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Case Report

Exercise and Psychomotor Rehabilitation in a Patient with Alzheimer's Disease: A Case Report

Catarina F. Martins [1, 2], Jorge Soares [1, 2], Maria Paula Mota [1, 2, *]

1. Research Centre in Sports Sciences, Health, and Human Development (CIDESD), University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal; E-Mails: ana_catarina_95@hotmail.com; jfpsoares@utad.pt; mpmota@utad.pt
2. Department of Sport, Exercise and Health Sciences, School of Life and Environmental Sciences (ECVA), UTAD, Vila Real, Portugal

* **Correspondence:** Maria Paula Mota; E-Mail: mpmota@utad.pt

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Abstract

Alzheimer's disease is a neurodegenerative condition that impacts an individual's physical, cognitive, and social well-being, ultimately resulting in a decline in independence and functionality. This case report explores how a program combining multimodal physical exercise and psychomotor rehabilitation can improve outcomes in interventions for Alzheimer's disease patients. This approach can enhance treatment effectiveness and provide researchers and practitioners with additional therapeutic options. The participant was an 85-year-old woman diagnosed with moderate Alzheimer's disease. The following evaluation forms were used before and after the intervention: Barthel Index, Mini-Mental State Examination, Tinetti balance scale, and Six Minute Walk Test. The results showed an improvement in gait velocity, balance, cognitive function, and cardiovascular capacity despite the participant experiencing a medical setback during the intervention. The combination of multimodal physical exercise and psychomotor rehabilitation provided a beneficial non-pharmacological approach for the patient with Alzheimer's disease, suggesting a promising area for future research.

Keywords
Cognition; dementia; older adults; psychomotor therapy; physical exercise

1. Introduction

Alzheimer's Disease (AD) is the most common cause of dementia worldwide and has been identified as a global public health concern [1]. It is a progressive neurodegenerative disease characterized by memory loss, difficulties with thinking, language, and problem-solving skills, along with issues in multitasking, increased dependence, and impaired mobility [2]. As the disease progresses, various symptoms manifest, indicating the extent of neuronal damage in different brain parts. Early diagnosis is advantageous, enabling early intervention to maintain mental function, manage behavioral symptoms, and slow or delay disease progression [3].

Numerous studies have supported the existence of potentially modifiable risk factors associated with human behavioral factors that can directly influence the development of dementia and AD, such as a sedentary lifestyle and reduced cognitive stimulation [2, 4, 5]. Staying mentally active has the potential to protect against cognitive decline or AD [6, 7]. Possible mechanisms for combating AD involve increasing or maintaining cognitive reserve despite pathology and neuropathological damage [7].

In psychomotor rehabilitation, human movement and body awareness are fundamental pillars of the intervention strategy [8]. This approach results in the preservation of cognitive skills and the adaptation of previously acquired processes by stimulating different brain regions with specific motor tasks [9]. It is beneficial to refer to domains involving human movement initiated by higher brain centers, such as the motor cortex, as most human movement results from such stimulation [10].

In addition to cognitive benefits, this therapy explores corporeality and physical activity (PA) in all its forms, allowing individuals to consciously achieve morphological, muscular, cardiorespiratory, metabolic, and motor benefits [8]. However, psychomotor rehabilitation is still a growing therapeutic area, and to our knowledge, there is no published and adapted psychomotor rehabilitation program specifically for Alzheimer's patients. Therefore, it is reported and explored in a focused manner in this study.

Recent research has demonstrated that combining cognitive stimulation and PA can promote neuroplasticity [11]. Additionally, Physical Exercise (PE) promotes beneficial effects on brain structures, producing a neuroprotective effect that can mitigate cognitive decline [12-14]. Although various approaches have demonstrated the potential benefits of PE for people with AD, the complementary use of a psychomotor rehabilitation program has not yet been explored [15]. Furthermore, it is essential to note that AD patients experience complex issues and symptoms across numerous domains, so interventions must be tailored to the individual and take the whole person into account [7].

This case report explores how a program incorporating multimodal PE and psychomotor rehabilitation can increase the effectiveness of outcomes in interventions with AD patients.

2. Case Description

The participant was an 85-year-old Caucasian female who was widowed. She weighed 73.1 kilograms and had a height of 1.62 meters. She completed fourth grade in school and is the mother of three daughters. Her past medical history included hypertension, osteoarticular problems (osteoporosis), asthma, type II diabetes mellitus since childhood, breast cancer (discovered at the age of 82 years in an early stage and treated with hormone therapy), heart problems (arrhythmias), and hospitalization for thrombophlebitis.

