Research Square

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Sleep Disturbances in Patients with Alzheimer's Disease: A Cross-Sectional Study in Nursing Home and Community-Dwelling Older Adults

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Abstract

Background

Sleep disturbances are among the most common non-cognitive symptoms of Alzheimer's disease (AD) and may substantially affect disease progression, patient functioning, and caregiver burden. Emerging evidence suggests that sleep disorders may appear in the early stages of neurodegeneration and may even precede the clinical diagnosis of dementia. However, limited research has compared sleep disturbances between patients with AD living in institutional care and those living in community settings.

Methods

This cross-sectional study included 70 patients diagnosed with Alzheimer's disease. Participants were recruited from two nursing homes and from individuals living at home who attended occupational therapy at a community support center for patients with AD. Sleep disturbances were assessed using a questionnaire developed for the purposes of this study as well as standardized instruments, including the Epworth Sleepiness Scale (ESS) and the Athens Insomnia Scale (AIS). Cognitive functioning was evaluated using the Blessed Dementia Scale and the Clock Drawing Test. Statistical analyses were performed using non-parametric methods, including the Mann–Whitney U test, Kruskal–Wallis test, and Spearman's rank correlation coefficient.

Results

Sleep disturbances were highly prevalent among the studied patients. The most frequently reported symptoms included excessive daytime sleepiness, frequent nocturnal awakenings, difficulty initiating sleep, and snoring. Many participants reported experiencing sleep disturbances prior to the clinical diagnosis of Alzheimer's disease. A significant positive correlation was observed between the duration of Alzheimer's disease and the severity of sleep disturbances. In addition, residence in nursing institutions was associated with a higher prevalence of sleep disturbances compared with community-dwelling patients. Frequent daytime naps were also associated with increased severity of sleep-related problems.

Conclusions

Sleep disturbances are highly prevalent in patients with Alzheimer's disease and may occur even before the clinical diagnosis of dementia. Both environmental factors and disease duration appear to influence the severity of sleep problems. Early recognition and management of sleep disturbances may represent an important component of comprehensive care and may contribute to improving the quality of life of patients with Alzheimer's disease.

Highlights

Sleep disturbances are highly prevalent in patients with Alzheimer's disease. [1,2]

Daytime sleepiness, nocturnal awakening, and insomnia were the most commonly reported symptoms. [3,4]

Sleep problems are frequently reported before the clinical diagnosis of Alzheimer's disease. [2]

Longer disease duration and institutional residence were associated with more severe sleep disturbances. [3]

The early identification of sleep disturbances may improve patient care and quality of life. [4]

Background

Alzheimer's disease (AD) is a heterogeneous neurodegenerative disorder characterized by diverse clinical, biochemical, neuropathological, and molecular features. These complexities make it difficult to identify a single reliable biomarker or diagnostic test that can clearly distinguish AD from normal aging. [5]

AD symptoms include neuropsychological impairments, such as amnesia, aphasia, apraxia, and agnosia, as well as neuropsychiatric symptoms related to psychiatric and behavioral disorders, leading to a decline in daily functioning. [6]

Clinically, AD progresses through three main stages: mild, moderate, and severe. The boundaries between these stages are often indistinct. In the initial stage, memory problems intensify, known as mild cognitive impairment. In the second stage, cognitive dysfunction worsens and is accompanied by emotional disturbances, visual-motor coordination issues, and significant ataxia. The third stage is marked by the progressive intensification of cognitive and emotional problems, eventually reaching a level comparable to that of a three-year-old child and then a newborn. [7]

Despite significant advancements in medicine, technology, and genetic engineering, many mechanisms underlying AD remain hypothetical and are subjects of ongoing research. Alzheimer's disease (AD) remains one of the most important challenges in modern neuroscience, and many mechanisms underlying its development are not fully understood. It is of utmost importance to discover the mechanisms responsible for the development and progression of AD and to develop effective methods for prevention, treatment, and patient rehabilitation.

Sleep disturbances are increasingly recognized as important components of the clinical presentation of Alzheimer's disease. A growing body of evidence suggests that disrupted sleep may contribute to neurodegenerative processes, whereas neuropathological changes associated with AD can, in turn, alter circadian rhythms and sleep–wake regulation.

Numerous scientific studies have confirmed the frequent occurrence of sleep disorders in patients with AD, with estimates suggesting that 25–35% of patients are affected by this problem. Interestingly, sleep disorders can occur during the preclinical stage of AD, many years before full clinical symptoms manifest.

