 [4]. Mild cognitive impairment (MCI) is considered an intermediate stage between the expected cognitive decline of normal ageing and dementia. The annual rate of conversion from MCI to dementia is around 5% to 15%, and up to 60% of people with MCI develop dementia within 10 years [5]. With increasing age, there is a decline in the ability to maintain general domains of cognition, mainly memory, processing speed, language, and executive functions [6]. These declines can lead to forgetting things and names, missing important appointments, and the slowing of thoughts, thus reducing quality of life. However, a growing and well-researched concept of cognitive neuroplasticity and cognitive reserve helps to convert MCI to normal or prevent decline [7]. Neuroplasticity refers to the physiological ability of the brain to form and strengthen dendritic connections, produce beneficial morphological changes, and increase cognitive reserves [8].

Many systematic reviews and meta-analyses suggest non-pharmacological interventions like a Mediterranean diet, moderate-intensity exercise, engaging in social activities, and computerized cognitive training help promote neuroplasticity [9, 10]. Recent studies suggested that dance interventions are effective in preventing and slowing the advancement of MCI as it is a combination of physical, social, and cognitive activities lowering the risk factors linked to comorbid diseases and aging [11, 12]. It also helps fend off neurodegenerative conditions like dementia and Alzheimer's disease [13].

A majority of the research has focused on cognitive health in the older population, but there is a need to investigate the impact of this form of aerobic intervention on middle-aged adults with MCI, as decline begins as early as the mid-thirties. Hence, the purpose of this study was to explore the effect of structured dance aerobics on cognitive function in middle-aged adults.

Subjects and methods

A single-blinded parallel-group randomized controlled trial was conducted in Pune, India.

Study participants

Screening camps were conducted in various residential areas of Pune city. Individuals aged 40–60 years, male and female, with good English language proficiency, i.e., able to read, write, and understand English well, preferably those who have done their education in English medium and are willing to actively participate, were considered in the study. They were then screened for cognitive function by using the Addenbrooke Cognition Examination Scale-III (ACE-III) Indian

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English version, and those who scored less than 88 were included.

The participants were excluded if they (1) had any neurological conditions like mental retardation, stroke, or spinal cord injury, (2) had uncontrolled hypertension (blood pressure: systolic ≥ 140 mm Hg and diastolic ≥ 90 mm Hg) or any severe cardiac conditions that could interfere with exercise, (3) had musculoskeletal pain and limitation like recent fractures, deformities, or arthralgias, (4) had a BMI > 30, (5) were on an exercise regime within the past six week, (6) were on any medications that can impair or improve cognitive performance, and (7) were involved in other clinical trials.

Written informed consent was obtained from all participants. Each was interviewed for their demographic details. The participants were randomized to receive either the intervention dance aerobic (group A) or control (group B) based on a computer-generated sequence. The researcher who assessed the pre- and post-outcome measures was blinded to the group allocations.

Sample size calculation [14]

The total sample size calculated was 54 (27 per group). Considering an alpha of 0.05, a desired power of 0.80, a mean for memory at 3 months to be 4.6, and an expected standard deviation of change of 8.4.

Outcome measures

Cognitive function was assessed for all participants at baseline and after 12 weeks by using the Neuropsychological Assessment Battery (NAB) developed by Robert A Stern and Travis White, copyrighted by PAR, USA. It is a comprehensive, modular battery constructed to evaluate a broad arrangement of cognitive skills and tasks in adults between 18–97 years. Different modules of the battery are based on the distinct cognitive domains available presently in the English language only. A stimulus book, record forms, and response booklet are included with each module in the battery. Each subtest is assessed, and the score is registered in the record forms for the respective module. The composite score was calculated from the manual of NAB.

Following are the subtests in each of the modules mentioned below:

(a) NAB-Attention Module: it contains tasks like a digit forward test, digit backward test, dots, numbers and letters, driving scenes that assess verbal and auditory attention, working memory, verbal and visual memory, processing speed, and psychomotor speed.

(b) NAB-Memory Module: checks immediate recall, short-delayed recall, long-delayed recall, and long-delayed forced choice recognition while performing the task of List learning, Shape learning,- Story learning, and Daily living memory thus evaluating recall, recognition, verbal fluency, and generativity.

(c) NAB-Executive Function Module: has mazes, judgment, categories, and word generation subtest that gauges the concept of formation, mental flexibility, cognitive responsiveness, generativity, logical organization, and planning.

