

Effects of Physical Exercise and Music Therapy on Cognitive Aspects in Tunisian Patients with Mild Alzheimer's Type Dementia

Oussama Gaied Chortane^{1,2}, Imen Ben Amar^{1,2}, Makrem Zghibi³, Yassmin Dhaouadi², Jaouher Hamaidi², Elmotez Magtouf², Riadh Khalifa², Sabri Gaied Chortane²

¹Department of Human and Social Sciences, Higher Institute of Sport and Physical Education of Ksar-Said, University of Manouba, Manouba, Tunisia

²Research Unit Sports Performance, Health & Society, Higher Institute of Sport and Physical Education of Ksar-Said, University of Manouba, Manouba, Tunisia

³Department of Human and Social Sciences, Higher Institute of Sport and Physical Education of Kef, University of Jendouba, Jendouba, Tunisia

Email: oussama.gaeid@gmail.com, imen_benamar21@yahoo.fr, makramezguibimakwiss@yahoo.fr, yassmin.dhaouadi1@gmail.com, Hamaidijaouhar@gmail.com, moetaz.magtouf@gmail.com, riadhkhal@yahoo.fr, sabrigaied1@gmail.com

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Abstract

Aim: The objective of this research is to highlight the effectiveness of physical exercise and music therapy in older patients with Alzheimer's disease (AD).

Methods: Patients with a mild level of AD were included in this study, divided into the therapy group (TG; N = 30, aged 68 ± 3.2 years) and the control group (CG; N=30, aged 65 ± 2.6 years). The therapy group was enrolled in an exercise-training program (walking, resistance and balance exercises) combined with musical therapy for 10 weeks (three sessions of 60 minutes per week). The Control group was instructed to follow their daily rhythm of life (e.g., rest, reading) under the same conditions. The intervention program was enrolled under the supervision of; one psychologist; a neurologist; two music therapists, and two physiotherapists, all belonging to the same hospital unit. After 10 weeks of participation in the combined program, cognitive parameters were improved in the therapy group measured with the Behavior Pathology in Alzheimer Disease (BEHAVE-AD), ($p < 0.05$) for activity disturbance, diurnal rhythm disturbances, anxieties and phobias, affective disturbance. The percentage range of improvements is 1.07% to 2.96%. **Results:** Our results demonstrate that physical exercise combined with music therapy improves cognitive function in patients with Alzheimer's disease. **Conclusions:** Physical exercise and music therapy are beneficial combined treatments for improving life quality in older patients. This approach may be useful to help

patients with a mild level of Alzheimer's disease improve their behavioral and psychological parameters.

Keywords

Alzheimer's Disease, Aged Patients, Physical Exercise, Music Therapy, Cognitive Function

1. Introduction

Alzheimer's disease (AD) is a progressive degenerative disease that involves the central nervous system (CNS). This pathology constitutes a major phenomenon in modern society and usually leads to a marked decrease in orientation, comprehension, memory, thinking, calculation, learning ability, language, and judgment [1]. Therefore, it is characterized by cognitive, mental, and motor disorders in the affected person [2] who, over time, needs assistance and support, especially in advanced disease level [3]. The incidence of AD increases exponentially with age. The estimated number of people living with neurodegenerative dementia exceeds 35.6 million worldwide. This huge number is predicted to double by 2030, and more than triple by 2050. In Tunisia, a North African, Arab, and Muslim country, the percentage of elderly subjects increased from 4.1% in 1956 to 9.6% in 2004 [4]. This changing age structure and the progression of the Tunisian population suffering from Alzheimer's disease affected the occurrence of dementia [5]. Available data on dementia prevalence in Tunisia are obtained from a door-to-door survey undertaken in 2001 between the Neurological Department of Charles Nicolle Hospital Tunis, and the Public Health Institute [6]. Changes in emotions, decreasing in quality of life are generally already present in patients with Alzheimer's disease due to physiological and psychological factors. It is generally known, that most AD patients suffer from psychological and behavioral disorders, such as apathy, isolation, depression, aggression, and gradual withdrawal from activities [7], leading cause of disability in older people, and has a major impact by decreasing life quality, patient well-being, and the capacity to live independently, which requires increasingly complex care assistants [8]. The essential treatment for patients with dementia consists of several parts. It is possible to pharmaceutically stabilize Alzheimer's symptomatology and smooth down its course, but there is no cure or possible way to reverse its evolution. Additionally, there is no best treatment that increases the quality of life definitively in people with Alzheimer's disease [9].

Various non-pharmacological studies, namely in functional neuroimaging, have been used to treat psychological and behavioral disorders in patients with Alzheimer's disease [10] [11]. During the last 10 years, it has been reported that physical activity has a beneficial effect and constitutes an effective solution for preventing neurodegenerative diseases such as Alzheimer [12]. Thus, a great amount of effort and research has been undertaken to understand the physiology of the aging brain,

which is changed by the type of physical activity [13]. According to the American College of Sports Medicine (ACSM) [14], physical exercise contributes to reducing and delaying the progression of chronic diseases, including those associated with the aging process and related to cognitive and motor disorders.

However, several studies have reported the beneficial impacts of exercise as a preventive therapy against Alzheimer's disease [15]. At present, we know that physical exercise decreases the progression of cognitive disorders in older patients, and has a multitude of beneficial effects, including improving motor and cognitive functions, increasing autonomy, and improving life quality for patients with neurodegenerative disease [16] [17]. Other non-pharmaceutical interventions for the prevention of cognitive decline in dementia patients have been used. Scientific reports have described the use of music therapy in patients with Alzheimer's disease to target cognitive impairments [18]. Music therapy is one of the therapies that have proven to be valid for reducing Alzheimer's disease symptoms and even improving the patient's feelings and emotions [19]. Music therapy is a goal-oriented activity in which a therapist works with an individual or a group by using musical expressions to stimulate the brain [20]. Choosing music connected to the individual's personal experience will stimulate memory and intellectual parameters [21], decrease the progression of depression and anxiety, and promote language skills in patients with cognitive disorders [22] [23]. Neurologists suggest using music therapy to enhance and improve patient well-being, increase motor and cognitive functions, and promote social interaction among patients [24] [25].