At the time of the study, her current medication included: daflon (500 mg), rivastigmine (4.5 mg), esomeprazole (20 mg), proxon, neurobion (0.2 + 200 mg + 100 mg), memantine (10 mg), sirvastatin (20 mg), izosorbid dinitrate (5 mg), furosemide (20 mg), metformin (500 mg), ferrous sulfate + folic acid (200 mg + 0.25 mg), calcium carbonate + cholecalciferol (600 mg + 200), and Anastrozole (1 mg). In the 6^{th} week of the program, she had a dysfunction in the mitral atrial valve. After that, the usual intake of izosorbid dinitrate (5 mg) was discontinued.

A neurologist with AD diagnosed the participant at the age of 83 years. Cognitive tests, magnetic resonance imaging, blood tests, and computed tomography were performed, indicating a progression to moderate AD.

After an AD diagnosis within a year, the participant's symptoms progressively worsened, impacting her mobility. Using two crutches and relying on her caregiver, she faced challenges in walking and performing basic movements. She was the first person in her family to be diagnosed with AD. Socially, she did not engage in sociocultural or leisure activities except for religious practices associated with Christianity. However, due to her profession in public interaction, she has always been interactive and communicative with the community.

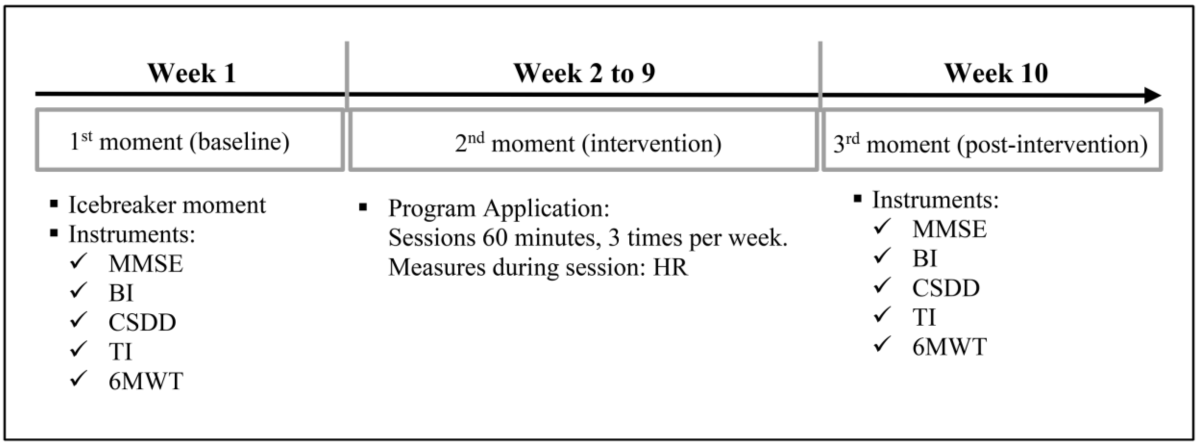
The participant and her caregiver (the participant's daughter) confirmed a history of stable economic circumstances. Additionally, in terms of lifestyle, the participant has never smoked, consumed alcohol, or used illicit drugs. She also maintains controlled and balanced eating habits for health reasons. The family doctor recommended these habits without the guidance of a nutritionist. Her daily exercise routine consists of supervised, short 10-minute walks at home, up to three times a day, established by the caregiver.

The participant was referred to the program through the Alzheimer Portugal Association.

This study received approval from the Ethics Committee of the University of Trás-os-Montes and Alto Douro (CE-UTAD) (FP.2717-399PA59819), and it adhered to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the study participant's caregiver.

3. Intervention Program

The study was conducted in three stages over 10 weeks by a psychomotricist specializing in exercise prescription for older adults (Figure 1). The initial assessment was carried out in two sessions, during which an icebreaker activity was held to help the participant feel more comfortable and engaged with the intervention. Icebreaker moments can be a helpful technique in research to introduce an intervention session and generate interest in the goals of the intervention [16]. Following that, the initial evaluations were conducted.



Abbreviations: MMSE= Mini-Mental State Examination; BI= Barthel Index; CSDD= Cornell Scale for Depression in Dementia; TI= Tinetti Index; 6MWT= 6 Minute Walking Test; HR= Heart Rate.

Figure 1 Study timeline and outcome measures.

The intervention integrated PE and psychomotor rehabilitation, aiming to synergize their effectiveness rather than isolating them. The intersection of these areas within the human dimension, encompassing movement intention, body, and action, guided the development of a psychomotor intervention plan tailored to the participants identified during the evaluation. Additionally, a multimodal PE plan was explicitly crafted to address the unique requirements of individuals with AD.

3.1 Outcome Measures

Cognitive function was assessed using the Mini-Mental State Examination (MMSE), evaluating six domains: orientation (time and place), registration, attention and calculation, recall, language, comprehension of verbal and written instructions, and spontaneous writing and constructive ability (copying).