The etiology of these sleep disturbances in patients with AD is complex and involves degenerative processes in the suprachiasmatic nucleus and its neural pathways, reduced secretion of melatonin, particularly in individuals with the APOE gene, impaired rhythmic activity of vasopressin neurons, and pathological changes in the retina (such as optic nerve degeneration and β-amyloid accumulation). Common types of sleep disorders observed in AD include circadian rhythm disorders (evening hyperactivity), multiple awakenings during the night with disorientation, agitation, and confusion, and increased daytime sleepiness accompanied by numerous naps throughout the day. These disorders further hinder daily functioning, causing decreased activity, irritability, and agitation. In addition, insomnia is positively correlated with worsening mental and cognitive disorders.

Polysomnographic studies on patients with AD have revealed reductions in the third and fourth phases of non-rapid eye movement (NREM) sleep, as well as a decrease in rapid eye movement (REM) sleep duration and amount. These changes may be a consequence of neurodegeneration in the hippocampal structure, leading to decreased sleep spindle density. Moreover, patients with AD experience a "vicious cycle in which sleep disorders exacerbate the progression of the cognitive decline characteristic of AD, and AD in turn intensifies the occurrence of sleep disorders. It is essential to recognize that sleep disorder patterns in AD result from a complex interplay of multiple factors, including morphological and functional changes in the brain, patient behavior and habits, neuropsychiatric symptoms, pharmacotherapy, and comorbidities. [7, 8, 9]

Sleep plays a crucial neuroprotective role in the brain. It aids memory consolidation, regulates metabolism, reduces mental fatigue, and allows specialized enzymes to repair neuronal damage caused by free radicals. Additionally, during sleep, the brain effectively removes by-products and cellular waste, including β-amyloid, which accumulates in the interstitium and in brain cells. It aids memory consolidation, regulates metabolism, reduces mental fatigue, and allows specialized enzymes to repair neuronal damage caused by free radicals. Additionally, during sleep, the brain effectively removes by-products and cellular waste, including β-amyloid, which accumulates in the interstitium and brain cells [7, 10].

Understanding the mechanisms connecting sleep disorders and neurodegenerative processes may be fundamental in planning preventive, therapeutic, and rehabilitative interventions for individuals with AD. [2, 11, 12, 13]

However, relatively few studies have compared sleep disturbances between patients with Alzheimer’s disease living in nursing homes and those living in community settings. Understanding these differences may help identify the environmental factors that influence sleep quality in dementia. [9]

This study aimed to assess the prevalence and characteristics of sleep disturbances in patients with Alzheimer’s disease and analyze their association with disease duration, daytime naps, and place of residence (i.e., nursing home vs. home environment). [10]

Methods

The study utilized a diagnostic survey research method employing both a self-developed questionnaire and standardized measurement scales, including the Cognitive Impairment Assessment Test (according to Blessed), the Clock Drawing Test (according to Sunderland), the Epworth Sleepiness Scale, and the Athens Insomnia Scale (AIS). [11]

Characteristics of Research Tools

This study used the following research tools:

1. Self-developed questionnaire: This comprised 24 single-choice questions and focused on the occurrence of 12 different types of sleep disorders (e.g., difficulty falling asleep, waking up at night, premature awakening in the morning, agitation in the evening, aggression, snoring, daytime sleepiness, sleep apnea, rapid leg movements, screaming at night, and nightmares). Additionally, the questionnaire included questions on respondents'sociodemographic characteristics. [12]

2. Cognitive Impairment Assessment Test by Blessed: This test assesses the degree of cognitive impairment and consists of six questions and tasks. Incorrect answers were recorded, and different coefficients were applied to Questions 4 and 5. The final result was obtained by summing the scores for all questions/tasks. A score within the range of 0–10 points indicates no or mild cognitive impairment, whereas a score of 11–28 points suggests moderate or severe cognitive impairment. [13]

3. Sunderland Clock Drawing Test: This test is used to assess cognitive impairment and evaluates visual-spatial functions, construction praxia, planning, and abstract memory thinking. The participants were asked to enter numbers in the appropriate places on the clock face and set the clock hands to a specified time (e.g., 11:10). The test was scored out of a maximum of seven points. Lower scores indicate poorer cognitive function. [14]

