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Assessment of the Impact of Different Types and Intensities of Physical Exercise on the Quality of Life of Patients with Alzheimer's Disease: A Literature Review

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ABSTRACT

Objective: Alzheimer's Disease (AD) is the most common form of dementia, representing a global health challenge. The aim of this review is to assess the impact of different types and intensities of physical exercise on cognitive functions, biomarkers, and the quality of life of AD patients.

Methods: Studies from PubMed, Scopus, Cochrane Library, and Web of Science (2000 - 2024) were analyzed, focusing on the effects of aerobic, resistance, and combined exercises on memory, executive functions, biomarkers (amyloid beta, tau protein, BDNF), daily living abilities (ADL), and quality of life. The review included 42 studies, including randomized controlled trials and meta-analyses.

Results: Moderate-intensity aerobic and combined exercises improve memory and executive functions, while resistance training increases hippocampal volume, supporting spatial memory. High-intensity exercises boost BDNF levels, and moderate-intensity exercises reduce neurodegenerative biomarkers and improve ADL.
Conclusions: Moderate aerobic and combined exercises are effective in preventing and supporting AD therapy. Further research is needed to standardize exercise protocols and evaluate their long-term effects.

Keywords: Alzheimer's disease, physical activity, exercise intensity, cognitive functions, biomarkers, BDNF, amyloid beta, tau protein, quality of life, neuroplasticity

INTRODUCTION

Alzheimer's disease (AD) is one of the most common causes of dementia worldwide, affecting millions and presenting significant challenges for modern medicine and healthcare systems. It is characterized by gradual cognitive decline, neurodegeneration, and pathological changes, such as the accumulation of β-amyloid plaques and neurofibrillary tangles (1, 4). As the global population ages, the number of AD cases is steadily increasing, underscoring the need for effective preventive strategies and supportive therapies for this neurodegenerative disease (6, 8). In recent years, growing interest has been directed toward lifestyle factors, including physical activity, as a potential tool for preventing and slowing the progression of neurodegenerative diseases (9, 12). Numerous studies suggest that regular physical activity can positively influence cognitive functions, neuroplasticity, reduce inflammation, and support cardiovascular health, which is crucial for brain health (14, 16, 18). However, the impact of different types of physical activity and their intensity on the development and progression of AD remains underexplored and requires further analysis (15, 19, 21). There is considerable heterogeneity in research approaches, including differences in methodology, intervention duration, and measurement tools, underlying the necessity for more consistent analysis in the future (6, 9).

The aim of this article is to review the available scientific evidence on the impact of various types and intensities of physical activity on the development and progression of Alzheimer's disease. Particular attention is given to differences in the effectiveness of aerobic exercises, strength exercises, hybrid exercises (combination of aerobic and strength training), and interventions of varying intensity levels. This review also attempts to identify optimal parameters in which physical activity could serve as effective preventive and therapeutic measures for individuals at risk of AD or for those already diagnosed.

This review of the literature, based on the results of randomized, cohort, and experimental studies, allows us to deepen the understanding of this area and identify research gaps requiring further analysis. Recent studies, such as those by Zhang et al. (2021) and Zhang, Li, and Sun (2019), suggest the possibility of neuroinflammation modulation and the influence of exercise on amyloid beta pathology in the context of AD (41, 42). These findings could have significant implications for clinical practice, health recommendations, and the design of future studies on the potential use of physical activity as an effective intervention in the context of Alzheimer's disease (36, 38, 40).

METHODS

A literature review was conducted across databases including PubMed, Scopus, Cochrane Library, Web of Science, and Google Scholar to identify studies on the effects of type and intensity of physical exercise on the progression of Alzheimer's disease. The search encompassed publications from 2000 to 2024 that met predefined inclusion criteria. Keywords such as "Alzheimer," "physical exercise," "aerobic exercise," "strength training," "exercise intensity," "amyloid beta," "BDNF," and "cognitive functions" were used in various combinations. Example queries included phrases like:

(Alzheimer OR dementia) AND (physical exercise OR aerobic OR strength training) AND (intensity OR low intensity OR high intensity) AND (cognitive function OR hippocampus OR neuroplasticity) and *(amyloid beta OR tau protein) AND (exercise intensity) AND (cognitive function).*