The validity and reliability of the attention module in NAB is 0.48 and $r = 0.91$, memory is 0.51 and $r = 0.92$, and the executive function domain is 0.46 and $r = 0.86$ [15].

Intervention

The participants in the intervention group (group A) attended a 40-minute aerobic dance session, 3 times a week for 12 weeks. To ensure safety as well as achieve the desired impact, the target heart rate (THR) zone was established initially at 55% of the age-predicted maximal heart rate. Progression was obtained by increasing by 5% every third week to maintain the moderate workout effect. Also, Borg's scale was performed to assess the perceived exertion after every 9th session i.e., 3 weeks. A physiotherapist who was a certified aerobics instructor, taught and supervised the intervention program.

Each session included 10 min of warm-up, 25 min of aerobic dance steps, and 5 min of cool-down.

Dance steps included V box jump, toe touch, hams curls, knee lift, jazz stretch, 1-2-3 kick, lunges, grapevine, Z step, attitude lift, polka, slow clock, step touch full diamond, half jack, hip rock, and heel dig [16]. These steps were synchronized with the verbal count of 8 beats 3 times for 4 sets which eventually progressed by more complex steps and increasing repetitions.

The session was terminated if an individual showed any unusual symptoms like giddiness, profuse sweating, chest discomfort, leg cramps, pounding or throbbing headaches, central or peripheral fatigue, dizziness, etc.

The control group (i.e., no intervention) was told to continue with their regular daily activities, and their occupation, and not get involved in any new form of exercise training.

Results

Ninety-six individuals who had memory loss or other subjective cognitive complaints and expressed interest in this study were screened. Forty-two were disqualified because they failed to meet the aforementioned requirements. Fifty-four participants were randomized to receive either the intervention ($n = 28$) or control ($n = 26$). Four participants dropped out due to poor follow-up, three from the intervention group and one from the control group (Figure 1). Therefore, the data from 50 adults were statistically analysed. Intent to treatment analysis was carried out. From baseline to 12 weeks, a total of 36 dance sessions were offered to the individuals in the intervention group. The median number of sessions attended by patients was 36 (IQR = 34, 36). Every patient attended at least 32 dance sessions. No adverse events were reported or observed. The mean age of the participants was 49.6 (± 4.83) years, the demographic data of participants, along with baseline cognitive parameter matching for both groups, is displayed in Table 1.

Within-group comparison of outcomes

Participants in the intervention group improved significantly in attention, memory, and executive function with p-value < 0.05 after 12 weeks. Also, the control group showed improvement in all 3 domains of cognition, $p < 0.05$ (Table 2).

Between-group comparison of outcomes

NAB for cognition, when compared between both groups, the intervention group showed significant improvements with large effect size in attention ($p < 0.0001$; $\eta^2 = 3.042$), memory ($p < 0.0001$; $\eta^2 = 2.13$), and executive functions ($p = 0.0001$; $\eta^2 = 1.37$) after 12 weeks compared to the controls (Table 3). Out of the three domains of cognition, attention exhibited greater change in both groups with a p-value < 0.0001, and the least change was observed in executive functions (Figure 2).

Male participants showed more improvement in the attention domain with a mean of 19.0 (± 3.9) than females (12.7 ± 6.3)