4. Epworth Sleepiness Scale: This scale assesses the degree of daytime sleepiness. Participants rated their likelihood of falling asleep in eight standard everyday situations on a scale of 0–3. The maximum score is 24, with results falling within specific ranges: 0–10 points indicate normal, 11–14 points suggest mild sleepiness, 15–18 points indicate moderate sleepiness, and scores above 18 points indicate very high daytime sleepiness. [15]

5. Athens Insomnia Scale: This scale was used to assess insomnia prevalence. It comprises eight elements, each rated on a scale of 0 (no difficulty) to 3 (severe difficulty). The maximum score is 24, with higher scores indicating poor sleep quality. A score of ≥ 8 indicates the presence of insomnia. [16]

Study Procedures

The study was conducted in Cracow and included two nursing homes and patients living at home who attended occupational therapy at the Community Home of Mutual Aid for People with Alzheimer's Disease. This study included 70 patients diagnosed with Alzheimer's disease (32 women and 38 men). To supplement the interviews and questionnaires, additional information was obtained through interviews

with family members or medical staff caring for the patients. Only patients who consented and met the inclusion criteria (diagnosis of Alzheimer's disease and ability to participate in the study based on the degree of disease advancement) were included. Patients with other types of dementia or those unable to participate were excluded.

This study was conducted once for each patient to investigate the severity of Alzheimer's disease and the incidence and types of sleep disorders in patients. The research design was approved by the Bioethics Committee (consent number: KBKA/75/O/2021).

Data were collected through several sessions between December 2021 and March 2022. Patients completed paper questionnaires with or without assistance (reading and typing answers) based on their level of independence and health status. Follow-up interviews were conducted with the patients' families or medical staff to supplement this information. Patients' medical records were also used to gather data on current comorbidities and pharmacotherapy.

The study included questions about patients' daily activities, occurrence and duration of daytime naps, regular bedtime and waking times, and potential use of hypnotic medications. The length of patients' stay in a nursing institution and the duration of Alzheimer's disease were also considered.

Statistical Analysis

Statistical analyses were performed using Statistica 10 (StatSoft Polska). As the quantitative variables did not follow a normal distribution according to the Shapiro–Wilk test, nonparametric tests were utilized. The Mann–Whitney U test was used to verify the hypothesis that the two analyzed samples were derived from separate populations, and the Kruskal–Wallis test was used to assess whether n independent samples were derived from the same population or from a population with the same median. The relationships between variables were evaluated using Spearman's rank correlation coefficient. Statistical significance was set at $P < 0.05$. The statistical analysis covered data from all scales, tests, questionnaires, and a self-developed questionnaire.

Characteristics of the Study Group

The study involved 70 patients diagnosed with Alzheimer's disease, of whom 51 permanently resided in a nursing home, and the remaining 19 patients lived in their family homes. The sex distribution in the study was relatively equal, with 46% of the participants being female and 54% male. The average age of the participants was 78 (± 8) years.

Regarding the severity of Alzheimer's disease, most patients (43%) were in the mild stage. In terms of health conditions and independent functioning, according to the Barthel Scale, 59% of the participants had moderately severe health conditions and were capable of independent functioning.

The detailed characteristics of the study group are presented in Table 1.

Results

Seventy patients with Alzheimer's disease were included in this study. The results obtained from the individual standardized measurement scales and the correlation analysis of the data are presented below.

Results obtained in the Blessed Cognitive Impairment Assessment Test

The Blessed Cognitive Impairment Assessment (UFP) test categorized respondents into two groups: those with normal or mild cognitive impairment and those with moderate or severe cognitive impairment. Of the participants, 44 (63%) had moderate or severe UFP, whereas 26 (37%) had mild UFP.

The average number of points obtained by the respondents in the Sunderland clock drawing test was three, which was 12 (17%). Twenty-three people (33%) received 0 points, the lowest score and the largest group of respondents. The highest number of points (six) was obtained by 10 people (14%); two people (3%) obtained one and four points, four people (6%) obtained two points, and 17 people (24%) obtained five points.

Results obtained in the Sunderland Clock Drawing Test

The average number of points obtained by the respondents in the Sunderland clock drawing test was 3. Among the participants, 12 (17%) scored average values. The largest group of respondents, 23 (33%), obtained zero points, representing the lowest score. In contrast, 10 participants (14%) achieved the highest score of 6. Furthermore, two people (3%) scored 1 and 4 points, four people (6%) scored 2 points, and 17 people (24%) scored 5 points (Table 2).