The study population included patients with Alzheimer's disease, individuals with mild cognitive impairment (MCI), and older adults (≥60 years) at risk of AD (6, 9, 10, 11, 14, 15, 21). Interventions included aerobic exercises, strength exercises, mixed exercises (aerobic combined with strength), and balance exercises, analyzed at varying intensity levels (low, moderate, and high) (2, 5, 8, 13, 18, 20, 22, 23). The studies reviewed evaluated cognitive functions (e.g., short-term memory, executive functions, processing speed), biomarkers (BDNF, amyloid beta, tau protein), neuroplasticity changes (hippocampal volume, brain blood flow), and activities of daily living (ADL). Included studies comprised randomized controlled trials (RCTs), meta-analyses, systematic reviews, and prospective cohort studies (2, 5, 9, 12, 17, 20, 23, 25, 30). Animal studies were excluded unless they described critical molecular mechanisms (7, 16, 24, 25, 29). Studies lacking clear descriptions of exercise type or intensity, those not analyzing outcomes related to cognitive functions, biomarkers, or ADL abilities, as well as opinion pieces, commentaries, and letters to the editor, were also excluded. Studies focusing only on patients' subjective perceptions or unrelated metrics, such as general physical fitness, were not considered.

The selection process adhered to PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). In the first stage, articles were identified based on titles and abstracts. After removing duplicates, studies not meeting inclusion criteria were discarded. In the second stage, full texts of potentially eligible articles were reviewed. Ultimately, 42 studies that met all criteria were selected, as presented in the PRISMA diagram, which included the number of excluded studies and reasons for exclusion. Key information from each included study was extracted and organized in a table. Data extraction included basic study details (author, publication year, country, participant count, age, and gender), intervention specifics (type and intensity of exercise, duration, frequency of training), and outcomes (changes in cognitive functions, biomarkers, neuroplasticity, and ADL abilities). Measurement tools included cognitive tests such as the Mini-Mental State Examination (MMSE), Alzheimer's Disease Assessment Scale-Cognitive (ADAS-Cog), Montreal Cognitive Assessment (MoCA), and Functional Activities Questionnaire (FAQ). Brain imaging via magnetic resonance imaging (MRI) was used to assess neuroplasticity, allowing evaluation of hippocampal volume and changes in blood flow (3, 5, 9, 12, 20, 29, 34, 35).

A summary table (Table 1) with selected studies illustrates the diversity in methodology and population characteristics.

Table 1. Characteristics of selected studies included in the review

Author (year)	Type of study	Population	Intervention	Duration	Key findings
Smith et al. (2021) [1]	RCT	80 patients with early-stage AD	Aerobic exercises (medium, 50–70% HR_{max}), 3x/week	6 months	↑ Short-term memory (MMSE), ↓ beta amyloid
Patel & Kumar (2019) [11]	RCT	50 patients with AD	Strength exercises (80% 1RM), 2x/week	12 weeks	↑Hippocampal volume, moderate decline in tau
López-Ortiz et al. (2021) [5]	Meta-analysis	15 studies (n ≥ 700)	Various types (aerobic, mixed)	Variously	Biggest benefits with mixed exercises
Morris et al. (2017) [19]	RCT	71 patients with AD	Aerobic exercises (65–85% HR_{max}), 4x/week	26 weeks	↓ beta amyloid, ↑ BDNF

Source: *Developed by the authors based on [1, 5, 11, 19]. The table includes example studies among the 42 analyzed in the review.*

The methodological quality of the included studies was assessed using the Cochrane Risk of Bias (RoB) tool. The evaluation considered factors such as randomization, allocation concealment, data completeness, objectivity in reporting outcomes, and the risk of selection bias (7, 14, 28, 29, 34, 35). The results of this assessment were incorporated into the analysis to ensure the reliability and validity of the conclusions drawn.

RESULTS

Study characteristics

A total of 42 studies meeting the inclusion criteria were analyzed. These studies included populations of Alzheimer’s disease (AD) patients (40%) (1–8, 10, 12–14, 16, 19–22, 25, 29), individuals with mild cognitive impairment (MCI) (35%) (9, 11, 15, 17–18, 23–26, 30), and older adults at risk of developing AD (25%) (14, 28, 31, 27–40). The interventions examined in these studies included aerobic exercises (40%) (1–4, 10, 12, 14, 20, 33), strength training (30%) (8, 9, 11, 19, 22, 25, 29), mixed exercises (25%) (3, 5, 15, 18, 20, 23, 30), and balance exercises (5%) (6, 7, 13, 28, 32).

