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RESEARCH PAPER

Comparison of dance and aerobic exercise on cognition and neuropsychiatric symptoms in sedentary older adults with cognitive impairment

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Key summary points

Aim To investigate the distinctive effects of dance and aerobic exercise on cognitive function, neuropsychiatric symptoms, and functional abilities in older people with cognitive impairment.

Findings The dance intervention significantly improved cognitive function, particularly memory recall. Both dance and aerobic exercise reduced depression and neuropsychiatric symptoms.

Message It is important that dancing be practiced in senior facilities in the same way as aerobic exercise (commonly known as "gymnastique douce" in France) because of its positive effect on cognition.

Abstract

Background To compare the effects of dance and aerobic exercise on cognition and neuropsychiatric symptoms in older people with cognitive impairment.

Methods Twenty-three older adults (mean age = 78 ± 7 years; males: $n = 7$, females: $n = 16$) attending a day care center and diagnosed with cognitive impairment were randomly assigned to a 16-week dance intervention or an aerobic exercise intervention (60 min/week). Cognitive function [Mini-Mental State Examination (MMSE)], neuropsychiatric symptoms [Geriatric Depression Scale-15 (GDS-15), Neuro-Psychiatric Inventory-R (NPI-R)], and physical function [Timed Up and Go (TUG), Activity Daily Living (ADL)] were assessed at baseline and at the end of the intervention. After Borg scale assessment, these two physical activities were performed at similar intensity (60–70% HRR).

Results MMSE score increased significantly after the intervention in the dance group (+ 3.3/+ 14%, $p = 0.03$), especially memory performance (+1/+220%, $p = 0.03$), but not in the aerobic exercise group. GDS-15 and NPI-R decreased significantly after the intervention in both groups ($p < 0.001$). However, no significant effect was found for TUG and ADL.

Conclusion Dance is a cost-effective multimodal intervention that could improve cognition. A low-frequency ecological dance intervention (once per week; 60 min) could improve cognition, especially verbal memory. These results should be further investigated for the practice of dance in facilities for older adults.

Keywords Behavior · Dance · Dementia · Exercise · Randomized controlled trial (RCT)

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Introduction

A relationship has been established between sedentary behavior and cognitive impairment and the risk of developing dementia [1]. Mild Cognitive Impairment (MCI) is considered an intermediate stage between normal cognitive aging and dementia [2]. However, MCI can manifest with a variety of symptoms including memory loss and/or neuropsychiatric symptoms (NPS) such as agitation/aggression, depression, and apathy [3]. Behavioral and psychological symptoms of dementia are common in people with dementia. NPS in Alzheimer disease (AD) are also associated with faster disease progression, earlier admission to long-term care facilities, faster impairment in activities of daily living (ADL), and accelerated deterioration in quality of life [4]. Several studies have shown that healthy aging without dementia or regaining normal cognitive abilities after MCI is possible [5].

To this end, interest in physical exercise as a non-pharmacological treatment for MCI and dementia has increased [6]. Non-pharmacological interventions have been recommended to improve cognition, NPS [7, 8] and ADL [8] in people with MCI and dementia [7, 9]. Aerobic exercises such as gymnastics helped to induce positive changes in age-related hormone levels and reduce depression in dementia [10]. On the other hand, dancing is a cost-effective non-pharmacological [11] multimodal intervention [12] that may show better efficacy on cognition and NPS than classical unimodal interventions such as aerobic exercise [13]. Two recent systematic reviews have shown that moderate or high intensity aerobic exercise training leads to a pronounced effect on global cognition in older adults with MCI or dementia [9, 14]. On the other hand, Verghese [15] proved that dancing is associated with a lower risk of dementia in healthy older adults. In addition, two recent meta-analyses have shown that dancing improves cognitive abilities in people with dementia [16] and MCI and reduces depression in people with MCI or dementia compared with controls although the effect size is small (Cohen's $d = 0.367$) [17]. These results are at odds with those of Wu [11]. Because of the heterogeneity of intervention designs [11] and rarely reviewed evidence, the results of psychological aerobic exercise remain so unclear [18], as do those of dance [11, 17]. Comparison of different types of exercise, studies with rigorous design, long-term follow-up, and comprehensive neuropsychological assessment are needed [9, 11] to overcome the limitations of previous studies, understand the mechanism of exercise and find the most effective type of exercise for disease prevention [11].

In this study, we aimed to determine the differential effects of dance and aerobic exercise on cognitive function and NPS in seniors with cognitive impairment. To our knowledge, this is the first study to examine multiple domains: cognitive, psychological, and functional effects of dance compared to aerobic exercise in older people with cognitive impairment.

Methods

This prospective intervention study was approved by the Research Ethics Committee of the STAPS College of Toulon (announcement number IRB00012476-2021-30-09-127) in accordance with the Declaration of Helsinki [19]. All participants were informed of the protocol using the information sheet and signed the informed consent form. Participants could refuse to participate in this study at any time. The study adhered to the guidelines of CONSORT [20].