Results obtained on the Epworth Sleepiness Scale

The Epworth Sleepiness Scale classifies respondents into four categories: no excessive daytime sleepiness (i.e., the norm), mild, moderate, and very high daytime sleepiness. Most participants (49 individuals, 70%) did not report symptoms of excessive sleepiness and fell within the normal range. Mild daytime sleepiness was reported by 19 participants (27%), while two participants (3%) reported moderate daytime sleepiness. None of the respondents exhibited features indicative of very high daytime sleepiness.

Results obtained on the Athens Insomnia Scale

The average score on the Athens Insomnia Scale was 10. Among the participants, the lowest score (1) was obtained by only one person, whereas the highest score of 18 was obtained by two participants (3%). The largest group of individuals scored between 9 and 12 points, comprising 23 (33%) individuals. Additionally, 18 people (26%) obtained scores ranging from 6 to 8 points, and the smallest group consisted of individuals with scores between 15 and 18 points, which included five people (7%).

The revised version of the "Assessment of the frequency of occurrence of particular types of sleep disorders (Table 2)" section is as follows:

Assessment of the frequency of occurrence of particular types of sleep disorders (Table 2).

The most frequently reported and observed sleep disorders include the following:

1. Daytime sleepiness: A total of 56 (80%) participants reported experiencing daytime sleepiness daily, while seven (10%) reported it once or twice a week, for a total of 63 (90%) participants experiencing daytime sleepiness.

2. Frequent night awakenings: A total of 43 participants (61%) reported waking up frequently at night daily, and 16 participants (23%) reported waking up 1–3 times per week, totaling 59 participants (84%) who experienced frequent night awakenings.

3. Difficulties with falling asleep: 35 people (50%) reported experiencing difficulties falling asleep daily, and 17 participants (24%) reported it once or twice a week, for a total of 52 participants (74%) experiencing difficulties with falling asleep.

4. Snoring: Forty-one participants (59%) reported daily snoring, and three participants (4%) reported snoring once or a few times a week, resulting in a total of 44 participants (63%) experiencing snoring.

Moderate-intensity sleep disorders and their frequencies of occurrence are as follows:

1. Waking up prematurely in the morning: Fifteen participants (21%) reported waking up prematurely in the morning daily, and 17 participants (24.3%) reported waking up prematurely 1–3 times a week, totaling 32 participants (45.3%).

2. Evening agitation: Eleven patients (16%) reported experiencing evening agitation daily, and 20 patients (29%) reported it once or three times a week, resulting in a total of 31 patients (45%).

3. Sleep apnea: Sleep apnea was reported by 24 participants (34 %) on a daily basis.

4. Jerky leg movements: Jerky leg movements were reported daily by 18 participants (26%).

The least-frequent sleep disorders were as follows:

1. Screaming at night: Of the total participants, 52 (74 %) never reported screaming at night, and 12 (17%) reported it less than once a week, totaling 64 (91%) participants.

2. Nightmares: 27 people (39%) had never experienced nightmares, while 36 participants (51%) reported having nightmares less than once a week, for a total of 63 participants (90%).

3. In the evening, 39 people (56%) never showed aggression, and 20 people (29%) reported aggression less than once a week, resulting in 59 people (85%).

4. Reversal of the circadian rhythm: 34 (49%) participants never experienced a reversal of the circadian rhythm, while 21 (30%) reported it less than once a week, totaling 55 (79%) participants.

Assessment of the presence of sleep disorders in the period preceding the diagnosis of Alzheimer's disease

The occurrence of sleep disorders before the diagnosis of Alzheimer's disease was reported by 47 respondents, who constituted 67% of all the participants. In contrast, 23 respondents (33 %) reported no sleep disorders.

Assuming a significance level of $p < 0.05$, we can conclude that there was a statistically significant difference in the sleep disturbance index depending on the occurrence of sleep disturbances before the diagnosis of Alzheimer's disease. By analyzing the data, we found that the median sleep disturbance index was higher in the group of people complaining of sleep disorders before the diagnosis of Alzheimer's disease (Table 3).