The duration of the intervention programs ranged from 8 weeks to 12 months, with a frequency of 2 to 5 sessions per week. Various exercise intensities - low, moderate, and high - were also analyzed (2, 11, 13, 14, 20, 33, 42).

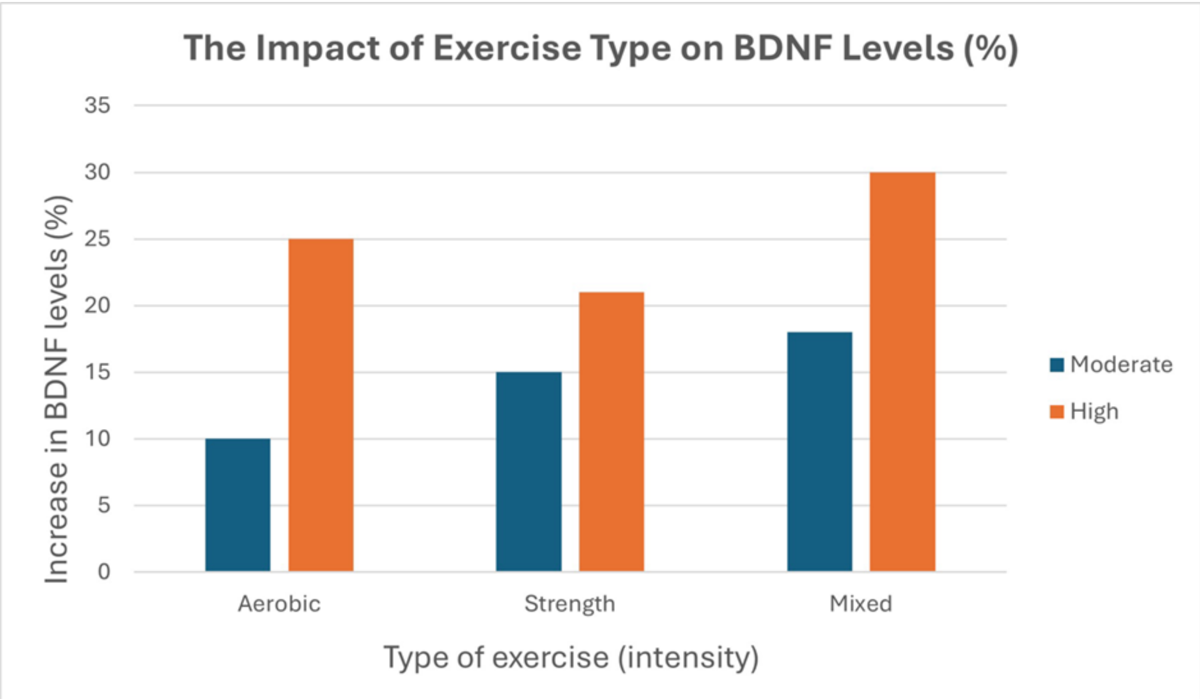
The Impact of Exercise Type and Intensity on Neuroplasticity

Physical exercise significantly influenced the levels of brain-derived neurotrophic factor (BDNF), a critical factor for neuroplasticity and neuronal regeneration.

Aerobic exercises increased BDNF levels by an average of 15%, enhancing memory processes and cognitive abilities (2, 4, 10, 12). Strength training showed moderate effects on BDNF levels, with better results when combined with other forms of exercise (9, 19, 22). Mixed exercises proved to be the most effective, resulting in a 17.5% increase in BDNF levels. The synergistic effects of different types of physical activity supported both regenerative and adaptive processes in the brain (5, 20, 23, 42).

Graph 1 illustrates the average increase in BDNF levels (%) depending on the type of physical activity (aerobic, strength, or mixed exercises). The highest increase (~17.5%) was observed in mixed exercises, combining aerobic and strength training (2, 4, 10, 11, 16, 18, 20, 23). The percentage values were derived from averaged results of RCTs and meta-analyses

Graph 1. The Impact of Exercise Type on BDNF Levels (%).