Participants

Twenty-five older adults (mean age $= 78 \pm 7$ years; males: $n = 9$, females: $n = 16$) were recruited from the "Aidants Alzheimer 83" day center (France) in 2022. Finally, 11 patients remained in the experimental group (dance group) and 12 patients in the control group (aerobic group; Fig. 1). This day care center for seniors is an associative health facility commonly referred to as EHPAD in France. The goal of this facility is to provide therapeutic cognitive and motor care in groups that respect patients' autonomy. To be admitted to the center, residents must suffer from sedentary lifestyle and memory disorders. The main inclusion criteria were diagnostic classification as MCI according to the Petersen criteria [21]. A probable AD was diagnosed according to the National Institute of Neurological and Communicative Disorders and Stroke and Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA) criteria [22]. Thus, our population is heterogeneous and presents with either MCI or mild dementia. Cognitive impairment was diagnosed, by an occupational therapist, using the Mini-Mental State Examination Score: MMSE GRECO (French version) [23], with a score of 19–30 considered comprehensive. The mean baseline score was (20.7 ± 3.46). Individuals were also selected by a physician based on the designation CDR. The relationship between very mild dementia and MCI is often supported by a total score of 0.5–1 on French's Clinical Dementia Rating Scale (CDR) [24]. Therefore, patients with a score of 0.5 or 1 were included. Participants with mild depression or mild behavioral problems such as anxiety, dysphoria, insomnia, and agitation were also included. In fact, participants with a GDS-15 score of 0–10 at baseline were included, and only those with an NPI severity score of 1 were included. NPI-R severity scores above 1 were excluded so as not to interfere with aerobic and dance sessions. All participants who had good general health and were able to exercise were included in the study. They were also able to understand and perform the dance or aerobic exercises during the workshops offered. All participants provided written informed consent. Participants with behavioral, visual, or hearing impairments that made group activities difficult or dangerous were also excluded. Neurological, cardiovascular, or psychiatric conditions (that discourage physical activity), amputations, or the need for orthopedic devices to maintain a standing position or a positive COVID-19 diagnosis were excluded from the study. Data collection (cognitive, behavioral, and functional assessments) was performed by

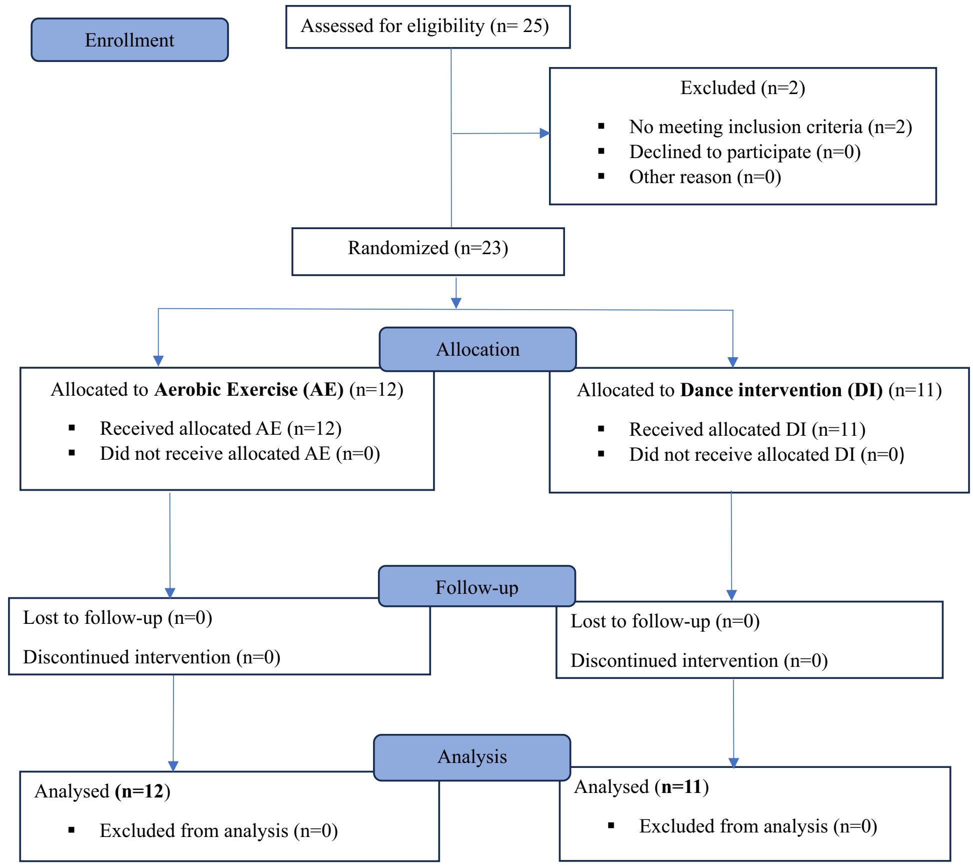

Fig. 1 CONSORT flow diagram. Flow-chart showing inclusion, randomization, and participation throughout the study

the same occupational therapist during the first week before the intervention and the first week after the intervention. This rater was blinded and had no information about the participants' practice.

