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# Body Composition, Dietary, and Gustatory Function Assessment in People With Alzheimer's Disease

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## Abstract

**Objectives:** Observe the association of foods habits, body composition, lifestyle habits, and loss of gustatory function with Alzheimer's disease (AD). **Methods:** This comparative study enrolled 75 patients with AD (mean age 77.5 years) and 267 healthy volunteers (mean age 73 years). Weight, height, body mass index (BMI), body fat, visceral fat, muscle mass, and waist circumference were measured. Adherence to the Mediterranean diet was measured by the Mediterranean-Diet-Adherence Screener. Gustatory function was investigated using a threshold and triangle test. **Results:** Cases with AD presented lower BMI and weight and higher sleep hours, being statistically significant the difference between cases and controls ($P = .02$; $P = .001$; $P = .001$, respectively). Patients with AD showed lower adherence to exercise and Mediterranean diet as shown by the Mediterranean Diet Adherence Screener–score ($8.12 \pm 2.5$ vs $8.65 \pm 2.4$). The gustatory function was impaired in patients with AD when compared to controls. **Conclusion:** Patients with AD show worst outcomes in terms of anthropometric measurements, lifestyle habits (diet, exercise), and gustatory function than controls.

## Keywords

Alzheimer's disease, body composition, sleep habits, nutrition, gustatory function.

## Introduction

Dementia is a clinical syndrome characterized by a deficit acquired in more than 1 cognitive domain, which represents a loss from the previous level and significantly reduces functional autonomy. Dementia often courses with behavioral and psychological symptoms.[1] The overall global incidence of dementia is estimated to be around 7.5/1000 person-years.[2] The emergence of new cases remains more or less stable up to 65 to 70 years (5/1000 person-years) and from then growth is exponential (around 15, 30, 50, and 70-75/1000 person-years at 75, 80, 85, and 90 years, respectively).[3] The annual incidence of dementia in a study conducted in Spain estimated 10 to 15 cases per 1000 person-years in the population older than 65 years of age.[4] In the European population, a prevalence of dementia between 5.9% and 9.4% is estimated in people older than 65, according to data from the Eurodem consortium and subsequent studies.[5] Prevalence studies in Spain have shown figures ranging from 5% to 14.9% for those older than 65 years of age and between 6.6% and 17.2% for those older than 70 according to a recent review of the National Epidemiology Center of population studies carried out in Spain.[6] In general, the prevalence is higher in women and increases with age.[7]

Alzheimer's Disease (AD) is a clinical and pathological entity of degenerative nature and progressive evolution, which is characterized clinically by cognitive impairment and dementia and neuropathologically by the presence of neurofibrillary tangles and neuritic plaques. It is the most frequent type of dementia, representing up to 70% of cases of dementia.[1] The fundamental symptom of AD is episodic memory loss, which

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initially manifests itself with greater difficulty in recording new information. Aspects of language, visuospatial skills, constructive skills, motor praxis, and executive functions are affected later. There is a progressive loss of autonomy in the usual activities of daily living with the evolution of the disease.[1] The incidence of AD increases with age from 1 to 3/1000 person-years between 65 and 70 years to 14 to 30/1000 person-years between 80 and 85 years and appears to be greater in women. At very advanced ages, it is even higher up to 38.6/1000 person-years between 85 and 89 years and more than 65/1000 person-years in people older than 95 years according to data from the Framingham study.[8] The prevalence of AD is around 0.6% to 0.7% in Europe at 65 to 69 years. The prevalence of AD in our country is around 6% in the group of older than 70 years and represents 70% of dementias.[9]

The main nonmodifiable risk factors for dementia are age (main risk factor for AD),[7] sex (AD is somewhat more frequent in women),[10,11] family history (10%-30% risk of AD in relatives of first degree of affections),[12] and Apolipoprotein E (APOE) allele ε4 (higher risk of AD)[13] according to population and case–control studies.

Among the potentially modifiable factors are cardiovascular risk,[14] hypertension in the middle age of life and hypotension in advanced age,[15] hypercholesterolemia, diabetes mellitus,[16] and hyperhomocysteinemia.[14] In terms of lifestyle, being an active smoker (not being an ex-smoker) is associated with a risk of almost twice as high as AD,[17] and the low consumption of omega-3 fatty acids (fish, Mediterranean diet) may increase the risk of dementia according to data from observational and biological studies.[14] Additionally, physical and intellectual activity is associated with a lower risk of AD or dementia in most longitudinal studies,[14] without being able to determine what type and amount of activity is required or the mechanism by which this association occurs. Moderate alcohol consumption, but not excessive consumption or abstinence, is associated with a lower risk of AD and dementia according to a meta-analysis of 23 longitudinal studies.[18] Obesity and underweight have been associated with increased risk of dementia according to a meta-analysis of prospective cohort studies.[19]

## Aim

### Main objective

The main aim of the study is to contribute to the improvement in scientific knowledge for the management of people with dementia, especially AD, in relation to nutrition and other healthy habits.

### Specific objectives

- Observe the association of different foods habits, body composition, physical activity, and sleep habits in patients with AD.
- Observe the relationship between patients with AD and the loss of the gustatory function.

## Methods

### Design

Cross-sectional, observational, descriptive, and comparative cohort study.