According to Santana et al. (2016) [17], the MMSE score for the Portuguese population ranges from 0 to 30 points. Cognitive impairment is indicated by specific cut-off values: 15 or less for illiterate individuals, 22 or less for those with 1 to 11 years of schooling, and 27 or less for those with higher education.

Participants’ dependence on daily activities was assessed using the Barthel Index (BI) [18]. The assessment covered ten activities: personal hygiene, eating, bathing, using the bathroom, stair navigation, sphincter control, dressing, walking, transferring, and wheelchair operation [19]. Scores on the 0-100 scale reflected levels of dependence: 0-20 (total dependence), 21-60 (severe dependence), 61-90 (moderate dependence), 91-99 (mild reliance), and 100 (complete independence) [20].

To assess participant balance, the Tinetti Index (TI) was employed to evaluate mobility, static and dynamic balance, and fall risk in older adults. Comprising 16 items, the first nine assess static balance, and the remaining seven assess dynamic balance, including gait, speed, distance, and step symmetry [21]. Validated cut-off values for fall risk in the Portuguese population are 0-19 points for high fall risk, 20-24 points for moderate fall risk, and 25-28 points for low fall risk [20].

Physical endurance was assessed using the Six Minute Walk Test (6MWT), measuring the distance covered in meters over six minutes. Participants walked on a fifty-meter course with markers every five meters [22]. Qualitative data on participants' performance outside sessions were collected weekly from the caregiver (daughter).

3.2 Description of the Psychomotor Rehabilitation Program

The psychomotor rehabilitation program was tailored to the participant's psychomotor performance, considering tonicity, balance, lateralization, body awareness, spatial-temporal structuring, and fine motor skills. Psychomotor therapy takes a comprehensive approach to the human being, integrating cognitive, socio-emotional, symbolic, psycholinguistic, and motor functions, specifically promoting intentional movement [23].

The participant displayed issues such as anterior trunk flexion, gait disturbances (slower speed, irregular stride frequency, and low stride regularity) [24], and altered postural reflexes, affecting sitting posture. Tackling these challenges, tonicity work aimed to enhance movement during daily activities. Sessions focused on improving sitting and standing posture, controlled movements of upper and lower limbs, and correcting walking posture. Exercises targeted extensibility, fostering joint mobilization and range of motion through upper and lower limb extension, flexion, adduction, and abduction movements.

Balance enhancement involved addressing both static and dynamic aspects. Static balance exercises included standing with feet parallel and supported on one leg, varying the support base. Additional balance work involved PE. Immediate balance was targeted by reducing rebalancing movements, adjusting stride length to different floor markings, varying support base during movement, adapting steps to obstacles and shapes, and increasing step height.

Global praxis work focused on enhancing motor coordination and implementing motor planning and self-control strategies in task performance. Oculo-manual coordination was also emphasized to improve the coordination of upper and lower limb movements with perceptual-visual references.

Structuring-temporal space work operated at an organizational level, involving the participant in assessing walking distances and adjusting motor plans accordingly. This was achieved through focused walking within defined spaces, prompting the participant to plan actions when encountering objects arranged in space. Temporal structuring involved understanding temporal location using a calendar, covering the year, month, day of the month, day of the week, and the chronological order of days. Additionally, the participant worked on spatial awareness, locating the country, district, and land of residence.

Cognitively, diverse memories were stimulated, emphasizing sensory memory (visual, auditory, tactile, and olfactory). The intervention targeted improving time management skills and attention, employing exercises to enhance everyday memories with logical temporal sequences. Personal objects stimulated self-biographical memory, while long-term memory recall involved song lyrics and sayings from youth.

Visual memory exercises included various colors, objects, and image sequences. Sensory memory activities focused on distinguishing and working with different textures, and auditory memory activities involved listening, identification, association, and reproduction of sounds and rhythms. Problem-solving skills were honed through activities like solving mathematical problems, puzzles, and mazes, requiring quick associations and task completion within set time frames.