Assessment protocol

Sedentary assessment

Sedentary activity was assessed with the International Physical Activity Questionnaire—Short Form (IPAQ-SF) [25]. According to the official guidelines of IPAQ-SF [26], data from IPAQ-SF were summed within the three basic items (vigorous intensity, moderate intensity, and walking) to estimate weekly physical activity (MET· min·week^{-1}). In addition, total physical activity (sum of vigorous, moderate, and walking activity) was included. According to the IPAQ scoring protocol, study participants were classified as lowly active (< 600 MET· min·week^{-1}), moderately active (600 MET·min·week^{-1} ≤ physical activity < 3000 MET·min·week^{-1}), and highly active (≥ 3000 MET·min·week^{-1}) [25]. The IPAQ-SF has been shown to be a valid tool for assessing physical activity in older adults according to Tran [27]. In this study, the IPAQ-SF was administered in the form of face-to-face interviews with patients by the facility neuropsychologist. A French validated version was used [28].

Cognitive measures

The Mini-Mental State Examination (MMSE) is used to assess general cognitive function. It tests orientation, immediate and short-term memory, attention and calculation, language, and praxis. There are the following cutoffs: severe cognitive impairment—1 to 9 points; moderate cognitive impairment—10 to 18 points; mild cognitive impairment—19 to 24 points; and normal cognitive status—25 to 30 points. The validity of the test is considered good. A French validated version was used [23].

All our participants were scored using the CDR. The participants who scored less than 0 (cognitively normal group), 0.5 points (questionable MCI groups) or 1 point (MCI groups) were included [24].

Psychological and behavioral measures

The Geriatric Depression Scale-15 (GDS-15) is a brief 15-item instrument specifically designed to assess depression in geriatric populations. The items require a yes/no response. This dichotomous response format (yes/no) facilitates implementation. According to conventional GDS-15 theory, a score of five positive items indicates mild depression, whereas a score of 10 positive items indicates moderate to severe depression, so a clinical examination is recommended to confirm the diagnosis. Since GDS-15 is a self-report scale, patients must be able to complete the questionnaire on their own. In addition, GDS-15 can detect depression in older people with mild to moderate dementia and physical illness. GDS-15 (Geriatric Depression Scale-15) is a reliable and valid instrument for measuring depression in older patients. A validated French version was used [29].

The Neuropsychiatric Inventory Questionnaire (NPI-Q) is a commonly used scale to assess NPS in dementia. The purpose of the NPI-Reduced (NPI-R) is to collect information about the presence, severity, and impact of behavioral disturbances in patients with AD or other neurocognitive disorders. It is a caregiver-relevant instrument that assesses the possible presence of 12 symptoms in dementia, including delusions, hallucinations, agitation/aggression, dysphoria/depression, anxiety, euphoria/elation, apathy/indifference, disinhibition, irritability/lability, deviant motor behavior, nocturnal behavior disorders, and appetite/eating disorders. The NPI-Q considers only the severity of the NPS and the level of caregiver distress. The severity scale includes scores from 1 to 3 (1 = mild; 2 = moderate; and 3 = severe), and the caregiver distress rating scale includes scores from 0 to 5 (0 = no distress; 1 = mild distress; 2 = mild distress; 3 = moderate distress; 4 = severe distress; and 5 = extreme distress). The advantage of the NPI-R is that the caregiver receives a self-completed questionnaire with complete instructions prior to the interview and that the caregiver only assesses the severity of psychobehavioral symptoms. The severity scale has been shown to correlate more strongly with caregiver distress and to be more clinically relevant than the symptom frequency rating. A validated French version was used [30].

Physical function evaluation

The Timed Up and Go test (TUG) measures the time in seconds it takes a subject to get up from a chair, walk 3 m, turn around, walk back to the chair, and sit down. A cutoff value of 12 s has been proposed for the TUG-score to distinguish between falls and non-falls in community-dwelling older people. TUG showed good sensitivity. This test is used to measure mobility, with lower TUG values indicating better mobility. A French version was used [31].

The Activity Daily Living (ADL) assesses total functional activity in the domains of (1) bathing, (2) dressing, (3) going to toilet, (4) transfer (movement), (5) continence, and (6) feeding. This is one of the defining characteristics of MCI that distinguishes it from mild dementia. MCI is a test of "essentially intact" ADLs. A validated French version was used [32].

Intervention

Twenty-three participants were randomly divided into two groups, a dance group ($n = 11$) and an aerobic exercise group ($n = 12$). Each group completed 4 months of training. The frequency of training was 1 session per week. Each session lasted 60 min. Exercise intensity was measured according to the Borg scale and was reported by both groups to be 60–70%HRR [33]. Sessions were conducted by two adapted physical activity specialists. An occupational therapist measured assessment scores at baseline and after 16 weeks of dance and aerobic training in the same order. Medication use was monitored and remained stable throughout the procedure.