It is reasonable to hypothesize that a combined program of physical exercise and musical stimulation will improve cognitive function in patients with Alzheimer's disease more than can be achieved separately. The aim of this method is to encourage, motivate patients, allow them to use and discover their remaining abilities and find their lost feelings and expressions, a psychotherapeutic approach to supporting patients suffering from psychological problems. Only three studies have examined the effects of separate physical or cognitive activity training compared to the effects of combined training. Fabre and his colleagues compared aerobic training, mental training, and combined aerobic-mental training for two months among 32 older patients aged 60 - 76 years old. Significant improvements were observed in memory, paired-associate learning, and story memory in the three selected groups. However, the mean difference in memory quotient pre- and post-training was significantly higher in the combined training group compared to the other two groups [26]. The second study investigated the long-term effects of mental, physical, and combination training for 1 year and 5 years in a sample of 375 older patients aged 75 - 93 years old. The extents of the positive impacts in the cognitive training condition and in the combined condition were superior across a range of cognitive outcomes 1 year and after 5 years of training [27]. Most recently, Shatil [28] studied whether combined cognitive training and physical activity training enhanced cognitive parameters more than either training regimen alone. The sample was divided into 4 groups of older patients who

embarked on 4 months of cognitive and mild aerobic training: cognitive, mild aerobic training, a combination of both methods, and book reading sessions. Findings indicated that older patients who engaged in cognitive training (separate or combined training groups) showed significant improvement in cognitive performance compared to older patients who did not engage in cognitive training (the mild aerobic and control book-reading groups). This suggests that the combination of physical exercise and cognitive training is a beneficial method for improving cognitive parameters in older patients with Alzheimer's disease.

The purpose of this study was to analyze and provide scientific evidence with the objective of assessing whether the progression of behavioral and psychological symptoms in patients with Alzheimer's disease can be made more bearable with non-pharmacological treatments, specifically focusing on physical activity and music therapy.

2. Materials and Methods

2.1. Consent

Subjects were informed about the experimental procedure and subsequently signed a written consent form according to the standards of the Committee for Protection of Persons of the University of Monastir (Tunisia). Principles and the guidelines for Good Clinical Practice, and approved by the Local Ethics Committee. Potentially eligible subjects (or their family or legal representative) signed the informed consent form (stating that they did not object) to take part in the project, even though the study does not entail any additional risks (music therapy session, no impairment of physical or psychological integrity).

2.2. Type of Study

The study design corresponded to a controlled and comparative evaluation and conducted over a total duration of 10 weeks.

2.3. Participants

The included patients were residents at the Neurology Department of Monastir Hospital from October 2021 to June 2022. All the patients were residents in the same Neurologic Center at CHU Fatouma Bourguiba of Monastir, and they all suffer from a mild level of AD. Every patient was required to have a baseline Mini-Mental State Examination [29] score between 20 and 25 (Table 1). Patients were diagnosed with Alzheimer's disease according to the International Working Group diagnosis criteria (IGW) [30]. We only recruited patients with mild-stage Alzheimer's disease (Clinical Dementia Rating (CDR) of 0.5 or 1 (very mild-to-mild dementia), who had the full capacity to consent [31]. Sixty-four patients in the age range of 65 - 70 years were recruited in this study, divided into the therapy group (N = 34), and the control group (N = 30). The Control group was instructed to follow their daily rhythm under clinical care (following normal activities only; reading, family visits). In the therapy group, two individuals refused to

Table 1. Characteristics of the Alzheimer’s patients in a control and intervention group.

Characteristics	Overall Population	Control Group	Therapy Group
Patients (N)	60	30	30
Gender		Women 17	15
		Men 13	15
Age (Years)	65 ± 3.0	65 ± 2.6	68 ± 3.2
Body Mass Index (kg/m²)	26 ± 1.5	25 ± 1.3	27 ± 1.1
Higher Education Level	22	10	12
Alcohol Use	31	16	15
Married Statut	51	24	27
Comorbidities	20	10	10
MMSE	20.93 ± 1.4	21.72 ± 2.2	20.84 ± 1.62

participate during the first cognitive evaluation, while one patient was institutionalized at the nursing home, and the caregiver of another showed unavailability to attend the training session with his relative patient. Thus, 30 patients were able to participate in all sessions from the first evaluation to the end of the intervention.

2.4. Inclusion and Exclusion Criteria’s

The following criteria for inclusion were: Mini-Mental State Examination [MMSE], a score between 20 and 25 “indicates a mild level of Alzheimer’s disease”, patients aged 65 to 70 years old; having a normal or corrected-to-normal vision and color perception; no drug treatment during the training protocol; living in medical care environment; being able to walk without technical assistance, and every patient must be accompanied by his relative partner or caregiver. Patients with clinically relevant medical conditions, e.g., heart disease, hypertension or diabetes or a medication that could influence cognitive functioning (e.g., benzodiazepines, sleep aids, or neuroleptics) were excluded from the study.

2.5. Neurocognitive Evaluation

After inclusion in the study, all the patients were rated according to the Behavior Pathology in Alzheimer’s Disease Rating Scale (BEHAVE-AD) [32]. Each subject underwent a clinical examination by a neurologist experienced in the diagnosis of AD, together with a neuropsychologist working in the same Neurology unit where the patient’s residents, and carried out all of the envisaged tests during the entire follow-up period. Before and after the intervention period, the following neuropsychological assessments were administered.