Assessment of the duration of Alzheimer's disease and its impact on the incidence of sleep disorders

The average duration of Alzheimer's disease was 4.5 years. The shortest disease duration was 1 year, with 16 patients (22.9%) affected, whereas the longest duration observed was 10 years, with only two patients (2.9%).

The most numerous group comprised individuals with the disease for 4-6 years, totaling 25 people (35.7%). On the other hand, respondents suffering from the disease for ≥ 8 years were the least frequent, with only two people (2.9%) in this category.

Spearman's R coefficient indicated the presence of a significant positive correlation between the sleep disturbance index and duration of Alzheimer's disease. In other words, as the duration of Alzheimer’s disease increased, the frequency of sleep disorders also increased ($R=0.259332$, $p=0.030167$).

Assessment of the mutual correlation between a daily nap and the occurrence of sleep disorders

The largest group of respondents reported the need for a nap every day (n = 58, 83%). The second group comprised individuals who never needed to nap during the day, with seven people (10%). Additionally, three people (4%) reported taking naps 1–3 times a week, and only two people (3%) took naps once a week.

Moreover, the average length of a nap was approximately 2 h, with 22 respondents (31%) sleeping for this duration during the day, representing the largest group. The longest reported nap time was 4 h, with nine participants (13%) requiring this much daytime sleep. In contrast, seven participants (10%) did not take any nap at all, 19 participants (27%) took a 1-h nap daily, and 13 participants (19%) took a 3-h nap.

Assuming a significance level of $p < 0.05$, we concluded that there was a statistically significant difference in the sleep disturbance index depending on the frequency of naps. Analyzing the data, we observed that the median sleep disturbance index had the lowest values in the group of people who took naps 1–3 times per week and the highest in the group who took daily naps (Table 4).

Assessment of the correlation between the length of stay of patients in Nursing Institutions and the severity of sleep disorders

The average length of the patients' stay in the nursing home was approximately two years. Among the respondents, 15 stayed in the nursing institution for two years, and 10 stayed for three years, making a total of 25 respondents (35.7%).

The largest group comprised people living in their family homes (19 people), and nine people stayed in the nursing home for one year, totaling 28 people (40%). Only two people (2.9%) had been living in a nursing home for eight years.

The obtained Spearman's R coefficient indicated the presence of a statistically significant positive correlation between the sleep disturbance index and length of stay in nursing homes. In other words, the longer the patients stayed in the Nursing Institution, the greater the severity of their sleep disorders ($R = 0.311839$, $p = 0.008591$).

Discussion

Recent experimental and clinical studies suggest that disrupted sleep may play an important role in the pathophysiology of Alzheimer’s disease. Sleep deprivation and fragmented sleep are associated with impaired clearance of β-amyloid and tau proteins through the glymphatic system, potentially accelerating neurodegenerative processes. Moreover, alterations in circadian rhythm regulation and reduced melatonin secretion observed in patients with Alzheimer’s disease may further exacerbate sleep–wake disturbance. These mechanisms highlight the potential importance of sleep-focused interventions in comprehensive dementia care. [17]

This study included 70 individuals diagnosed with Alzheimer's disease, comprising 32 women and 38 men. Most respondents had mild or moderate Alzheimer's disease, and the average age of the participants was 78 years. The respondents’ levels of education were generally high, with the vast majority having higher or secondary education. Almost all individuals in the study group experienced sleep disorders, with certain types being more prevalent. [18]

The most frequently reported and observed sleep disorders were daytime somnolence, often requiring a daily nap for several hours; frequent nighttime awakenings accompanied by confusion and anxiety; difficulty in falling asleep; and snoring. The average time required to fall asleep was approximately 1 h. Sleep disturbances of moderate severity and frequency included premature awakening in the morning, evening agitation often associated with aggression and sundowning syndrome, sleep apnea, and rapid leg movements. The least frequent sleep disturbances were related to night screaming, nightmares, evening aggression, and circadian rhythm reversal. [19]

Interestingly, most respondents reported the presence of sleep disorders several years before the manifestation of classic Alzheimer’s disease symptoms and its clinical diagnosis. These preclinical sleep disturbances, often related to insomnia and treated pharmacologically, could have prognostic value,

increasing the risk for Alzheimer's disease. The early detection of such sleep disturbances might enable the implementation of preventive and therapeutic measures before the appearance of dementia symptoms. [20]