Dance intervention

At the beginning of the session, participants completed a 10-min warm-up in the form of dance movements from the head to the lower limbs, which were choreographed step by step (learning by imitation). During the warm-up, participants were asked to generate laughter and smiles through mime, and then transitioned from joking to spontaneous laughter. They also played with musical instruments such as maracas and tambourines to develop the concept of rhythm. Breathing exercises were offered to the rhythm of the music. The main part of the session consisted of a 30-min improvised dance. With the help of the trainers, the participants were gradually offered exercises in which they could move freely until they arrived at an improvisation with a musical sequence of 30 s to 1 min. The music that accompanied the dance sessions was mainly from the 1980s and was complemented by tango, rock 'n' roll, and jazz. At the end of the session, a cold warm-up was performed by singing and some diaphragmatic breathing exercises or a relaxation exercise.

Aerobic exercise intervention

The duration of the aerobic session was 60 min. The session consisted of an approximately 10-min warm-up in which residents formed a circle, verbalized their daily form, and performed deep diaphragmatic breathing and movement analytic exercises. This was followed by a session of about 30 min consisting of several workshops aimed at strengthening muscles by using weights, stretching with elastic bands, training coordination by grasping the ball with both hands, improving agility by kicking in an ascending rhythm and dribbling and playing the ball with both hands, and improving balance by walking straight ahead or through an obstacle course (straddles and slalom) or with parachutes. Often two opposing groups are formed to play with the ball. Finally, in a third phase, one or more quieter activities are proposed to gradually reduce the intensity of the physical work and the attention demand (e.g., a breathing or relaxation exercise) and return to a rhythm as before the session (about 10 min). At the end of the session, there is also an exchange with the participants to get their feedback and impressions of the session, verbalize them and appeal to their memory. As in the dance sessions, the music that accompanied the aerobic sessions was mainly taken from the 80s, complemented by tango, rock 'n' roll and jazz.

Statistical analysis

Values are expressed as means ± standard deviations. Statistical analysis was performed using Statistica 6.1. Normality of distributions was tested using the Shapiro–Wilk test. Descriptive statistics were calculated to determine the basic sociodemographic data of the groups. In case of normal distribution of the variables, two-way analysis of variance with repeated measures (ANOVA) was used to compare the scores of cognitive, psychological, behavioral, and physical functions between the groups (dance group versus aerobic group) at the beginning and at the end of the training program (pre versus post). Post hoc comparisons were performed using the Scheffe test. In the absence of a normal distribution, comparisons were made using a nonparametric univariate analysis (Friedman test).

Effect sizes were calculated using partial eta squared ($\eta 2p$) and Cohen's d. A significance level of 5% was set for all statistical analyses.

Results

The mean adherence in dance and aerobic exercise were 86.7% and 86.4%, respectively, and the mean attrition in each group was 0%. As described in Table 1, at baseline, there were no significant differences between groups in sociodemographic and clinical characteristics at baseline, except for schooling and BMI. The dance group had higher schooling than the aerobic exercise group ($p=0.03$). The latter had a higher BMI than the dance group ($p=0.01$).

A main effect of time was observed for MMSE ($p=0.048$, $\eta 2p=0.17$), NPI ($p<0.001$, $\eta 2p=0.56$) and GDS-15 ($p<0.001$, $\eta 2p=0.75$) independently of the two groups. These parameters improved after the intervention (MMSE: +7%, NPI: -34%, GDS-15: -54%, Table 2). However, a significant interaction effect was observed only for the MMSE score. Figure 2 illustrates this interaction effect. Indeed, the MMSE score increased significantly after the intervention in the dance group (+3.3/+14%, $p=0.03$, $d=1.04$), while this parameter did not change significantly in the aerobic group. Moreover, the analyzed MMSE domains showed a significant improvement in memory performance (recall) only in the dance group after the intervention (+1/+220%, $p=0.03$, $d=0.95$; Fig. 3). The other domains of the MMSE did not change significantly in either group. A main effect of group was observed only for NPI independent of time ($p=0.006$, $\eta 2p=0.31$). The NPI was higher in the aerobic group (3.4 ± 1.4) than in the dance group (1.6 ± 1.2). No significant main effect of group, main effect of time, and interactions were found for TUG (time and score) and ADL.