2.5.1. Mini Mental State Examination (MMSE)

The MMSE is the most widely used brief screening measure for patients with

Alzheimer's disease. This test is used to verify the degree of the disease level in patients with cognitive disorders. In the present study, we only selected patients with a mild level of AD. Administration takes 5 - 10 min, and the following domains are evaluated: concentration or working memory; language and praxis; orientation; memory; and attention span [29] (Figure 1).

2.5.2. Behavior Pathology in Alzheimer's Disease (BEHAVE-AD)

The Behavioral Pathology in Alzheimer's Disease Rating Scale was developed to assess common behavioral symptomatology associated with Alzheimer's disease. The scale is composed of 25-items rated on a 4-point scale across 7 categories: Delusions (7 items), Hallucinations (5 items), Activity disturbances (3 items), Aggressiveness (3 items), Sleep-wake disturbances (1 item), Affective disturbances (2 items), and Anxieties and phobias (4 items) [34].

2.6. Physical Exercise Program

Patients in the therapy group participated in an adapted physical program 3 sessions of 60 minutes per week, in a total period of 10 weeks. The objective of this selected program is to improve the quality of life through a bio-psycho-social approach based on adapted and individualized physical exercise as a support for controlling and stimulating mental and physical functions in this elderly population. Physical educators were professional's trainers on adapted physical activity for older patients who held a professional License degree The physical activity program is composed of 3 types of exercises (walking, resistance, and balance). Each session is conducted for 1 hour: 10 minutes of warm-up (walking on a treadmill at 3 km/–1) 20 minutes of walking, muscle building and joint movement, 20 minutes of resistance training for upper and lower body members, and 10 min of stretching.

The first 20 minutes were based on specific walking exercises, with motor athletic parkour within 30 m of walking distance. The parkour area was composed of three lines 10 m apart, indicated with six different colored cones: two red cones

Score	Degree of Impairment	Formal Psychometric Assessment	Day-to Day functioning
25-30	Questionably significant	If clinical signs of cognitive disorders are present, formal assessments of cognition may be valuable.	May have clinically significant but mild deficits. Likely to affect only most demanding activities of daily living.
20-25	Mild	Formal assessment may be helpful to better determine pattern and extent of deficit.	Significant effect. May require some supervision, support and assistance.
10-20	Moderate	Formal assessment may be helpful if there are specific clinical indications.	Clear impairments. May require 24- hour supervision.
0-10	Sever	Patient not likely to be testable.	Marked impairments. Likely to require 24- hour supervision and assistance with ADL.

Figure 1. Illustration of the interpretation of MMSE score results. Mini-mental state: A practical method for grading the cognitive state of patients for the clinician [33].

indicated the first 10 m, two blue cones were used for the second line and two yellow cones for the final line. Participants were encouraged to walk the entire distance of the three lines, touching the two cones of each line on the two sides. The second main 20 minutes were based on resistance and balance exercises, in which patients practiced static and dynamic balance exercises with low to moderate intensity. All resistance and balance exercises were based on the patient's quotidian and daily activities (setting, stand-up, hand and leg movements), utilizing a chair with grips, a softball, and a stick. Resistance and balance exercises were composed of 12 different activities, separated into 3 groups: 1: Thigh resistance exercises; 2: Thigh and abdominal resistance exercises; and 3: Elbow resistance exercises. During all the effort, patients were equipped with a cardiofrequencemeter (Beurer P-100®). We did not realize an effort test, only measuring the target heart rate between 60 and 70% of the maximum theoretical heart rate according to the method of Astrand.

2.7. Music Stimulation

The individual receptive physical activity and music therapy method was used. Every patient participated alone in the session. This may help reduce behavioral and psychological problems such as anxiety, depression, and agitation in patients with Alzheimer's dementia [35]. As with physical educators, music therapists are professionals in dementia diagnosis, with ample experience in mental rehabilitation and working in the psychiatric service of CHU Fatouma Bourguiba of Monastir. The music style was related to the patient's memory (including childhood and adolescence period), after an interview with the patient's relative partner or caregiver. Choosing music connected to the individual's personal experience is a very important detail, it might help to determine the period of their life that has been most frequently affected. However, music was played in harmony with the physical exercises. The therapy group received 30 combined sessions of physical activity and music therapy, each lasting 1 hour, three times a week for a total period of 10 weeks. The music therapist uses a CD player containing the selected songs (Tunisian Traditional music) [35], which are specifically related to the patient's memory and stimulated music for engaging patients in various actions of joy and pleasure [36] [37] [38]. The selected music was composed of two different styles: 25 minutes of Tunisian music and 25 minutes for joy engagement music, sometimes patients had the urge to move and dance in harmony with the music and seemed to enjoy the session, and that was allowed freely [39].

2.8. Procedure

Before starting the session, 5 minutes were needed to verify that the patients were in a resting position and dressed in comfortable clothes, and this was conducted and verified by 4 nurses already taking care of those patients in the same unit with knowledge of dementia symptoms. Together, the physical educators and the music therapists explained the session to the patients that if they could

not continue the session, they could rest and restart again. The combined program was enrolled in the same unit and under the same conditions, supervised by the same staff members, on three separated days (Monday, Wednesday, and Friday), at 10 a.m. after breakfast. **Figure 2** illustrates the design of the study. The presence of relative partners or caregivers is important to assist and support patients during all the exercises. In our study, we used auto-evaluation feedback, and each caregiver or relative partner of the patient was allowed to film the session. This approach requires prior programming of each session and allows the evolution of the content of the patient's activities according to individual progress.