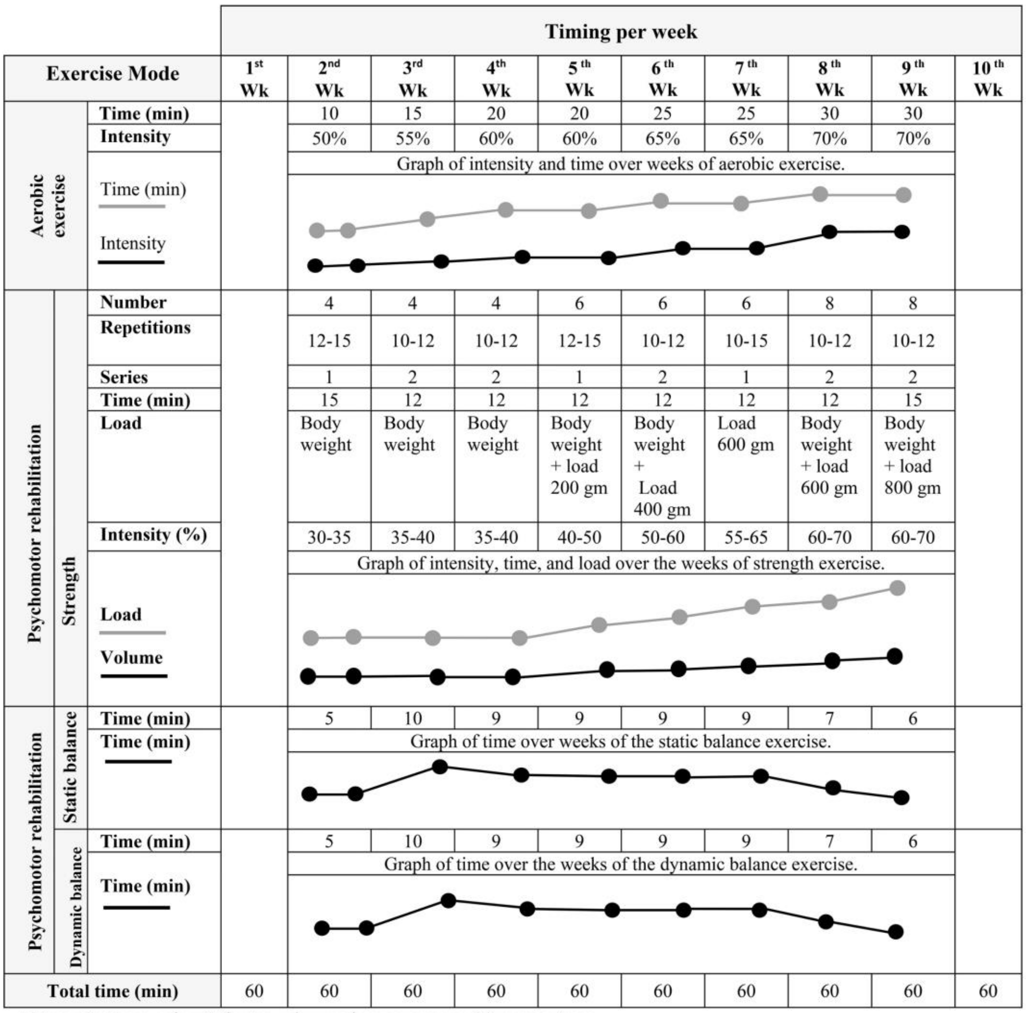
The therapeutic psychomotor intervention goals were personalized based on the participant's needs and interests [25]. Sessions consistently considered the participant's preferences, incorporating techniques and experiences she remembered. This approach ensured a meaningful and easily understandable intervention. For instance, joint mobility exercises integrated the participant's imagination and memories, such as handwashing clothes, making movements more relevant, and enhancing her connection with the exercise. This transition from familiar knowledge to exercise intent had a significant emotional impact, boosting adherence to the therapeutic process [26].

3.3 Description of the Physical Exercise Program

The physical exercise (PE) program was designed considering two fundamental pillars: the characteristics presented by the participant at the initial assessment and the available literature and guidelines [7, 27-31]. AD often induces global motor challenges, manifesting as difficulties in movement planning, slower and more cautious gait, and an elevated risk of falls [32]. Tailored exercise programs for AD patients demonstrate positive physical effects and cognitive benefits [13, 33-38]. Despite the acknowledged benefits of exercise programs, inconsistencies persist, especially in factors like type, intensity, load, and duration, potentially impacting AD.

Joint mobility exercises consistently initiated sessions, integrating sensory materials like cloths, hoops, balls, and foam tubes. Rotating these materials weekly aimed to prevent monotony and concurrently engage the sensory component during exercises.

Aerobic training centered on walking, commencing at an intensity of 50% of the maximum heart rate (HRmax) calculated by Takana et al. (2001). It gradually escalated to 70% of Hrmax over 8 weeks [39]. Heart rate was continuously monitored using a heart rate monitor during the walk, which initially lasted ten minutes and progressed towards a target of thirty minutes (Figure 2). With ongoing HR monitoring, this gradual development and adaptation were responsive to the participant's performance.