Table 1 Clinical and sociodemographic outcomes at baseline for the dance and aerobic exercise groups

	Dance group ($n=11$)	Aerobic exercise group ($n=12$)
Age (years)	79.8 ± 7.7	77.2 ± 5.3
Men/women (frequencies)	2/9	5/7
Schooling (years)	6.5	3.2*
BMI (kg.m^{-2})	23.9 ± 2.1	26.3 ± 3.5*
Hypertension (frequencies)	5/11	5/12
Falling (frequencies)	2/11	9/12
CDR	0.5 ± 0.4	0.6 ± 0.4
MMSE (score/30)	20.1 ± 3.5	21.2 ± 3.5
IPAQ-SF (MET·min·week^{-1})	425	475

Data presented as mean ± SD

MCI Mild Cognitive Impairment, *BMI* Body Mass Index, *CDR* Clinical Dementia Rating, *MMSE* Mini-Mental State Examination, *IPAQ-SF* International Physical Activity Questionnaire-Short Form (score: MET·min·week^{-1})

*$p<0.05$ significant difference between dance group and aerobic exercise group

Discussion

The purpose of this study was to investigate the effects of different types of exercise (dance and aerobic) on cognitive, psychological, and physical functioning, as well as performance in daily life, in sedentary older adults with cognitive impairment. Participants attended the "Aidants Alzheimer 83" day center (France) 2 days per week. Both the dance and aerobic exercise groups were sedentary and had low levels of physical activity. There was high adherence to both programs. The mean attrition in each group was 0%. The mean adherence in dance and aerobic exercise were 86.7% and 86.4%, respectively. Adherence is the set of conditions (motivation, acceptance, information, etc.) that enable patients to adhere to the program by relying on their participation. Attrition rate measures how many individuals voluntarily or involuntarily discontinue a follow-up. For the

Table 2 Effects of 16 weeks of dance and aerobic exercise intervention on cognition behavioral, psychological states, activity daily living and mobility

	Dance group ($n=11$)		Aerobic exercise group ($n=12$)	
	Pre	Post	Pre	Post
MMSE	20.1 ± 3.5	**23.3 ± 3.8***	21.2 ± 3.5	21.1 ± 4.6
Orientation	6.4 ± 1.8	8.1 ± 2.3	6.9 ± 2.2	7.4 ± 2.2
Registration	3 ± 0	3 ± 0	3.2 ± 0.8	2.7 ± 0.8
Attention and calculation	2.3 ± 1.6	2.8 ± 1.7	2.6 ± 1.7	2.6 ± 1.5
Recall	0.4 ± 0.7	**1.4 ± 1.1***	1.2 ± 1.4	0.8 ± 0.9
Language	7.1 ± 0.9	7.4 ± 0.8	7 ± 0.9	6.9 ± 1
Constructive praxis	0.5 ± 0.5	0.57 ± 0.5	0.5 ± 0.5	0.7 ± 0.5
GDS-15	6.5 ± 1.7	2.5 ± 1.8	8.1 ± 2.6	4.1 ± 2.9
NPI	2.5 ± 1.6	1.6 ± 1.2	5.1 ± 2.5	3.4 ± 1.4
TUG-score	− 2.5 ± 2.3	− 2.1 ± 2.1	− 2.6 ± 2.7	− 1.3 ± 1.1
TUG-time	13.6 ± 4.2	11.7 ± 3.8	15.4 ± 6.8	13.5 ± 6.0
ADL	0.6 ± 0.8	0.7 ± 1.0	1.3 ± 1.1	1.3 ± 1.1

Values are displayed by means ± standard deviation

MMSE Mini-Mental State Examination, *GDS-15* Geriatric Depression Scale, *NPI* Neuropsychiatric Inventory, *TUG* timed up and go, *ADL* activity daily living

*$p<0.05$ significant difference between dance group and aerobic exercise group

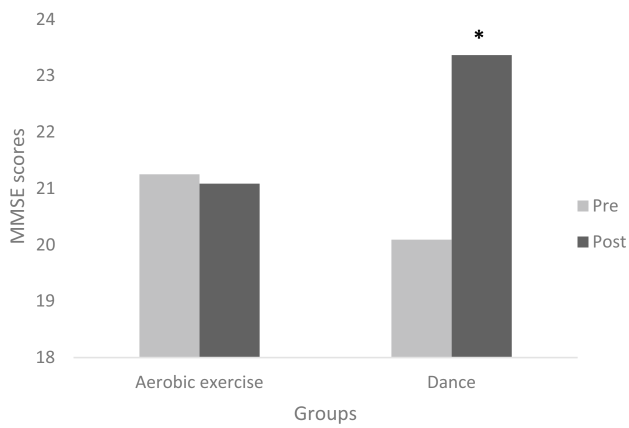

Fig. 2 Effects of a 16-week intervention of dance and aerobic exercise on global cognitive function after 16 weeks of intervention. *MMSE* Mini-Mental State Examination. Data presented as mean ± SD. *$p<0.05$ significant difference from pre-intervention. Main effect of group not significant, main effect of time $p=0.048$, $\eta^2p=0.17$, interaction group × time $p=0.03$, $\eta^2p=0.20$