2.9. Data Analysis

All of the randomized patients were included in the intent-to treat Population. An over-all description of each variable considered was drawn up for each group. Quantitative and qualitative data were described in terms of sample size, mean, standard deviation. The normality of data was verified using the Kolmogorov-Smirnov test. The comparability of the 2 groups was verified on the baseline data. Intra-group comparisons were made using the Wilcoxon signed-rank tests because BEHAVE-AD is an ordinal ranking scale. A multivariate analysis was performed by means of ANOVA with repeated measures, in order to study the overall changes in the psychologic parameters during the two visits.

3. Results

The assessments were performed on 30 patients in the control group: mean age (SD) was (65 ± 2.6), and 30 patients in the therapy group: mean age (SD) was (68 ± 3.2). They all suffer from mild type of AD and originate from the same hospital region. There were no statistical differences in age ($p = 0.05$) and gender ($p = 0.046$) between the two groups (**Table 1**). Most of the patients had been stable regarding their dementia during all the follow-up period. The most prevalent symptoms were activity disturbances, diurnal rhythm disturbances, anxieties and phobias, and affective disturbance. However, we did not find significant improvements for the rest of cognitive items.

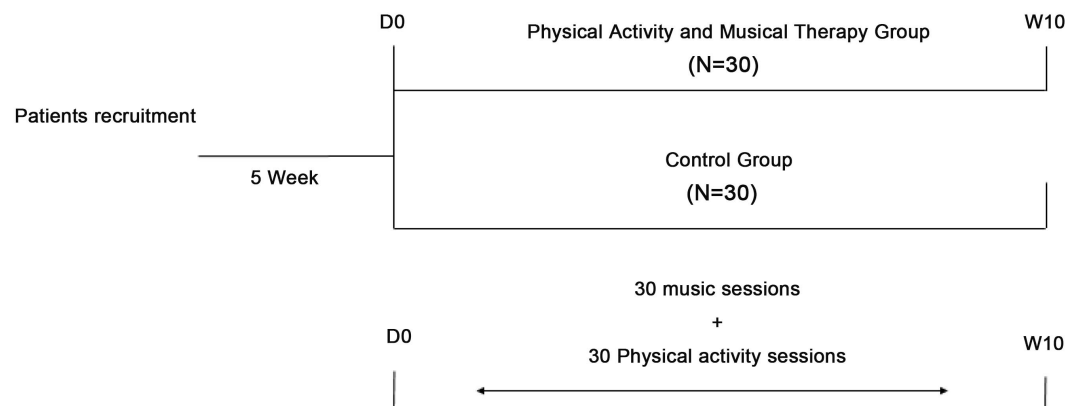


Figure 2. Study plan.

Principal Endpoint: Effect of Physical Exercise and Music Therapy on Behavioral and Psychological Parameters

The BEHAVE-AD test used to evaluate patient's behavioral and psychological disorders was determined before and after intervention program. **Figure 3**, illustrate the significant changes in BEHAVE-AD score in both therapy and control group. Behavioral-AD total score improved significantly after 10 weeks of the intervention period 0.01*. Patients in the therapy group have a better result in comparison with the baseline measure (D0).

Effects of Physical Exercise and Music Therapy on Cognitive Function

Effects of physical exercise and music therapy were measured after 10 weeks of intervention. The mean values and analysis of the BEHAVE-AD results for both groups are shown in **Table 2**. Regarding the effects of physical exercise and music therapy intervention on cognitive function in the therapy group, five items were reduced: (affective disturbance, $Z -2.3$, $p < 0.025$; anxieties and phobias, $Z -2.3$, $p < 0.025$; paranoid and delusional ideation, $Z -2.7$, $p < 0.025$; aggressiveness, $Z -2.6$, $p < 0.025$; and activity disturbance, $Z -2.5$, $p < 0.025$). For the control group, only activity disturbance ($Z -2.5$, $p < 0.025$) and affective disturbance were decreased ($Z -2.4$, $p < 0.025$).

4. Discussion

The present study suggests that physical exercise enhances the cognitive function of older patients with AD when combined with music therapy. The realization of this work has allowed a deepening of the scientific evidence regarding the use of non-pharmacological therapy for the treatment of Alzheimer's disease and its impact on patients' health. Supporting combined physical and musical intervention

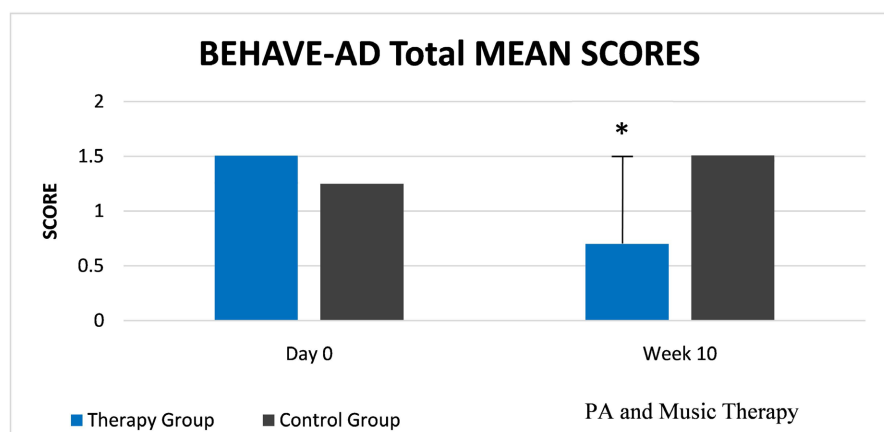


Figure 3. Comparisons within and between groups in cognitive parameters at baseline and post intervention measured with the BEHAVE-AD test. Values and means (\pm SD), significantly different ($p < 0.05$) for the therapy group after 10 weeks of physical activity and music therapy. The mean values and analysis of BEHAVE-AD test from each group are shown in **Table 2**.

Table 2. Scores of the BEHAVE-AD before and after intervention in both groups.