Exercise Mode			Timing per week: 1st Wk	2nd Wk	3rd Wk	4th Wk	5th Wk	6th Wk	7th Wk	8th Wk	9th Wk	10th Wk
Aerobic exercise		Time (min)		10	15	20	20	25	25	30	30	
		Intensity		50%	55%	60%	60%	65%	65%	70%	70%	
		Time (min); Intensity		Graph of intensity and time over weeks of aerobic exercise.								
Psychomotor rehabilitation	Strength	Number		4	4	4	6	6	6	8	8	
		Repetitions		12-15	10-12	10-12	12-15	10-12	10-15	10-12	10-12	
		Series		1	2	2	1	2	1	2	2	
		Time (min)		15	12	12	12	12	12	12	15	
		Load		Body weight	Body weight	Body weight	Body weight + load 200 gm	Body weight + Load 400 gm	Load 600 gm	Body weight + load 600 gm	Body weight + load 800 gm	
		Intensity (%)		30-35	35-40	35-40	40-50	50-60	55-65	60-70	60-70	
		Load; Volume		Graph of intensity, time, and load over the weeks of strength exercise.								
Psychomotor rehabilitation	Static balance	Time (min)		5	10	9	9	9	9	7	6	
		Time (min)		Graph of time over weeks of the static balance exercise.								
	Dynamic balance	Time (min)		5	10	9	9	9	9	7	6	
		Time (min)		Graph of time over the weeks of the dynamic balance exercise.								
Total time (min)			60	60	60	60	60	60	60	60	60	60

Abbreviations: min= Minute; wk=week; gm=grams; %=percentage.

Figure 2 Intervention program.

At the onset and conclusion of aerobic exercise, participants were prompted to take small, giant, and lateral steps with varying amplitudes in different directions, lengths, and speeds. This practice aimed to enhance balance, coordination, stability, and movement reaction, mitigating the risk of falls.

Static and dynamic balance exercises were incrementally incorporated, integrating proprioceptive training and playful exercises. These exercises were integrated into aerobic sessions to reinforce dynamic balance and within joint mobility exercises to fortify static balance.

Strength exercises targeted various muscle groups, encompassing lower body exercises such as squats, leg extensions, flexions, and heel raises for muscle strengthening. Upper body exercises included elbow flexions and extensions, shoulder abductions, shoulder shrugs, shoulder presses, chest adductions, and lat pulldowns. Trunk exercises involved hip hinges, back extensions, and abdominal crunches. Plantar flexion and extension exercises were also included. Session intensity was regulated through exercises, repetitions, sets, and loads. The weight load was gradually increased from 200 grams to 800 grams.

In Figure 2, we present a synthesized intervention plan highlighting the integration of interventions from the two therapeutic areas described earlier. This plan is designed to be implemented consistently and seamlessly throughout the sessions.

4. Outcomes

Outcome measures were collected in the 1st and 10th weeks (Table 1). Regarding temporal structuring, the participant initially struggled with identifying the day of the week, the day of the month, and the month. However, she could locate the name of the country and city where she lives. As the intervention progressed, the participant's recollection of the month's name increased with time, and she could recall it more frequently, along with the day of the week and the month, as the intervention continued. Nevertheless, in the 6th week, the participant began experiencing health problems, which made it more difficult for her to locate herself temporally, even in contents that she had previously known. Towards the end of the intervention, it was observed that she once again found it easier to locate herself.

Table 1 Outcome measures at week 1 (baseline) and week 10 (post-intervention).

Measure	1st Week	10th Week
MMSE		
Orientation	5	6
Retention	3	3
Attention and calculation	0	1
Recall	0	0
Language	7	8
Constructive ability	0	0
Total	15	18
IB		
Eating	5	5
Dressing	5	0
Bathing	0	0
Personal hygiene	0	0
Going to the bathroom	5	5
Intestinal control	0	5
Sphincter control	0	0
Going up the stairs	5	0
Bed-chair Transfer	10	10
Walking	10	10
Total	40	35
TI		
Static Balance	8	8
Dynamic Balance	7	9
Total	15	17
6MWT (meters)	85	90

Abbreviations: MMSE = Mini-Mental State Examination; BI = Barthel Index; TI = Tinetti Index; 6MWT = 6 Minute Walking Test.

The participant demonstrated well-preserved logical-practical reasoning skills during cognitive activities, proficiently creating problem-solving strategies, performing mental calculations, and maintaining focus. Long-term memory remained intact, allowing effective information recall. However, challenges were observed in spatial structuring and abstract perception.

The caregiver, through daily observations, noted cognitive improvements in the participant. Increased attention to tasks and reduced passivity in actions were observed. The participant reported a positive connection between session tasks and daily activities.

The participant successfully decreased imbalances in the sessions until the sixth week, improving gait rebalance. Overcoming challenges in maintaining dynamic balance became easier, requiring less assistance. Increased confidence was evident in performing both reintroduced and more challenging exercises.

In static balance, fewer lateral oscillations were noted. Positive changes in walking quality, including increased speed and improved gait patterns, were observed.