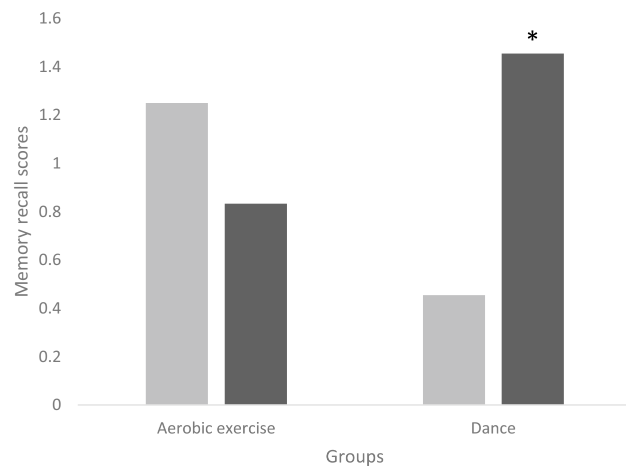

Fig. 3 Effects of 16 weeks of dance and aerobic exercise intervention on memory (MMSE recall domain). *MMSE* Mini-Mental State Examination. Notes: data presented as mean ± SD. Main effect of group $p=0.8$, main effect of time $p=0.36$, interaction group × time $p=0.03$, $\eta^2p=0.20$. Post hoc: *$p<0.05$ significant difference from pre-intervention

overall group, our results showed that the 16-week intervention significantly improved cognition (MMSE: + 7%) and positive mood and improvement in emotional state (NPI: − 34%; GDS: − 54%). However, the dance group improved cognitive function (MMSE), while this parameter did not change in the fitness group. It is important to note that physical function, measured by the TUG and the performance of (ADLs), did not change significantly after the intervention in both groups.

According to our data, 60 min per week of structured and improvisational dance for 16 weeks significantly improved global cognition (MMSE), particularly verbal recall, in older people with cognitive impairment. The mean difference in improvement between the dance group and the aerobic training group was 3.44 in MMSE, corresponding to a mean effect size of 0.9. Therefore, the effect of the dance intervention can be considered clinically relevant.

Similarly, Doi [34] showed that a 40-week dance course of 60 min per week improved not only MMSE scores but also memory scores compared to control groups. Interestingly, our results are consistent with those of these authors, even though our intervention duration is shorter than the duration they used. In a recent meta-analysis, Wu [11] indicated that dance interventions significantly improved global cognition regardless of the duration of the intervention. The moderate intensity of dance used in our study might be responsible for the improvement in memory by activating bilateral frontotemporal entorhinal, anterior cingulate, and para-hippocampal cortex, as shown by Qi [35]. Nevertheless, we did not find cognitive improvements in the aerobic exercise group, although the same intensity was used in both groups. These results are consistent with the "Lifestyle Interventions and Independence for Elders" study [36], which showed that structured physical training of moderate intensity (unimodal training) compared with educational workshops and the group that stretched the upper extremities (multimodal training) did not show improvements in global or specific cognitive functions in sedentary older adults. According to our results, because dancing combines physical, social, emotional, and cognitive stimulation, it has a stronger effect on cognition than unimodal training (aerobic exercise). Our findings are consistent with the results of a meta-analysis that showed that dance interventions have a significant effect on overall cognitive function and especially on memory in MCI [11]. Barnstaple [37] stated that biomechanical movements accompanied by music stimulate the parietal lobes, provide somatosensory input that increases neurotrophic factor, and can improve visuospatial function and global cognition. Positive neuroplasticity was observed in both gray and white matter after long-term (many years) dance training in experienced adult dancers compared to non-dancers. Although they had thinner gray matter, dancers performed better on learning and memory tasks than the non-dancer group showing a link between cognitive decline and atrophy GM often observed in MCI patients transitioning to AD. However, the other components of the MMSE score (orientation, registration, attention and computation, language, and constructive practice) did not differ significantly after the intervention in the dance group.

This lack of effect could be explained by the fact that our dance intervention program was conducted only once a week. Indeed, in MCI and dementia, increased dance duration and/or frequency has been shown to improve cognitive abilities in the visuospatial domain. In this regard, dance interventions have been shown to improve global cognition, as demonstrated by a recent meta-analysis [11]. Our results differ from the study by Ho [38], in which neither DMT nor exercise interventions showed significant effects on cognitive function in older people with mild dementia compared with controls.

In addition, our study did not demonstrate improvement in cognitive function after aerobic exercise intervention. Ho [38] argued two plausible explanations. First, the exercise intervention should last at least 6 months. Second, the intensity must be sufficient to challenge the individual's physical performance and produce cognitive improvement. Third, the frequency of exercise is also important for cognitive improvement. Indeed, the literature has shown that high-frequency aerobic exercise (3t/week for 8 weeks) improves global cognition (MMSE scores) in older adults.