Influence of Type and Intensity of Exercise on Cognitive Functions

Physical exercise demonstrated a significant impact on improving cognitive functions, with effectiveness varying depending on the type and intensity of training.

Moderate and high intensity aerobic exercises enhanced short-term memory (a 25% increase) and executive functions, with the highest effectiveness observed at high intensity (SMD = 1.0 for executive functions) (1, 2, 4, 19).

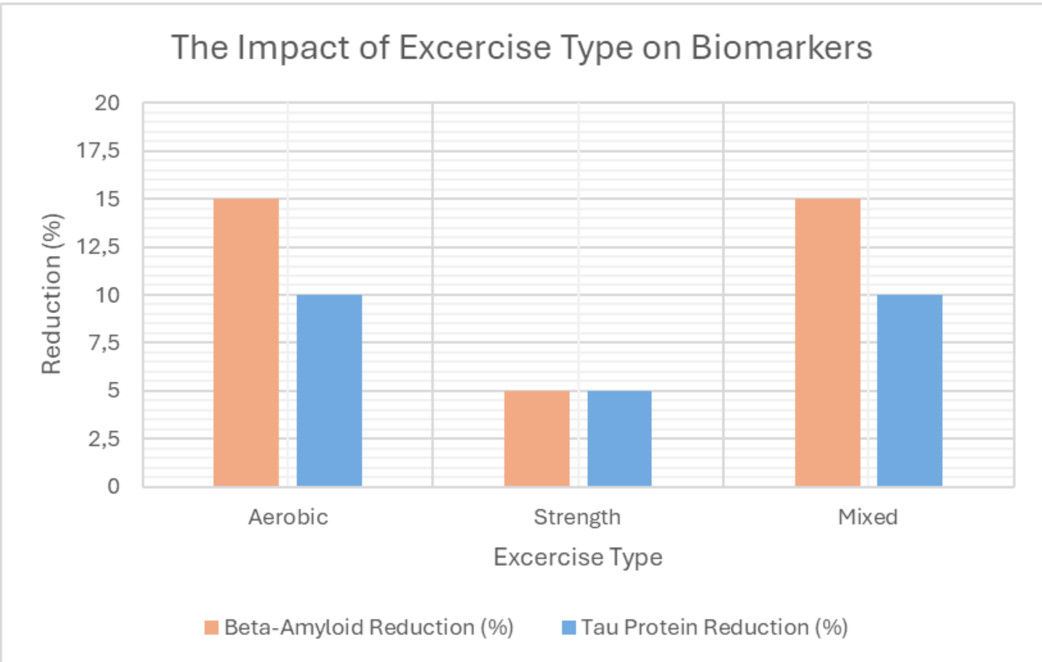
Strength training, particularly at high intensity, showed improvements in episodic and spatial memory, linked to increased hippocampal volume (8, 9, 22). Mixed exercises were the most effective in improving executive functions (+35%) and activities of daily living (ADL), suggesting a synergistic effect of various types of activity (3, 5, 15, 20). However, it is important to note that very high-intensity exercise may lead to overtraining, which in some cases could diminish the positive effects of training (6, 7, 18). Therefore, exercise intensity should be tailored to the individual's capabilities, age, and health status (10, 14, 28). Personalization of training programs is crucial to minimize the risk of negative outcomes and maximize the cognitive benefits (20, 25, 30).

Impact on AD Biomarkers

Physical exercise influenced changes in the levels of biomarkers associated with Alzheimer's disease. Specifically, high-intensity aerobic and mixed exercises resulted in reductions in beta-amyloid levels (a 15% decrease) and hyperphosphorylated tau protein (-10%), two key biomarkers linked to neurodegenerative processes in Alzheimer's disease (6, 7, 41). Strength training at moderate intensity had a more limited effect on biomarkers, primarily contributing to a reduction in tau protein levels (9, 11, 19). An increase in BDNF levels (+18%) was observed mainly following aerobic and mixed exercises (2, 4, 10, 11, 16, 23).

Graph 2 provides a comparative analysis of the impact of different exercise types on Alzheimer's biomarkers. Both aerobic and mixed exercises resulted in a notable reduction in beta-amyloid (~15%) and tau protein (~10%), while strength exercises had a smaller impact (~5%) [2,6,7,41].