However, a setback occurred after six weeks due to heart failure, leading to motor and cognitive regression. Gait characteristics reverted to the initial state, marked by decreased stride amplitude, a more dragging gait, and increased imbalances. Yet, in the remaining weeks, improvements were observed, as outlined in Table 1.

Intermittency in exercise duration across sessions (Figure 3) was noticeable and often linked to external factors such as tiredness and poor predisposition. Up to the seventeenth session, the participant increased exercise duration owing to locomotion improvements. Despite a setback, subsequent progress was evident, both in the duration of walking and in gait patterns.

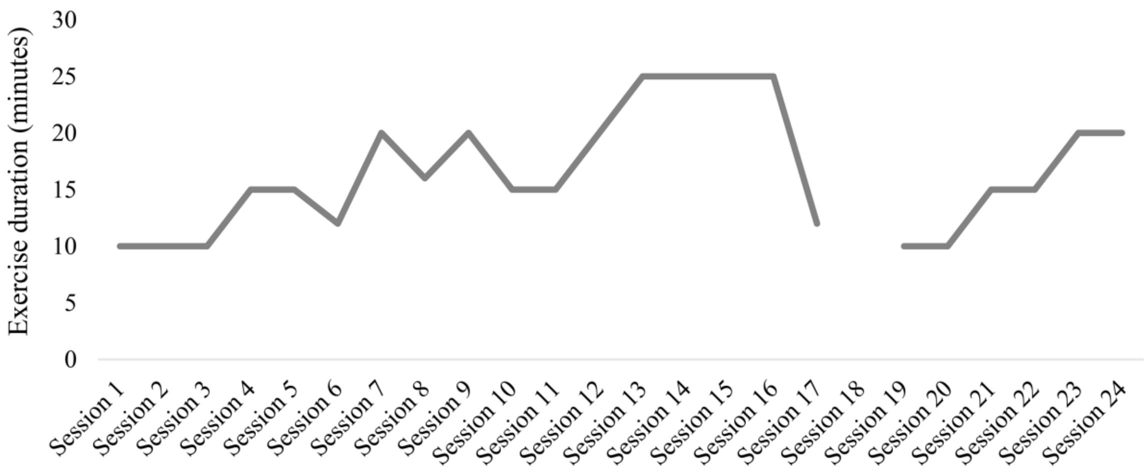


Figure 3 Results of aerobic training during the eight weeks of intervention (session eighteen is missing the record due to an adverse event of heart failure).

The participant exhibited increased strength-generating capacity, reflected in the rising training volume over the weeks. All sessions were successfully completed by the sixth week. Initial sessions posed some challenges, but the participant overcame them by adhering to the prescribed exercise intensity and complexity. The fourth and fifth weeks showed notable improvements, potentially from the participant's increased adaptation to exercises and enhanced comfort with their specifics, leading to improved technical execution.

Strength exercises were omitted during the seventh and eighth weeks. The caregiver noted improvements in walking, possibly attributed to a smoother gait, in daily observations. At a practical level, the caregiver reported the participant's newfound ability to lie down independently and exhibit improved bed posture. Additionally, the participant demonstrated easier sitting and standing, requiring less assistance with strength.

5. Discussion

This case study aimed to showcase the outcomes of an intervention utilizing multicomponent exercise along with psychomotor rehabilitation for a participant with moderate AD. The implemented strategies played a crucial role in preserving the autonomy and enhancing the quality of life of the older participants with AD.

The combined program, encompassing multimodal exercise and psychomotor rehabilitation, proved effective in improving physical parameters, particularly gait and balance, alongside cognitive enhancements. Notably, the intervention demonstrated its efficacy even in a medical setback where rapid regression occurred. However, substantial progress was once again achieved upon recovery from the health issue. These findings underscore the effectiveness of the intervention in maintaining and enhancing the participant's overall well-being.

The participant's cognitive function exhibited improvement through the implemented program, as evaluated by the MMSE. The MMSE assesses various cognitive domains, including orientation to time and place, registration, calculation, repetition, 3-step command, reading and obeying, recall, naming, writing, and copying. Widely utilized across various professional fields, including psychomotor rehabilitation, the MMSE proves valuable for its comprehensive assessment capabilities [17].

In the "calculation" item, the participant demonstrated improvements. Brain imaging studies suggest that the parietal lobe is crucial for calculating and processing numbers, while the frontal lobe plays a role in recalling numerical knowledge and working memory [40-42]. In cognitive stimulation, numerical calculation tasks were integrated with delicate motor tasks. A customized board game, designed to meet the participant's needs, involved practicing real-money calculations through buying and selling objects while advancing through board squares. These tasks facilitated the development of counting skills, money knowledge, addition, and subtraction abilities. Furthermore, they engaged in oculomotor movements and appendicular motor functions (reaching, grasping, controlling arm, hand, finger movements, gripping, and manipulation), as evidenced by the hand muscles' actions when handling objects.