According to our data, there was a significant time effect after both aerobic and dance interventions, which was reflected in improvements in mood and behavior. In fact, we found a significant decrease in NPS, particularly agitation/aggressiveness, apathy/indifference, insomnia, anxiety, and depression. These results suggest that physical activity is generally effective against psychological and behavioral symptoms in dementia and MCI. At baseline, both groups suffered from probable depression; after the intervention, both groups returned to "normal" GDS scores that did not reflect depression. Steichele [39] suggested that aerobic exercise can effectively reduce NPS in older adults with dementia. In the dance group, these results are consistent with the findings of Ho [38] regarding depression and negative mood in older adults with mild dementia and with the findings of Lazarou [40] regarding depression and anxiety in older adults with MCI. We hypothesize that the familiar music that accompanied the aerobic exercise and dance sessions was responsible for these improvements. Several studies have shown that emotional and reward-related brain networks are more activated by familiar music than by unfamiliar music. In our study, we had selected different types of music for both groups, such as tango, jazz, and rock and roll from the 1980s that the participants liked. Participants also chose music that they liked to listen during their fitness and dance sessions. This music was familiar to them and reminded them of their youth. Listening to receptive music compared to silence was also associated with a healthier heart rate and lower blood pressure during stress. Listening to music has also been linked to neurochemical changes associated with a reduction in stress; these may include an increased release of endogenous opioids and dopamine, and a reduction in beta-endorphin and cortisol. Cortical thickness in superior temporal regions has been found to be increased in dancers and musicians compared to controls [41]. As shown above, thinner gray matter does not impair learning and memory. In the present study, participants in the dance group danced and played with various musical instruments such as maracas and tambourines. In addition, at each session, the seated participants were happy that we had come to make them dance. The smiles and joy did not leave their faces throughout the sessions. They danced together and interacted with each other; social relationships were established throughout the group. Ihara [42] showed that older people with dementia who listened to familiar music showed more eye movements, more eye contact, more joy, more engagement, more speech, and less sleep, movement, and dance.

In this context, Ho [38] suggest that dance movement therapy (DMT) and dance have a potential impact on improving quality of life and reducing symptoms such as depression and anxiety, with additional effects on subjective well-being, positive mood, affect, and body image. These areas can be improved not only through dance, but also through the laughter we used in the dance sessions. In the dance group, there was one resident who made the other residents laugh by imitating the way the women walked or danced. All the participants laughed while watching him. As shown by Ko [43], laughter significantly decreased GDS-15 scores in older adults. Wang [17] confirmed in a meta-analysis that dance-based interventions significantly alleviate depression in individuals with MCI and dementia. These results contradict a meta-analysis conducted by Wu [11]. The authors concluded that dance interventions do not have a statistically significant impact on depression in individuals with MCI, which contradicts the literature [11]. Our study shows that both aerobic exercise and dance are effective against anxiety and depression. However, Ho [38] showed that neither the physical exercise group nor the control group showed positive effects in the psychosocial domains (depression and anxiety) compared with the DMT group. These results contradict the results of Widiyawati [10], who recommended aerobic physical training for the management of depression in healthy older adults and older adults with depression [10]. In the aerobic exercise group, we observed that participants enjoyed playing balloon games in the group and using parachutes to train balance, laughing, and cheering each other on, and applauding each other when they won. Strong social interaction and solidarity were found. Huang [44] has shown that Chinese gymnasts have a higher gray matter volume in somatosensory and visuospatial areas than non-gymnasts, and that glial cells such as oligodendrocytes, astrocytes, and microglia are present in addition to neuronal components such as dendrites, axons, and synapses. There is a possibility that changes in the microstructure of these cells affect gray matter volume and function. In fact, individuals with lower left hippocampal gray matter volume experienced more negative mood and rumination in their daily lives. In addition, Wang [45] found significant differences in left and right middle frontal gyrus gray matter volume in patients with mood disorders and suicidality. Our participants expressed their satisfaction and happiness after the sessions. This satisfaction can be seen in their GDS and NPI scores, which decreased significantly (− 49% and − 33%, respectively). The increase in gray matter volume could be the cause of the positive mood, as explained by Wang [45].

Moreover, according to our data, ADL and TUG values remained stable in both the dance and aerobic groups. Regarding ADL, we explain this stability of scores by a good level of autonomy in ADL at baseline. Participants already had good scores close to the maximum before the intervention. Ho [38] showed that short-term, multifaceted dance movement therapy improved instrumental ADL compared with a wait-list control. These results are inconsistent with our findings. Like previous studies, we suggest that this should be a long-term intervention to reduce ADL deterioration with an exercise intervention. Our participants are independent in ADLs and already had good ADL scores before the intervention, which explains why we did not observe improvements in their scores after the intervention. Moreover, neither dance nor aerobic exercise improved mobility, contrary to the findings of many authors such as Charras [46]. These authors pointed out that physical activity, including dance, improves muscle strength and balance, minimizing the risk of falls in the aged people. Charras [46] stated that the shorter execution times of TUG could be due to participants being more familiar and comfortable with the movements of standing up and walking. Another plausible explanation is that several studies have shown that high serum concentrations of inflammatory markers such as IL-6 and TNF-α are associated with lower muscle mass, lower muscle strength, slower walking speed, poorer balance, and lower self-reported functional ability in older adults [42]. Anderson-Hanley [47] demonstrated that 6 months of aerobic and cognitive training were sufficient to improve functional abilities in older adults with MCI, and this improvement was associated with a reduction in the inflammatory cytokine IL-6. In our study, muscle strengthening during aerobic training was performed only in the upper limbs, and it is quite possible that stimulation in lower limb was not sufficient to promote positive adaptations.