The duration of AD significantly increased the incidence of sleep disorders among respondents. As disease duration increases, various factors exacerbate sleep disturbances, such as progressive disability and dependence, deepening depression, worsening mental and cognitive functions, increasing pharmacotherapy, and the presence of comorbidities and somatic symptoms. [21]

Contrary to expectations, daytime napping, which is common among older adults, had an antagonistic effect. Respondents who napped for approximately two hours each day had a significantly higher rate of sleep disturbances than those who napped less frequently or not at all. The need for daytime naps often results from negative factors, such as sleep disruption during the night, pathological daytime sleepiness, lack of activities, boredom, depression, and side effects of pharmacotherapy. Frequent and prolonged daytime naps also disrupt the circadian rhythm in patients with Alzheimer's disease. [22]

Moreover, hospitalization in nursing institutions increases the occurrence of sleep disorders. The reasons for this could include leaving the family home, lack of security in a large, multi-person building, shared rooms, noise generated by other residents, lack of personalized therapeutic care, and insufficient daily activity due to a limited number of rehabilitation and activating activities. [23]

These findings indicate the complex nature of sleep disturbances in Alzheimer's disease and the need for further research and comprehensive interventions to address this critical aspect of the disease. A deeper understanding of the factors influencing sleep disorders could improve the quality of life and care for individuals with Alzheimer's disease. [24]

This study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the results. Second, the cross-sectional design does not allow causal relationships between sleep disturbances and AD progression to be established. Third, sleep disturbances were assessed primarily using questionnaire-based methods rather than objective measurements, such as polysomnography. Finally, the study was conducted in a single geographical region, which may limit the applicability of the findings to other populations.

The results of the present study are consistent with previous research, indicating that sleep disturbances are highly prevalent in patients with Alzheimer’s disease and may represent an important clinical feature of the disorder. Neurodegenerative changes affecting brain regions responsible for circadian rhythm regulation, including the suprachiasmatic nucleus and other sleep–wake regulatory structures, may contribute to the development of these disturbances. Furthermore, sleep disruption may accelerate neurodegenerative processes through mechanisms involving impaired clearance of neurotoxic proteins, such as β-amyloid. These findings highlight the importance of early recognition and management of sleep disorders in patients with Alzheimer’s disease. [25]

In conclusion, this study led to the following key findings:

1. Alzheimer's disease is associated with the occurrence of various sleep disorders, including excessive daytime sleepiness, difficulty falling asleep, frequent nighttime awakenings, snoring, premature morning awakenings, evening agitation, sleep apnea, and sudden leg movements.

2. Sleep disorders observed in the preclinical period before the diagnosis of Alzheimer's disease can intensify and persist throughout the course of the disease and serve as a negative prognostic factor.

3. The duration of Alzheimer's disease was positively correlated with the incidence of sleep disorders, with a longer disease duration resulting in an increased presence of sleep disturbances.

4. Frequent and prolonged daytime naps among patients with Alzheimer's disease can negatively impact nighttime sleep and contribute to the occurrence of sleep disturbances.

5. The stay of patients with AD in nursing home care institutions may exacerbate sleep disorders.

To sum up, sleep disturbances are highly prevalent among patients with Alzheimer’s disease and may occur even before the clinical diagnosis of dementia. Early identification and appropriate management of sleep disorders may play important roles in improving the quality of life and care of individuals with Alzheimer’s disease.

Declarations

Human Ethics and Consent to Participate declarations

This study was approved by the Institutional Bioethics Committee at Andrzej Frycz Modrzewski Cracow University (approval number: KBKA/75/O/2021). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants or their legal guardians.

Consent for publication

Not applicable.

Clinical trial number

No applicable

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon **reasonable request**.

Competing interests

The authors declare that they **have no competing interests**.

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Authors' contributions

MW-P and AT conceptualized and designed the study.

AT collected the data and performed the statistical analysis.

MW-P and AT interpreted the results and drafted the manuscript.

MW-P prepared the final version of the manuscript and approved the final submission.

GD supervised the study and approved the plan of the study.

MR-B supervised the study and critically revised the manuscript.

All authors critically revised the manuscript, read, and approved the final version.

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Tables

Table 1. Characteristic of the study group.