The efforts undertaken in the sessions appear to have yielded positive results in maintaining the participant's cognitive capacity. Her background in commerce, involving daily mental calculation, likely contributed to this outcome. Following the adverse event, cognitive function was initially impaired, manifesting in signs of mental confusion and a decline in abilities. However, there has been a gradual and positive progression since then.

The "Orientation" task yielded positive results, encompassing two components: orientation to time and orientation to place [17]. Functional magnetic resonance imaging studies indicate the involvement of various brain regions in the orientation system, including the precuneus, posterior cingulate cortex, medial prefrontal cortex, inferior parietal lobe, lateral temporal cortices, and lateral frontal cortex [43]. In sessions, tasks activating these areas and encoding orientation-related information were provided. One task involved the participant filling in a monthly calendar, incorporating details like year, month, day of the month, day of the week, country, city, and land of residence in each session. The aim was to enhance the participant's orientation in time and space, utilizing oculomotor movements and appendicular motor functions to mark relevant information for the day. This task likely contributed to the observed positive results, highlighting the potential of such activities in preserving capacities in Alzheimer's patients.

Certain items on the MMSE provide insights into various cognitive functions assessed during the sessions. Items like "recall," "copying," "3-step command," and "calculation" necessitate working memory and attentional capacity [44]. The evaluative "writing" task, involving sentence construction, assesses visuospatial function and the ability to adjust writing within a given space [45]. This task engages complex cognitive functions such as sentence formulation, executive function, and specific language areas [46]. The "copying" task requires visuospatial functions and fine praxis, constituting complex psychomotor tasks [47]. Additionally, the "registration" and "repetition" tasks evaluate immediate memory performance [48].

During cognitive stimulation, corporeality was emphasized, focusing on integrating multisensory elements. Visual tasks involved diverse aspects such as colors, figures, weights, sizes, shapes, discrimination, recognition, identification, and visual memory combined with motor tasks. Auditory stimulation included creating rhythms and songs with the simultaneous engagement of oculomotor movements and appendicular motor functions using various musical instruments. Tactile stimulation incorporated different sensations and textures, targeting mechanical sensory receptors in the sense of touch. The olfactory system was engaged through smells, integrating short and long-term memory exercises during motor tasks. As the program advanced, the difficulty level increased, aligning with the demands of each activity. Motivational strategies like positive reinforcement, demonstration, guided discovery, and verbalization were consistently employed. Encouraging the participant to perform tasks autonomously was also a recurring incentive.

Literature indicates that individuals with AD may display balance and gait deficits [49, 50], with gait speed impairment considered a clinical marker of AD [51]. Muscle mass loss is more accelerated in AD [52]. Gait deficits are noticeable even in the mild stage of AD [49], and motor dysfunction increases across AD stages [53]. Gait speed decreases [54, 55], with a direct link between slowing gait speed and dementia progression [56]. The combination of various PE, including aerobic, strength, and balance exercises [13, 30, 31] and psychomotor exercises in the motor and cognitive stimulation component [10, 57], has proven beneficial in enhancing motor performance. These improvements are directly associated with fall prevention [13].

The participant initially exhibited a shallow quality and speed of gait. However, with the program's implementation, significant improvements were observed in the participant's gait quality, encompassing speed, agility, coordination, and safety while walking. Notably, dynamic balance showed the most noticeable improvement, rendering the participant more independent with reduced need for rebalancing and hesitations during exercises. Starting from the fourth week, with necessary precautions, the participant was encouraged to take short steps without the walking aid. The aid caused the participant to lean forward, diminishing her visual contact with the surrounding space.

Consequently, the participant's awareness of space and posture improved. Looking forward instead of down became a notable shift, crucial for motor execution. Recognizing action boundaries, primarily perceptual and stepping-forward boundaries, is vital in addressing age-associated deterioration of locomotor skills [58].

After the sixth week, a rapid decline occurred due to an adverse event in the study, leading to the loss of several motor skills previously acquired by the participant. This event offers a realistic perspective on the intervention process for AD. Additionally, as cognitive impairment worsens, various aspects of balance control are also affected. Tangen et al. (2014) observed a direct relationship between the severity of cognitive impairment and the degree of balance impairment.

Despite the participant experiencing a decline after one week without exercise and psychomotor stimulation, subsequent progress was evident in the following two weeks of the program. This progress was reflected in improved balance and an increased distance covered in the 6MWT. The participant also exhibited heightened strength levels due to alternating loads in strength exercises (intensity, volume, complexity).