Thanks to this study, we could clearly explain the effect of dance and aerobic exercise in older people with cognitive impairment. The results are related to cognition, behavior, and physical function. We demonstrated that dance was more effective than aerobic exercise in improving cognitive functions, particularly verbal memory. These findings provide guidance for health care professionals. Nonetheless, aerobic exercise is the most practiced physical activity in nursing homes, community dwelling, and day care facilities in France. We have shown that a single dance session per week is sufficient to improve cognition. In the study day care center, participants visited the facility only twice a week, on Wednesdays and Saturdays, arriving at 10 a.m. and leaving at 4:30 p.m.; on Wednesdays, they participated in cognitive stimulation workshops, our current intervention: aerobic exercise or dance exercises; and on Saturdays, they had an all-day outing and ate outside. This schedule did not allow us to do dance or aerobic exercises twice a week.

Thus, this study has many limitations. First, randomization resulted in the dance group having a significantly higher school level at baseline than the aerobic group, which is a confounding factor. The second confounding factor is body mass index (BMI), because the aerobic exercise group had a significantly higher body mass index than the dance group. It has been demonstrated, in the literature, that there is an association between the degree of adiposity (inflammation) and cognitive dysfunction in older adults [48]. However, in our study, this association is not clear because the same group (aerobic) that had a higher body mass index was also the one that had a better cognitive score (MMSE) at baseline. Second, the frequency of the intervention was too low (1 time/week) to improve mobility and ADL. Scores for the latter were already good at baseline, reflecting good autonomy in activities of daily living. However, as with TUG, there was no significant improvement in TUG scores, although both groups had an increased risk of falls from the beginning. In fact, a score of ≥ 13.5 s is used as a cutoff point to identify individuals at increased risk of falls in the community [49], our two groups had a high risk of falls at baseline (> 13.5), after the intervention, a slight nonsignificant improvement was observed in both groups, the dance group had a lower risk of falls than the aerobic exercise group, but this improvement was not significant. Therefore, the optimal exercise frequency could be further improved. Third, our relatively small sample size compared to Ho [38], who conducted a RCT with 204 subjects, might affect the generalizability of the results. Fourth, the literature shows that dance movement therapy significantly improves cognitive, memory, and executive functions in MCI patients [35, 50, 51]. To our great regret, due to the conditions imposed by the host structure, we were not able to evaluate the effect of dance on executive functions using the MoCA test. The latter measures executive functions more accurately than the MMSE [52, 53]. We cannot measure this cognitive ability with the MMSE [52]. In future studies, the use of other cognitive instruments such as MoCA and TEA could provide more information in different areas such as reaction time, selective attention, executive functions, and attentional switching.

In conclusion, this longitudinal study shows that a 16-week ecological dance intervention significantly improves global cognition, particularly verbal memory, in older people with cognitive impairment compared with aerobic exercise. Both dance and aerobic exercise improved positive psychological mood. However, dance and aerobic exercise did not improve functional abilities (mobility) or activities of daily living. However, the small sample size and confounding factors, particularly the school level of the dance group, could bias the results. We strongly recommend that similar studies comparing a dance group and an exercise group with a large sample be conducted in the future. The effects of dance on global cognition, particularly verbal memory, also remain unclear. Research into the mechanisms underlying dance, such as inflammation (adiposity), brain plasticity, and neural connections, may, therefore, provide us with further insights. The relationship between depression, cognitive impairment, and/or inflammation has been widely demonstrated in the literature. Our study today showed that depression and cognitive impairment decreased significantly in the dance group, so we wonder if inflammation also decreased systematically. The effect of dance on proinflammatory and anti-inflammatory cytokines in this population has never been studied before and, therefore, could be a potential direction for further research.

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Author contributions SA conceived and designed the research, AK and MG performed the methodology/experiments, AA supervised the experiments and assessments, SA, RB, and OG analyzed the data, SA wrote the manuscript, SS revised the draft, and OG supervised and validated the design, experiments, assessments, and results. All the authors read and approved the manuscript.

Data availability We consent to data sharing.

Declarations

Conflict of interest The authors declare no competing interests. No grant is required.

Ethical approval This prospective intervention study was approved by the Research Ethics Committee at STAPS University of Toulon (IRB00012476-2021-30-09-127), France, in accordance with the Declaration of Helsinki.

Consent to participate All participants provided written informed consent before participating in the study.

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