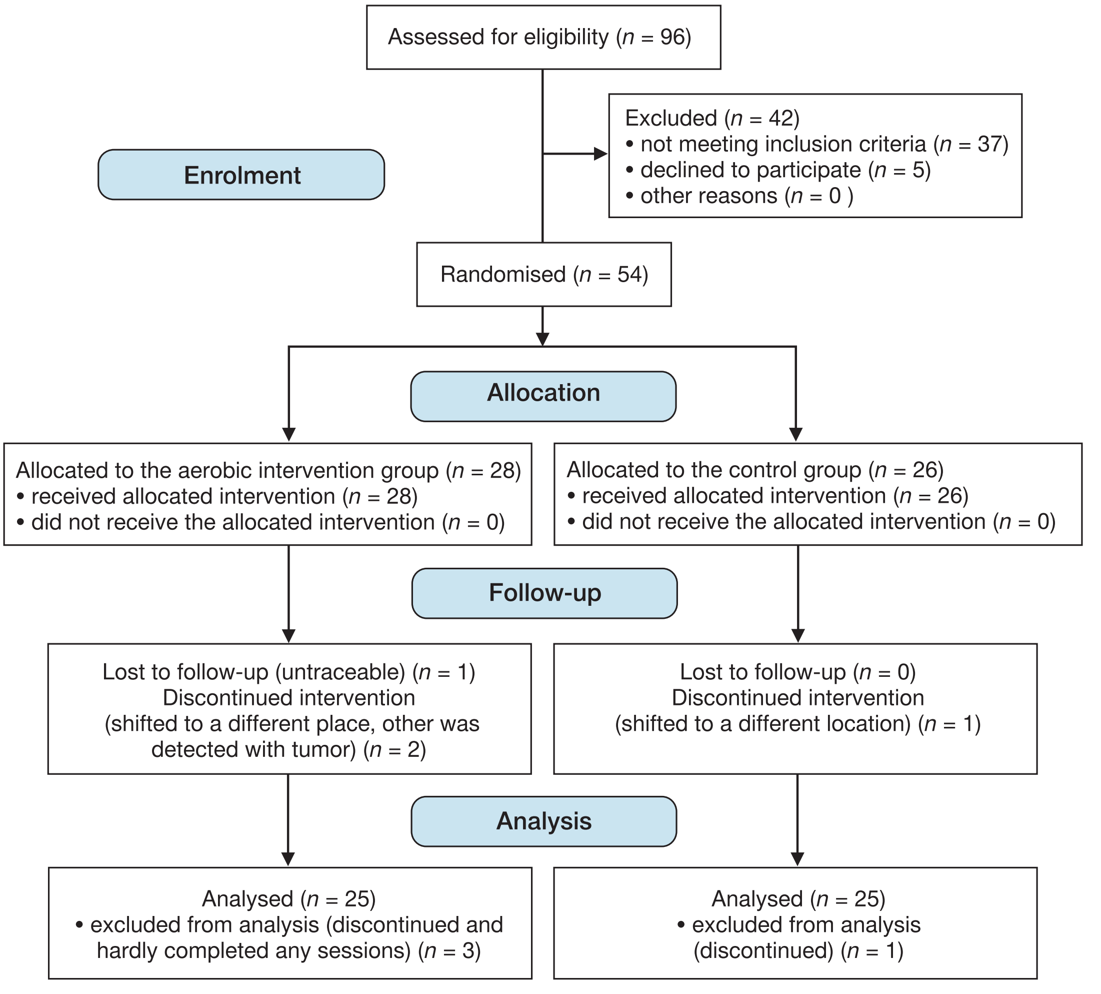

Figure 1. CONSORT flow diagram

Table 1. Demographic and baseline data of participants in both groups

Characteristics	Group A (*n* = 25)	Group B (*n* = 25)
Age (years, mean ± *SD*)	48.64 ± 5.35	50.56 ± 4.14
Gender		
females [*n* (%)]	14 (56)	13 (52)
males [*n* (%)]	11 (44)	12 (48)
Level of education		
schooling [*n* (%)]	7 (28)	8 (32)
graduates [*n* (%)]	12 (48)	13 (52)
post-graduates [*n* (%)]	6 (24)	4 (16)

Baseline characters of the cognitive domain in both groups

Cognitive domains	Group A baseline (mean ± *SD*)	Group B baseline (mean ± *SD*)	Normality
Attention	50.12 ± 10.8	50.6 ± 10.28	*p* = 0.25 accepted
Memory	43 ± 4.59	42.92 ± 4.63	*p* = 0.68 accepted
Executive function	33.8 ± 9.4	33.4 ± 9.3	*p* = 0.82 accepted

Normality was assessed by the Shapiro–Wilk test. Based on it, *t*-tests or Wilcoxon rank tests were used for within-group analysis and independent *t*-tests or Mann–Whitney tests for between-group comparisons. The level of significance was set at $p < 0.05$.