Behave-AD	Therapy Group N = 30		Control Group N = 30			
Paranoid/delusional ideation						
Before intervention	2.1 ± 2.1	0.01*	2.08%	2.2 ± 2.1	0.8	
After treatment	0.9 ± 1.5			2.1 ± 2.4		
Hallucination						
Before intervention	2 ± 2.9	0.05		1.2 ± 1.7	0.3	
After treatment	2.1 ± 2.5			1.6 ± 1.9		
Activity disturbance						
Before intervention	3 ± 2.4	0.01*	2.96%	2.3 ± 1.8	0.01*	2.25%
After treatment	1.2 (1.1)			2.1 ± 1.9		
Aggressiveness						
Before intervention	2.5 ± 2.4	0.01*	2.48%	0.4 ± 0.7	0.3	
After treatment	0.6 ± 1.0			0.5 ± 0.9		
Diurnal rhythm disturbances						
Before intervention	0.5 ± 0.9	0.6		2.5 ± 3.1	0.4	
After treatment	0.6 ± 1.0			3.2 ± 3.0		
Affective disturbance						
Before intervention	1.1 ± 1.3	0.02*	1.07%	0.6 ± 1.2	0.02*	0.59%
After treatment	2.2 ± 1.7			0.4 ± 0.3		
Anxieties and phobias						
Before intervention	1.1 ± 1.3	0.01*	1.09%	1.1 ± 1.49	0.1	
After treatment	0.3 ± 0.6			1.2 ± 1.7		
Total score						
Before intervention	1.5 ± 0.7	0.01*	1.48%	1.3 ± 0.7	1.0	
After treatment	0.7 ± 0.6			1.5 ± 0.8		

will play a key role in helping develop clinical guidelines for both physical educators and music therapists.

Cognitive function and behavioral parameters can be positively affected by combining physical exercise and music therapy in older patients with dementia. This study aimed to investigate whether music-based physical training focused on walking, resistance, and balance exercises affect cognitive parameters in older patients with AD.

Music was used to synchronize body movements to music, control movement frequency, and intensity, motivate, persuade, and engage participants in physical activity. The reduction in cognitive parameters that we observed among patients

with mild level of dementia treated with physical activity and music therapy is particularly relevant for care practice because interactions between environmental stimuli have previously been reported to influence BPSD due to patients' lowered stress thresholds [40]. Taken together, our results indicate that the participation in activity using individualized and familiar music results in decreased cognitive disorders and increased positive emotional response. Both of these effects may improve behavioral and cognitive parameters and increase daily living among older patients with dementia.

To examine the impact of the combined intervention of physical and music therapy, behavioral and cognitive disturbances were evaluated as risk factors in older patients with Alzheimer's. One of the most commonly used tests for older patients with dementia was used for this purpose. A scientific and clinical consensus on these aspects is required. Our study shows a positive effect of physical activity and music therapy on cognitive function in our patients, which may consequently decrease the risk of cognitive dysfunction. After the intervention protocol, improvements in Affective disturbance (1.07%); and anxieties and phobias (1.09%), have been found, in accordance with the findings of Gerdner [34]. We also saw improvements in Paranoid or delusional ideation (2.08%); Aggressiveness (2.48%) and Activity disturbance (2.96%). The combined program was found to reduce stress, induce laughter, and evoke positive memories. These results support that practicing physical exercise and hearing music stimulated cognition in older patients with dementia, in accordance with previous studies [41]. In contrast, the control group exhibited a reduction in cognitive function at the end of the intervention, possibly, because of further deterioration causing a decrease in stress thresholds for psychological, physiological, and emotional parameters [42] [43]. As shown in **Table 1**, the general characteristics of the two groups were very close and similar. As described above, the improvements in cognitive function in the therapy group might be caused by the beneficial impacts of the combined program, which simultaneously acts as both cognitive and physical training. Concerning the control group, two cognitive items improved after the intervention, but the BEHAVE-AD total score showed no significant difference. These improvements can reasonably be attributed to the increased amount of personal contact (nursing home routine and social contact with clinical staff), however, in the study of Katona *et al.* [42], the results of the control group show a global decrease and deterioration for the BEHAVE-AD score, possibly because of further deterioration causing a decrease in stress thresholds for physiological, psychological, and emotional factors in older patients with a mild level of Alzheimer's.

Studies about combined physical activity and music therapy are very limited, but today this field has become an important subject for many researchers. Mathews, Clair and Kosloski (2001) observed that the participation of patients with dementia increased when physical exercises were accompanied by familiar music [44]. The project of Satoh, *et al.* combined physical training and music therapy [45]. They indicated that physical activity combined with music, resulted in

greater positive effects on cognitive function and activities of daily living (ADL) in patients with mild dementia in comparison to cognitive stimulation without music [45].

Most studies have shown that the combined programs composed of physical exercise and music therapy were practiced separately. Music is used as an accompanying instrument and/or lessening during the training process, however, studies have also shown a greater effect in motor and emotional responses when functional parameters have been synchronized to the music therapy [46].

The intervention group exercised 1 hour of physical activity combined with music therapy for 10 weeks. Significant improvement in cognition was seen after the walking, resistance, and balance exercises. The vital component for the improvement in this study was the combination of music and exercise, but the underlying mechanism concerning our results remains unclear. It can be hypothesized that music increases emotions and, in combination with exercise, improves behavioral parameters and motivation. The precise mechanism by which music facilitated the improvement is unknown, but data suggest three complimentary hypotheses. First, music might facilitate the efficacy of physical activity itself. There are many cases in which music has influenced physical movements and mental capacity. The content of the intervention program used in this study was developed by a collaboration through professional physical educators and music therapists, so the high quality of the program might enhance the effects of the physical exercise. Second, physical activity combined with music therapy might act as both cognitive and physical training simultaneously, which would cause a greater improvement in cognitive parameters. Patients in the intervention group listened to music, perceived the rhythm and tempo of the selected songs, judged whether their body movements and music were synchronous or not, and controlled their movements accordingly.