Sex	woman	46%	*n = 32*
	men	54%	*n = 38*
Age	< 70 year	15,7%	*n = 11*
	70 – 80 year	45,7%	*n = 32*
	80 – 90 year	30%	*n = 21*
	90+ year	8,6%	*n = 6*
Education	primary	11%	*n = 8*
	vocational	20%	*n = 14*
	secondary	23%	*n = 16*
	higher	46%	*n = 32*
Duration of Alzheimer's disease	1 – 2 years	22,9%	*n = 16*
	2 – 4 years	22,9%	*n = 16*
	4 – 6 years	35,7%	*n = 25*
	6 – 8 years	15,7%	*n = 11*
	> 8 years	2,9%	*n = 2*
The severity of Alzheimer's disease	mild	43%	*n = 30*
	moderate	33%	*n = 23*
	severe	24%	*n = 17*
Length of stay in the Nursing Home	0 – 1 year	40%	*n = 28*
	1 – 3 years	35,7%	*n = 25*
	3 – 5 years	18,6%	*n =*

			13
	5 – 7 years	2,9%	*n = 2*
	> 7 years	2,9%	*n = 2*
Sleep disturbance before Alzheimer's disease	yes	67%	*n = 47*
	no	33%	*n = 23*
Sleep disturbance index	3 – 4	4%	*n = 3*
	4 – 6	36%	*n = 25*
	6 – 8	33%	*n = 23*
	8 – 10	21%	*n = 15*
	> 10	6%	*n = 4*
Cognitive Impairment Test	normal condition or mild cognitive impairment	37%	*n = 26*
	moderate or severe cognitive impairment	63%	*n = 44*
Clock Drawing Test	0	33%	*n = 23*
	1	3%	*n = 2*
	2	6%	*n = 4*
	3	17%	*n = 12*
	4	3%	*n = 2*
	5	24%	*n = 17*
	6	14%	*n = 10*
Epworth Sleepiness Scale	no excessive daytime sleepiness / normal	70%	*n = 49*
	mild daytime sleepiness	27%	*n = 19*
	moderate daytime sleepiness	3%	*n = 2*
The Athens Insomnia Scale	0 – 3	13%	*n = 9*

	3 – 6	10%	*n = 7*
	6 – 9	26%	*n = 18*
	9 – 12	33%	*n = 23*
	12 – 15	11%	*n = 8*
	> 15	7%	*n = 5*

Table 2. Types and frequency of sleep disorders.

Sleep disturbance	Never		< Once a week		1-3 times a week		daily	
	Number of observations		Number of observations		Number of observations		Number of observations	
	[n]	[%]	[n]	[%]	[n]	[%]	[n]	[%]
Difficulty falling asleep	2	3%	16	23%	17	24%	35	50%
Waking up at night	1	1%	10	14%	16	23%	43	61%
Waking up prematurely in the morning	28	40,0%	10	14,3%	17	24,3%	15	21%
Agitation in the evening	17	24%	22	31%	20	29%	11	16%
Aggression	39	56%	20	29%	9	13%	2	3%
Reversal of the circadian rhythm	34	49%	21	30%	11	16%	4	6%
Snore	25	36%	1	1%	3	4%	41	59%
Daytime sleepiness	5	7%	2	3%	7	10%	56	80%
Sleep apnea	46	65,7%	0	0,0%	0	0,0%	24	34%
Jerky movements of the legs	52	74%	0	0%	0	0%	18	26%
Screams in the night	52	74%	12	17%	6	9%	0	0%
Nightmares	27	39%	36	51%	7	10%	0	0%

Table 3. The results of the Mann-Whitney U test of the sleep disturbance index in relation to sleep disorders before the diagnosis of Alzheimer's disease.

Variable	Mann-Whitney U test relative to the variable: Sleep Disorders Before Alzheimer's Disease Diagnosis marked results are significant with p <0.05000						
Sleep disturbance indicator	Sum of ranks yes	Sum of ranks no	U	Z	p	N important yes	N important no
	1948,000	537,0000	261,0000	3,388613	0,000486	47	23

Table 4. The results of the Kruskal-Wallis rank test of the sleep disturbance index depending on the frequency of naps.

Dependent: sleep disturbance index	Kruskal-Wallis rank ANOVA: sleep disturbance index Independent (grouping) variable: Nap Kruskal-Wallis test: H (3, N=70) = 12,94912 p = ,0047			
	Code	N important	Sum of ranks	Average rank
never	1	7	95,000	13,57143
< once a week	2	2	42,000	21,00000
1-3 times a week	3	3	65,000	21,66667
daily	4	58	2283,000	39,36207