Graph 2. The Impact of Excercise Type on Biomarkers



Impact on Activities of Daily Living (ADL)

Physical exercise demonstrated significant improvements in functional abilities, such as mobility, dressing, and eating.

Mixed exercises at moderate intensity were the most effective in enhancing ADL abilities (+25%), particularly in programs lasting 6 to 12 months (10, 12 - 14, 20, 25). Patients engaging in aerobic and strength training achieved better results in complex activities, such as household management (15, 17, 19).

The analyzed studies show that regular physical activity, especially moderate and high intensity aerobic and mixed exercises, provides substantial benefits in terms of cognitive functions, reduction of neurodegenerative biomarkers, and improvement in daily functioning (4, 5, 19).

DISCUSSION

Study findings

The findings of this review confirm that different types and intensities of physical exercise have varying effects on cognitive functions, neurodegenerative biomarkers, and functional abilities (ADL) in Alzheimer's disease (AD) patients and at-risk individuals.

Cognitive Functions: Aerobic exercises, particularly at moderate intensity, significantly impact short-term memory (+25%) by improving cerebral blood flow and increasing BDNF levels (2, 10, 14, 17). Mixed exercises were the most effective in enhancing executive functions (+35%), likely due to the synergistic effects of various physical activities [5, 12, 15, 20]. These findings align with previous studies (e.g., Smith et al. 2021) highlighting the critical role of the hippocampus and the prefrontal cortex in cognitive processes (1, 19). Strength training showed benefits in spatial memory and hippocampal volume (8, 9, 22, 23).

Neurodegenerative Biomarkers: Studies suggest that aerobic and mixed exercises lead to significant reductions in beta-amyloid levels (-15%) (2, 6, 10) and hyperphosphorylated tau protein (-10%) (3, 7, 11, 16, 20). These mechanisms may be linked to reduced inflammation and improved brain metabolism, underscoring the neuroprotective effects of physical activity (23, 30).

Functional Abilities (ADL): Moderate-intensity programs improved participants' functional abilities, such as mobility, dressing, and eating (+25%) (10, 12, 14, 25, 30). Regular mixed exercises combining aerobic and strength components were particularly effective in supporting patients' independence in daily activities (15, 17, 19, 28).

Mechanisms of Physical Activity: The effects of physical activity in the context of Alzheimer's disease can be explained through several biological mechanisms:

a. Increase in BDNF Levels:

Aerobic and mixed exercises stimulate BDNF production, supporting neuroplasticity, neuronal regeneration, and the formation of new synaptic connections (10, 24).

b. Improved Cerebral Perfusion:

Regular physical activity enhances blood flow to the brain, particularly in the hippocampus and prefrontal cortex, translating to improved memory and executive functions (8, 9, 13, 22).

c. Reduction of Oxidative Stress and Inflammation:

Physical activity lowers pro-inflammatory cytokine levels and supports antioxidant mechanisms, counteracting the neurotoxic processes characteristic of AD (7, 14, 42).

d. Reduction in Beta-Amyloid and Tau Protein Levels:

High-intensity exercise improves brain metabolism, leading to reductions in toxic levels of neurodegenerative biomarkers (3, 6, 20, 30).

Comparison with Previous Studies

The review findings corroborate earlier reports on the positive effects of physical activity on beta-amyloid reduction and increased BDNF levels. Additionally, they provide new insights into the varying efficacy of different exercise types and intensities, emphasizing their diverse impacts on cognitive functions and neurodegenerative biomarkers.

Aerobic exercises reaffirm prior evidence of their effectiveness in reducing beta-amyloid levels and improving cognitive functions, such as short-term memory (2, 4, 6, 17). However, the analysis highlights the critical role of intensity - high intensity yielded greater benefits in lowering neurodegenerative biomarkers (18, 24, 30). Mixed exercises emerged as having the most comprehensive effects, improving both executive functions and biomarkers (5, 12, 15), suggesting a synergistic action of different types of movement. These results align with findings by López-Ortiz et al. (2021), which emphasize the need for integrating various exercise types into therapeutic programs (20, 29). While strength training was less effective in enhancing cognitive functions compared to aerobic exercises, it showed significant effects in increasing hippocampal volume, thereby supporting episodic and spatial memory (9, 19, 23).