Table 2. Analysis of cognitive parameters for group A and group B

Group	Within group				Between the group			
	baseline mean ± *SD*	post mean ± *SD*	stats	*p*-value	mean diff. ± *SD*	95% CI	*Z*-stats	*p*-value
Attention								
group A	50.12 ± 10.7	65.6 ± 10.14	$Z = –4.34$	< 0.0001^S^	15.48 ± 6.16	12.93, 18.02	$Z = 5.6$	< 0.0001^S^
group B	50.6 ± 10.28	52.6 ± 10.05	$Z = –4.19$	0.0001^S^	1.96 ± 1.24	1.44, 2.47		
Memory								
group A	43.0 ± 4.6	50.24 ±5.27	$t = 11.99$	< 0.0001^S^	7.24 ± 3.01	5.99, 8.48	$Z = 5.64$	< 0.0001^S^
group B	42.92 ± 4.63	45.04 ± 4.26	$Z = –3.85$	< 0.0001^S^	2.12 ± 1.58	1.46, 2.77		
Executive function								
group A	32.84 ± 6.5	37.6 ± 4.8	$Z = –4.18$	< 0.0001^S^	4.7 ± 2.86	3.58, 5.94	$Z = 4.64$	< 0.0001^S^
group B	32.7 ± 8.01	34.04 ± 8.21	$t = 3.31$	< 0.002^S^	1.32 ± 2.0	0.5, 2.14		

S – denotes significant

Table 3. Comparison of cognitive domains in females and males

Cognitive domains	Aerobics			Control		
	female (mean ± *SD*)	male (mean ± *SD*)	*p*-value	female (mean ± *SD*)	male (mean ± *SD*)	*p*-value
Attention	12.71 ± 6.3	19 ± 3.90	$p = 0.008^{S}$	1.77 ± 1.3	2.16 ± 1.2	$p = 0.4^{NS}$
Memory	7.57 ± 3.7	6.81 ± 1.94	$p = 0.54^{NS}$	2.61 ± 0.96	1.58 ± 1.97	$p = 0.1^{NS}$
Executive function	3.79 ± 3.09	6 ± 2.05	$p = 0.053^{NS}$	1.00 ± 1.6	1.66 ± 2.3	$p = 0.41^{NS}$

S – significant, NS – non significant

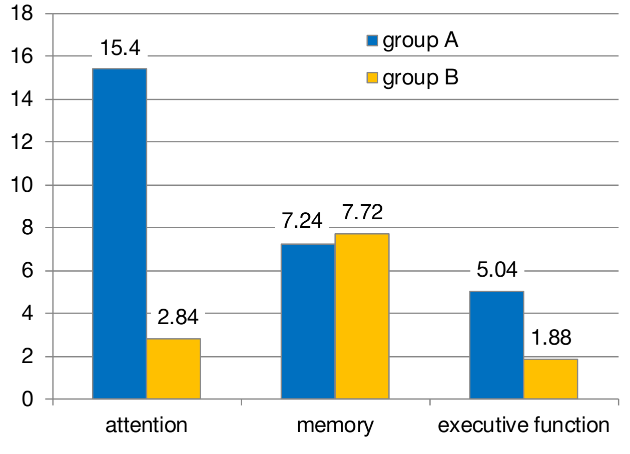

Figure 2. Comparison of mean difference of NAB for cognition in groups A and B

in the aerobics group, which was statistically significant with a *p*-value = 0.008 (Table 3). In the other domains, both genders had similar effects.

Discussion

The study aimed to find the effect of structured dance aerobics performed for 12 weeks on cognitive function in middle-aged adults (40–60 years) with MCI. The results showed that moderate-intensity aerobics significantly improved the cognitive domains of attention, memory, and executive function as compared to controls (no intervention, routine care) with a *p-value* < 0.0001.

The aerobics sessions designed in the study had a series of steps that needed to be performed in a certain sequence. To effectively perform these steps, practice and repetitions were necessary, which involved cognitive abilities such as attention, memory, learning, consciousness, and concentration. This could be the reason why the aerobic group improved their scores on cognitive measures compared to the control group, which is supported by the previous studies by Tsuk et al. [13], Zhu et al. [14], and a meta-analysis of RCT by Chan et al. [17]. A cohort study of 469 dementia-free older adults for five years found that dance aerobics was the only exercise activity compared to walking, stair climbing, biking, and swimming, to significantly reduce the risk of dementia [18].