The important factor is that these processes were performed simultaneously and continuously, such that the older patients were also receiving cognitive training during their physical exercise program. The third hypothesis suggests that the parietal lobes might play a key role in the improvement that occurred with musical therapy. Therefore, it is well known that the parietal lobes participate in visuospatial and somatosensory functions, including body image. During the physical exercise program, patients monitored the movement of their bodies and perceived the positions, postures, and movements. Several activations [47] [48], and case studies [49] [50] have shown that the parietal lobes likely participate in music perception in the brain. Therefore, the stimulation of the parietal lobes by music and by the somatosensory inputs from physical exercise could cause improvements in cognitive function.

This study aims to investigate the effects of music-based walking resistance and balance training on cognitive function in people with dementia. No patient has stopped the therapy session. Most of patients were motivated, clapping, and responding directly to the familiar melodies by singing along, usually with the

words, and continuing to sing even after the music session. Patients impressions recorded at the end of the sessions, such “This music reminds me of my childhood and family memories,” and having the same qualified unit staff during all the follow-up period is also an essential detail to consider.

Limitation of the Current Study

The current study has several limitations that should be considered. First, we did not test the optimal time and exercise intensity for conducting this intervention. Future studies should vary the length of intervention to determine the most effective duration and intensity level and should include a longer intervention protocol with a larger sample size. However, we only examined the effects of both “physical activity and music therapy together”, but we did not compare the results separately. Due to insufficient evidence and limited research in the area of combined physical training and music intervention, especially in countries with low to middle incomes such as Tunisia, it would be useful in future studies to examine the impact of active and passive music intervention and other aspects of physical exercise in patients with Alzheimer’s disease to determine more clearly the beneficial effects of this therapy on cognitive function.

5. Conclusion

Alzheimer’s disease represents a serious health problem. Moreover, today’s main medical treatments are essentially symptomatic and remain highly controversial. Studies support the idea that physical activity and music therapy improve life quality and positively influence cognitive and behavioral levels in older patients with Alzheimer’s. In this context, our study has shown that a physical activity program combined with music therapy is a beneficial strategy for improving cognitive decline in older patients with Alzheimer’s. These effects might be attributable to the combination of two different therapies which act simultaneously as both mental and physical training.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the ethical advisory committee of the Research Unit(UR17JS01) Sports Performance, Health and Society, Higher Institute of Sport and Physical Education of Ksar Said, University of Manouba, Tunis, 2010, Tunisia. Additionally, all procedures performed in studies involving human participants were in accordance with the ethical standards. The study protocol was accepted by the Ethical Commission of CHU Monastir (Ref. TN02196550, April 2020).

Informed Consent Statement

Informed consent was obtained from all subjects and guardians involved in the study.

Data Availability Statement

The data presented in this study are available on reasonable request from R.H.

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Conflicts of Interest

The authors declare no conflict of interest.

References

- [1] Haapasalo, A., Pikkarainen, M. and Soininen, H. (2015) Alzheimer's Disease: A Report from the 7th Kuopio Alzheimer Symposium. *Neurodegenerative Disease Management*, **5**, 379-382. <https://doi.org/10.2217/nmt.15.31>
- [2] Alzheimer's Association (2018) 2018 Alzheimer's Disease Facts and Figures. *Alzheimer's Dement*, **14**, 367-429. <https://doi.org/10.1016/j.jalz.2018.02.001>
- [3] Rapporto Censis (2007) I costi economici e sociali della malattia di Alzheimer: Cosa è cambiato? Roma.
- [4] Hajjem, S. and Achour, N. (2001) Espérance de vie sans incapacité' de la population tunisienne âgée. Institut National de la Sante' Publique, Tunis, 17-25.
- [5] Gouiaa, R. (2015) Geriatric Medicine in Tunisia: Still Young. *European Geriatric Medicine*, **6**, 96. <https://doi.org/10.1016/j.eurger.2014.06.015>
- [6] Yount, K.M., Agree, E.M. and Rebellon, C. (2004) Gender and Use of Health Care among Older Adults in Egypt and Tunisia. *Social Science & Medicine*, **59**, 2479-2497. <https://doi.org/10.1016/j.socscimed.2004.04.004>
- [7] Starr, J.M. and Lonie, J. (2007) Relationship between Behavioural and Psychological Symptoms of Dementia and Cognition in Alzheimer's Disease. *Dementia and Geriatric Cognitive Disorders*, **24**, 343-347. <https://doi.org/10.1159/000108632>
- [8] Prince, M. and Jackson, J. (2010) Alzheimer's Disease International. Relatorio sobre a Doença de Alzheimer no mundo de 2009. Alzheimer's Disease International, Resumo Executivo em Portugues, Londres.
- [9] Cohen, L., Binagwaho, A., Galea, S., Grover, A., Jabbour, S. and Nuwayhid, J. (2017) Supporting Families to Care for People with Dementia. *Bulletin of the World Health Organization*, **95**, 734-735. <https://doi.org/10.2471/BLT.17.021117>
- [10] Lou, M.F. (2001) The Use of Music to Decrease Agitated Behaviour of the Demented Elderly: The State of the Science. *Scandinavian Journal of Caring Sciences*, **15**, 165-173. <https://doi.org/10.1046/j.1471-6712.2001.00021.x>
- [11] Li, C.H., Liu, C.K., Yang, Y.H., et al. (2015) Adjunct Effect of Music Therapy on Cognition in Alzheimer's Disease in Taiwan: A Pilot Study. *Neuropsychiatric Disease and Treatment*, **11**, 291-296. <https://doi.org/10.2147/NDT.S73928>
- [12] Nobari, H., Azimzadeh, E., Hassanlouei, H., Badicu, G., Pérez-Gómez, J. and Ardigò, L.P. (2021) Effect of Physical Guidance on Learning a Tracking Task in Children with Cerebral Palsy. *International Journal of Environmental Research and Public Health*, **18**, Article 7136. <https://doi.org/10.3390/ijerph18137136>
- [13] Nobari, H., Rezaei, S., Sheikh, M., Fuentes-García, J.P. and Pérez-Gómez, J. (2021) Effect of Virtual Reality Exercises on the Cognitive Status and Dual Motor Task Per-