The enhanced lower limb muscle strength likely played a direct role in improving balance and gait quality. The intervention strategies incorporated adjustments to sets and repetitions during exercises, motivation for completion, and positive feedback. Additionally, visualization strategies involving demonstration and performance of exercises were employed. Contrary to expectations, there were no observed improvements or maintenance in ADLs, as assessed by the Barthel Index. The participant's level of dependence in dressing and climbing stairs increased, indicating a severe level of dependence [20]. These outcomes were attributed to the medical conditions experienced by the participants.

Supplementing the results from the intervention program, we conducted an analysis based on the participant's caregiver's input to determine if there were any impacts on the participant's daily tasks. The study revealed improvements in aspects such as lying down, sitting up, and getting up during the program. However, it is crucial to approach the caregiver report cautiously, as there is a potential for reporting bias where caregivers may anticipate improvements due to participation in an intervention. Despite this, the observations were genuine and grounded in the participant's daily life experience.

It is crucial to highlight that the aspects identified as worsening on the Barthel Index align with the overall regression observed in the participant's motor abilities. These activities are interconnected and dependent on the participant's motor function. While programs combining multicomponent PE with cognitive tasks in patients with cognitive impairment have generally shown improvements or maintenance of cognitive performance [59, 60], it's important to note that the intervention program recommended here may not be universally applicable to all patients with AD. Individual factors such as education level, professional practice, engagement in PE, leisure activities, and social involvement must be considered when tailoring interventions. Understanding these personal characteristics in a patient with Alzheimer's is crucial.

Additionally, it is essential to identify the skills that the participant still possesses. Considering the stage of AD and adopting an individualized approach to interventions is vital. More scientific research focusing on the personalized nature of interventions for Alzheimer's patients is necessary. This will enable health professionals to provide more targeted and practical guidance in their interventions. The results also suggest that individualized interventions should be considered for Alzheimer's patients in future interventions.

One of the limitations of intervening with Alzheimer's patients is the challenge of modifying their behavior, especially if these changes are introduced during the progression of AD. The participants may struggle to understand the benefits of these changes and may resist altering their routines. However, the participants in this study readily accepted the various changes proposed in the intervention program.

Additionally, we consider it essential to include a clinical assessment, especially for cardiovascular diseases [61]. Although the participant in this study had a medical diagnosis, maintaining medical supervision can provide appropriate information for the intervention and help formulate individualized cardiovascular prevention and care strategies.

We also suggest that future studies include some objective measurement parameters to study the neurobiological aspect of this combined program. Among others, it would be pertinent to use magnetic resonance imaging to assess prefrontal cortex activation, heart rate variability analysis to monitor autonomic response, and surface electromyography to measure muscle activation [62].

The materials used in the sessions should be tailored to the individual's manipulative skills and cognitive abilities [63]. Throughout the program, various materials were used, including ones that the participant was already familiar with from her daily life. This facilitated quick adaptation and enhanced stimulation.

In implementing this study, the sessions were conducted by specialists in PE prescription and cognitive stimulation. It is emphasized that specialized training in integrating motor, cognitive, and emotional aspects should play a key role in such a program, ensuring the activities are appropriately tailored to individual participant needs. Additionally, we believe it is crucial to consider the integration of these interventions within multidisciplinary teams, where collaboration and coordination among professionals from different specialties can optimize therapeutic outcomes and enhance the quality of life for Alzheimer's disease patients. Furthermore, it is underscored that reevaluating non-pharmacological intervention measures and integrating programs of this nature into frontline approaches are of utmost importance, advocating for their inclusion and prescription within the healthcare system.

In addition to the main limitations of conducting the case study, we should also consider that our main focus was to gain a thorough understanding of AD. This may make the findings less applicable to different contexts or populations. Despite this, this case study provides valuable information and a deep understanding of fundamental strategies that can be applied.

6. Conclusion

A multimodal physical exercise and psychomotor rehabilitation program, implemented over 8 weeks, positively impacted the cognition, balance, and gait of a participant with AD. It also increased cardiovascular capacity and strength despite a medical setback during the intervention. The combination of these two interventions provided a beneficial non-pharmacological approach for the patient with Alzheimer's, suggesting a promising area for future research.

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Author Contributions

All authors have made substantial contributions to most elements of the research explained in this manuscript. Conceptualization, C.F.M. and M.P.M.; Study design: C.F.M. and M.P.M. Methodology, C.F.M., J.S., and M.P.M.; Acquisition of the data: C.F.M. and M.P.M. Formal analysis and interpretation, C.F.M. and M.P.M.; Writing: C.F.M. and M.P.M. Drafting and revising: C.F.M., J.S., and M.P.M. All authors contributed to the critical revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Competing Interests

The authors report there are no competing interests to declare.

Data Availability Statement

Data will be made available on request.

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