Several explanations as to how and why dance aerobics improves cognitive function have been suggested. Firstly, dance aerobics performed with moderate intensity shows a positive effect on cognition and brain structure by maintaining cerebrovascular integrity by sustaining blood flow by supplying oxygen and nutrients, increasing brain-derived neurotrophic factor (BDNF), and by synaptogenesis and promoting neural plasticity [19]. Various neuro-imaging studies have shown dance aerobics can slow down the degeneration of fornix and white matter thereby improving attention as well as global cognition [20]. Increases in grey matter volume in the prefrontal, parietal circuits, and temporal regions, and white matter volumes in the corpus callosum genu are associated with executive function and regulation of emotions [21]. Also, an increase in hippocampal and medial temporal lobe volumes showed improved memory [22]. Secondly, the rhythmic steps in dance aerobics induce relaxation and relieve stress, anxiety, and depression, which negatively affect cognition. There is a release of “happy” hormones and endorphins that increase the levels of serotonin and norepinephrine and reduce cortisol secretion, mitigating cognitive decline and improving well-being [23]. It also moderates the effect of many comorbid conditions like diabetes, hypertension, and obesity, which are covariates for cognitive decline [24].

However, certain studies do not support aerobic exercises to improve cognition in certain domains. A meta-analysis of 13 studies reported that dance had positive benefits on cognition in older adults, but the analysis may not support it in comparison to other exercises, particularly for memory and executive function [12]. Similarly, a study analysed the effect of walking to be non-significant on cognitive function in MCI; however, it induces beneficial effects on aerobic capacity [25]. Meta-analyses have demonstrated that although aerobic exercise increases the cognitive function of healthy senior adults, the increase is not significant when compared to the control group [26]. The reasons quoted for no differences seen between the groups were the existence of high heterogeneity across the included studies due to the variation in cognitive measures by subgroups, the nature of intervention lacking sufficient physical and mental challenges, and no clarity in the diagnosis or criteria for MCI. All the studies conducted to find the effects of aerobic exercises like walking, running, treadmill, cycling, tai-chi, and specific dance forms (Latin, Salsa, and Indian classical) have provided inconsistent findings on the cognitive function of elderly people.

The present study demonstrates a considerable improvement in the control group as well, which could be explained by the fact that many participants on their first assessment test experienced performance anxiety, fear of judgment, or varied perceptions related to cognitive decline, which might have led to a subpar result that improved during the second assessment. This may be due to some degree of learning effect, as stated by Richland et al. [27], and/or confidence among maximum participants, which was noticeable. However, in comparison between groups, the cognitive function of the control group showed less significant improvements in the dance aerobics group.

We also observed that males, in comparison to females, showed more improvement in the attention domain, whereas in memory and executive function, both genders performed equally. In India, males are more educated as compared to females and are the primary family earners therefore hold the responsibility of managing finances. They, comparatively, deal with more challenging social perspectives and are more focused. These factors act as a stimulus for cognitive reserve that has the potential for neuronal efficiency, capacity, and flexibility/plasticity [28]. However, certain studies have shown females exceeding males in language learning, verbal abilities, and memory aspects of cognitive domains [29]. The fact that many studies draw different conclusions on whether there is a gender difference in the functions based on small modifications to task designs suggests that differences in strategy and outcome preference drive apparent effects on executive function, rather than a difference in ability between genders [30].

The novelty in the current study is the age of the participants, 40–60 years which has seldom been studied. Very limited literature has been focused on this age group for interventional as well as observational studies. Most of the meta-analyses of RCT place emphasis on the need to use more sensitive assessment tools to measure cognition, this study has incorporated a comprehensive neuropsychological battery to assess cognitive domains in-depth.

Performing aerobic exercise is somewhat challenging for middle-aged adults due to time constraints, job workload, gender bias, etc. As this study was conducted during COVID-19, many participants acknowledged the importance of exercise and showed adherence to exercise. Aerobic dance routines, when performed with synchronized rhythmic counts in an enhanced environment, can be more alluring and joyful.

There are certain aspects like circadian rhythm, the biological clock of the individual, and environmental factors that should be considered while assessing cognition as they influence the results. Limitations of the study include not taking into account the types of MCI, the causative factors of cognitive decline, and the factors influencing cognition, such as comorbid conditions, occupation, socioeconomic status, BMI, lifestyle, etc.

Conclusions

In line with traditional aerobic training, structured dance aerobics is an effective intervention to improve and prevent cognitive decline and has a significant impact on attention, memory, and executive function. Dance is a complex sensorimotor rhythmic activity integrating multiple physical, cognitive, and social elements. Therefore, implementing this form of aerobics can be beneficial for mental health in middle-aged adults with MCI.

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Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Institutional Ethics Committee (approval No.: DYPCPT/IEC/24/2020).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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