- formance of the Aging Population. *International Journal of Environmental Research and Public Health*, **18**, Article 8005. <https://doi.org/10.3390/ijerph18158005>
- [14] American College of Sports Medicine (2014) ACSM's Guidelines for Exercise Testing and Prescription. Indianapolis.
- [15] Radak, Z., Hart, N. and Sarga, L. (2010) Exercise Plays a Preventive Role against Alzheimer's Disease. *Journal of Alzheimer's Disease*, **20**, 777-783. <https://doi.org/10.3233/JAD-2010-091531>
- [16] Valenzuela, P.L., Castillo-García, A., Morales, J.S., de la Villa, P., Hampel, H., Emanuele, E., Lista, S. and Lucia, A. (2020) Exercise Benefits on Alzheimer's Disease: State-of-the-Science. *Ageing Research Reviews*, **62**, Article ID: 101108. <https://doi.org/10.1016/j.arr.2020.101108>
- [17] Shams, A., Nobari, H., Afonso, J., Abbasi, H., Mainer-Pardos, E., Pérez-Gómez, J., Bayati, M., Bahrami, A. and Carneiro, L. (2021) Effect of Aerobic-Based Exercise on Psychological Well-Being and Quality of Life among Older People: A Middle East Study. *Frontiers in Public Health*, **9**, Article 764044. <https://doi.org/10.3389/fpubh.2021.764044>
- [18] World Federation of Music Therapy (2013) WFMT/ FAQ Music Therapy.
- [19] Robles, A., Del Ser, T., Alom, J., Peña-Casanova, J. and Asesor, G.X. (2002) Proposal of Criteria for the Clinical Diagnosis of Mild Cognitive Impairment, Dementia and Alzheimer's Disease. *Neurología*, **17**, 17-32.
- [20] Oneca, N. (2014) Music Therapy: Fundamentals, Practical Aspects and Application to Hospitalized Children. Ph.D. Thesis, Navarra University, Navarra.
- [21] Samson, S., Clément, S., Narme, P., Schiaratura, L., Ehrlé, N. (2015) Efficacy of Musical Interventions in Dementia: Methodological Requirements of Nonpharmacological Trials. *Annals of the New York Academy of Sciences journal*, **1337**, 249-255. <https://doi.org/10.1111/nyas.12621>
- [22] Association AMT (2021) Definition and Quotes about Music Therapy. <http://www.music-therapy.org>
- [23] Clair, A.A. (1996) The Effect of Singing on Alert Responses in Persons with Late Stage Dementia. *Journal of Music Therapy*, **33**, 234-247. <https://doi.org/10.1093/jmt/33.4.234>
- [24] Kneafsey, R. (1997) The Therapeutic Use of Music in a Care of the Elderly Setting: A Literature Review. *Journal of Clinical Nursing*, **6**, 341-346. <https://doi.org/10.1111/j.1365-2702.1997.tb00326.x>
- [25] Kim, M. and Tomaino, C.M. (2008) Protocol Evaluation for Effective Music Therapy for Persons with Nonfluent Aphasia. *Topics in Stroke Rehabilitation*, **15**, 555-569. <https://doi.org/10.1310/tsr1506-555>
- [26] Fabre, C., Chamari, K. and Mucci, P. (2002) Improvement of Cognitive Function via Mental and/or Individual Aerobic Training in Healthy Elderly Subject. *International Journal of Sports Medicine*, **23**, 415-421. <https://doi.org/10.1055/s-2002-33735>
- [27] Oswald, W.D., Gunzelmann, T., Rupprecht, R. and Hagen, B. (2006) Differential Effects of Single versus Combined Cognitive and Physical Training with Older Adults: The SimA Study in a 5-Year Perspective. *European Journal of Ageing*, **3**, 179-192. <https://doi.org/10.1007/s10433-006-0035-z>
- [28] Shatil, E. (2013) Does Combined Cognitive Training and Physical Activity Training Enhance Cognitive Abilities More than Either Alone? A Four-Condition Randomized Controlled Trial among Healthy Older Adults. *Frontiers in Aging Neuroscience*, **5**, Article 8. <https://doi.org/10.3389/fnagi.2013.00008>