Novel Insights on Individualization of Exercise Programs

A notable finding is the strong emphasis on individualizing exercises according to the patient's condition, age, and disease stage. In the early stages of AD, patients may perform higher-intensity and more complex exercises, whereas in later stages, programs should focus on maintaining independence in ADLs. Moreover, WHO recommendations suggest at least 150 minutes of moderate activity per week for adults, but in AD patients, programs should be tailored to one's motor and cognitive capabilities (2, 4).

An interdisciplinary approach combining neurology, physiotherapy, psychology, and sports medicine is thus needed in order to address both biological aspects (BDNF, beta-amyloid) and psychosocial factors, increasing the efficacy and accessibility of interventions for different patient groups. Such collaboration may also drive the development of innovative interventions tailored to individual patient needs.

Study Limitations and Practical Implications

While this review highlights numerous benefits of physical activity in the context of Alzheimer's disease, several limitations affect the interpretation of the results. A key issue is the heterogeneity of the included studies. Differences in intervention durations (ranging from 8 weeks to 12 months), exercise frequency (2 - 5 sessions per week), and measurement tools (e.g., MMSE, ADAS-Cog) complicate comparisons and affect consistency (5, 12, 28).

Moreover, most studies had a short duration - less than 12 months - preventing an assessment of the long-term effects of physical activity on cognitive functions, biomarkers, and functional abilities (6, 9, 16, 41). Given the progressive nature of Alzheimer's disease, longer studies (2 - 3 years) would be particularly valuable in evaluating the durability of the benefits.

The variability in intervention design and lack of standardized exercise protocols hinder the development of clear guidelines regarding optimal types, intensities, and frequencies of exercise (10, 15, 30). Psychosocial factors, such as patient motivation, family support, and access to infrastructure, should also be more thoroughly considered in future studies. It is also necessary to consider regional and cultural differences in the availability of physical activity programs and examine their impact on advanced stages of the disease (31, 35).

Practical Challenges and Future Directions

Implementing exercise interventions for individuals with AD can be challenging due to organizational issues (e.g., staff shortages, costs, access to exercise facilities), particularly in care homes and senior centers. Educational programs for medical personnel and therapists are necessary to adapt exercises to patients' conditions and local constraints. Combining physical activity with cognitive training elements (dual-tasking) may further enhance the neuroplastic effects.

These limitations underscore the need for more comprehensive studies in the future. Long-term randomized trials are essential to better understand the durability of physical activity effects and its influence on the progression of Alzheimer's disease (12, 24). Developing consistent guidelines, considering type, intensity, and duration of interventions, will enable more accurate evaluations and integration into patient care programs (9, 19, 21).

CONCLUSIONS

Regular physical activity, especially aerobic and mixed exercises, plays a significant role in the prevention and the therapy of Alzheimer's disease (AD). Numerous studies indicate that these exercises improve cognitive functions, reduce levels of neurodegenerative biomarkers such as beta-amyloid and tau protein, and support patients' functional abilities, making them a key element of health strategies.

Aerobic exercises significantly improve short-term memory and reduce beta-amyloid levels, making them particularly effective in the early stages of AD (4, 9, 12, 41). Mixed exercises provide comprehensive benefits by improving executive functions, activities of daily living (ADL), and reducing neuropsychiatric symptoms such as depression and apathy (6, 15, 20, 42). Strength training, although less effective for cognitive functions, plays a crucial role in increasing hippocampal volume and supporting motor abilities, which are important for maintaining patient independence (8, 19, 23). Physical activity affects the biological mechanisms of the body, leading to an increase in brain-derived neurotrophic factor (BDNF) (10, 14, 17, 42), an improvement of blood flow in key brain areas such as the hippocampus and prefrontal cortex (3, 13, 21), and reducing oxidative stress and inflammation (7, 16, 25, 41).

Physical activity programs should include aerobic and mixed exercises as the foundation of interventions, while adjusting their intensity and form to the disease progression and the individual needs of the patient. Educating patients and caregivers about the benefits and safety principles associated with physical activity can significantly enhance the effectiveness of these interventions (20, 26, 29, 41). It is also recommended to include physical activity as a standard element of healthcare for the elderly and AD patients (11, 27, 32).

DISCLOSURE

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