- [29] Folstein, M.F., Folstein, S.E. and McHugh, P.R. (1975) "Mini-Mental State": A Practical Method for Grading the Cognitive State of Patients for the Clinician. *Journal of Psychiatric Research*, **12**, 189-198. [https://doi.org/10.1016/0022-3956\(75\)90026-6](https://doi.org/10.1016/0022-3956(75)90026-6)
- [30] Guyatt, G.H., Pugsley, S.O., Sullivan, M.J., Thompson, P.J., Berman, L., Jones, N.L., Fallen, E.L. and Taylor, D.W. (1984) Effect of Encouragement on Walking Test Performance. *Thorax*, **93**, 812-822. <https://doi.org/10.1136/thx.39.11.818>
- [31] Morris, J.C. (1993) The Clinical Dementia Rating (CDR): Current Version and Scoring Rules. *Neurology*, **43**, 2412b-4. <https://doi.org/10.1212/WNL.43.11.2412-a>
- [32] Reisberg, B., Borenstein, J., Salob, S.P., Ferris, S.H., Franssen, E. and Georgotas, A. (1987) Behavioral Symptoms in Alzheimer's Disease: Phenomenology and Treatment. *Journal of Clinical Psychiatry*, **48**, 9-15. <https://doi.org/10.1037/t13385-000>
- [33] Sclan, S.G., Saillon, A., Franssen, E. and Hugonot-Diener, L. (1996) The Behavioral Pathology in Alzheimer's Disease Rating Scale (BEHAVE-AD): Reliability and Analysis of Symptom Category Scores. *International Journal of Geriatric Psychiatry*, **11**, 819-830. [https://doi.org/10.1002/\(SICI\)1099-1166\(199609\)11:9<819::AID-GPS389>3.0.CO;2-S](https://doi.org/10.1002/(SICI)1099-1166(199609)11:9<819::AID-GPS389>3.0.CO;2-S)
- [34] Schulkind, M.D., Hennis, L.K. and Rubin, D.C. (1999) Music, Emotion, and Autobiographical Memory: They're Playing Your Song. *Memory and Cognition*, **27**, 948-955. <https://doi.org/10.3758/BF03201225>
- [35] Jebali, R. (2010) Approches interculturelles de la musicothérapie en Tunisie: De la Musicothérapie traditionnelle Stambâli, à la musicothérapie moderne. *Revue Française de Musicotherapie*, **4**, 69.
- [36] Salimpoor, V.N., Benovoy, M., Larcher, K., Dagher, A. and Zatorre, R.J. (2011) Anatomically Distinct Dopamine Release during Anticipation and Experience of Peak Emotion to Music. *Nature Neuroscience*, **14**, 257-262. <https://doi.org/10.1038/nn.2726>
- [37] Sherratt, K., Thornton, A. and Hatton, C. (2004) Music Interventions for People with Dementia: A Review of the Literature. *Aging & Mental Health*, **8**, 3-12. <https://doi.org/10.1080/13607860310001613275>
- [38] Olderog-Millard, K.A. and Smith, J.M. (1989) The Influence of Group Singing Therapy on the Behavior of Alzheimer's Disease Patients. *Journal of Music Therapy*, **26**, 58-70. <https://doi.org/10.1093/jmt/26.2.58>
- [39] Hall, G.R. and Buckwalter, K.C. (1987) Progressively Lowered Stress Threshold: A Conceptual Model for Care of Adults with Alzheimer's Disease. *Archives of Psychiatric Nursing*, **1**, 399-406.
- [40] Gerdner, L.A. (2000) Effects of Individualized versus Classical Relaxation Music on the Frequency of Agitation with Alzheimer's Disease and Related Disorders. *International Psychogeriatrics*, **12**, 49-65. <https://doi.org/10.1017/S1041610200006190>
- [41] Sacks, O. (2006) The Power of Music. *Brain*, **129**, 2528-2532. <https://doi.org/10.1093/brain/awl234>
- [42] Katona, C. (2007) International Psychogeriatric Association Consensus Statement on Defining and Measuring Treatment Benefits in Dementia. *International Psychogeriatrics*, **19**, 345-354. <https://doi.org/10.1017/S1041610207005145>
- [43] Cerejeira, J., Lagarto, L. and Mukaetova-Ladinska, E.B. (2012) Behavioral and Psychological Symptoms of Dementia. *Frontiers in Neurology*, **3**, Article 73. <https://doi.org/10.3389/fneur.2012.00073>
- [44] Mathews, R.M., Clair, A.A. and Kosloski, K. (2001) Keeping the Beat: Use of Rhyth-

- mic Music during Exercise Activities for the Elderly with Dementia. *American Journal of Alzheimer's Disease & Other Dementias*, **16**, 377-380.
<https://doi.org/10.1177/153331750101600608>
- [45] Satoh, M., Ogawa, J.I., Tokita, T., Nakaguchi, N. and Nakao, K. (2017) Physical Exercise with Music Maintains Activities of Daily Living in Patients with Dementia: Mihama-Kiho Project Part 21. *Journal of Alzheimer's Disease*, **57**, 85-96.
<https://doi.org/10.3233/JAD-161217>
- [46] van der Steen, J.T., van Soest-Poortvliet, M.C., van der Wouden, J.C., Bruinsma, M.S. and Scholten, R.J. (2017) Music-Based Therapeutic Interventions for People with Dementia. *Cochrane Database of Systematic Reviews*, **5**, CD003477.
<https://doi.org/10.1002/14651858.CD003477.pub3>
- [47] Sergent, J., Zuck, E., Terriah, S. and MacDonald, B. (1992) Distributed Neural Network Underlying Musical Sight-Reading and Keyboard Performance. *Science*, **257**, 106-109. <https://doi.org/10.1126/science.1621084>
- [48] Satoh, M., Takeda, K., Nagata, K. and Tomimoto, H. (2011) The Lateral Occipital Complex Is Activated by Melody with Accompaniment: Foreground and Background Segregation in Auditory Processing. *Journal of Behavioral and Brain Science*, **1**, 94-101.
<https://doi.org/10.4236/jbbs.2011.13013>
- [49] Mazzoni, M., Moretti, P., Pardossi, L., Vista, M. and Muratorio, A. (1993) A Case of Music Imperceptions. *Journal of Neurology, Neurosurgery & Psychiatry*, **56**, 322-324.
<https://doi.org/10.1136/jnnp.56.3.322>
- [50] Satoh, M., Nakase, T., Nagata, K. and Tomimoto, H. (2011) Musical Anhedonia: Selective Loss of Emotional Experience in Listening to Music. *Neurocase*, **17**, 410-417.
<https://doi.org/10.1080/13554794.2010.532139>