### Sample Size

Initial sample includes n = 342. Cases were recruited at Agencia Madrileña de Atención Social centers in the Community of Madrid and Cognitiva Unidad de Memoria, Spain. Controls who did not have severe chronic diseases, a history of AD diagnosis, or any related disease were recruited at Research Centers in Nutrition and Health, Madrid, Spain. The mean age of controls and participants with AD were 73 ± 7.1 and 77.5 ± 7.7 years, respectively.

Volunteer participants were divided into 2 study groups: group (1) cases with AD and group (2) controls (healthy controls).

### Inclusion criteria

- Men and women with ages between 65 and 96 years old.
- Diagnosed AD, according to Pfeiffer Scale,[20] by experienced psychiatrists in group 1 (cases).
- Controls with no AD diagnosis or severe chronic diseases.
- Sufficient level of understanding to allow their participation in the study.
- Acceptance and voluntary participation.

### Exclusion criteria were as follows

- Severe chronic diseases and any AD drug treatment.
- Participants who did not complete the study correctly or did not sign an informed consent.

### Data Collection

Demographic and clinical data were obtained from all participants. The whole evaluation from the first to the last visit lasted at most 6 weeks. The study variables were established in order to find possible correlations that could help elucidate and achieve the objectives.

### Anthropometry

The following body measures were taken: height (m), body weight (kg), body mass index (BMI), body fat (%), visceral fat (%), muscle mass (kg), waist circumference (cm), and basal metabolic rate (kcal). Height was measured with portable height rod SECA with precision of 1 mm, following the established procedure by the World Health Organization.[21] Body weight, body fat, visceral fat, muscle mass, and basal metabolic rate were measured with a tetrapolar, monofrecuency (20-100 Hz), digital bioimpedance InBody M230 (InBody, UK). Body mass index was calculated from body weight and height with

the Quetelet index.[22] To define cutoff points in BMI, we resorted to Spanish Society of Geriatry and Gerontology and Spanish Society of Parenteral and Enteral Nutrition guidelines for nutritional assessment in elderly individuals.[23] Waist circumference was measured with an inelastic body measuring tape (range 0-150 cm) in the intermediate abdominal region between the last rib and the crest of the ilium.[24]

### Dietary Assessment

The Prevención con Dieta Mediterránea (PREDIMED)[25] test was used to assess adherence to the Mediterranean diet. The PREDIMED study was a primary prevention randomized clinical trial designed to test the hypothesis that the Mediterranean diet would be superior to a low-fat diet for cardiovascular disease protection. The PREDIMED consists of 12 questions on food consumption frequency and 2 questions on food intake habits considered characteristic of the Spanish Mediterranean diet. Each question was scored 0 or 1. One point was given for using olive oil as the principal source of fat for cooking, preferring white meat over red meat, or for consuming (1) four or more tablespoons (1 table spoon = 13.5 g) of olive oil/day (including that used in frying, salads, meals eaten away from home, and so on); (2) two or more servings of vegetables/day; (3) three or more pieces of fruit/day; (4) <1 serving of red meat or sausages/day; (5) <1 serving of animal fat/day; (6) <1 cup (1 cup = 100 mL) of sugar-sweetened beverages/day; (7) seven or more servings of red wine/week; (8) three or more servings of pulses/week; (9) three or more servings of fish/week; (10) fewer than 2 commercial pastries/week; (11) three or more servings of nuts/week; or (12) teo or more servings/week of a dish with a traditional sauce of tomatoes, garlic, onion, or leeks sautéed in olive oil. If the condition was not met, 0 points were recorded for the category. The final Mediterranean Diet Adherence Screener (MEDAS) score ranged from 0 to 14, with higher scores indicating greater adherence to the Mediterranean diet. It allows classifying diet quality into 3 groups: $\leq$8, poor quality diet; 9 to 12, need to improve eating pattern to match Mediterranean model; and >12, optimal Mediterranean diet. For our statistical purposes, we grouped results 0 to 8 as "not adherent or value not optimal" and $\geq$ 9 value as "optimal or adherent."

### Physical Activity

Regular physical activity was assessed using an adapted version of the International Physical Activity Questionnaire (IPAQ) questionnaire that classifies participants into groups doing intense, moderate, and light physical exercise, both during their main activity and in their free time over the last 7 days. A minimum of 150 minutes of exercise a week was established, as reflected by the physical activity levels recommended by the WHO for healthy > 65-year-olds.[26]

### Sleep

Sleep quality was assessed by compiling hours of sleep on week days, including naps as well as hours of sleep on weekends. The resulting average of total weekly hours was compared to the recommendations in the National sleep foundation's,[27] which establishes that elderly individuals older than 65 years should sleep between 7 and 8 hours a day.

### Sensory Analysis of Taste

A battery of ad hoc sensory tests and a score to measure the threshold were designed. The threshold test was used to determine if there was any alteration in taste, giving water with sugar or salt in different concentrations: threshold 1 to 5 for sugar corresponded to 2.5, 5, 7.5, 10, and 12.5 g/500 mL, respectively, and threshold 1 to 5 for salt corresponded to 0.5, 2.5, 5, 7.5, and 10 g/500 mL, respectively. The triangle test was also used, where 3 glasses were offered, one of them with a discordant taste. The participants were asked to identify if there was a different taste among the 3 glasses and to indicate which the discordant flavor was. For these tests, concentrations higher than the threshold concentrations described in Velasco-Rodríguez et al[28] were selected to ensure that all individuals perceive the sweet and salty flavors: solution 1, sucrose 0.075 mol/L: $0.075 \times 342 = 25.65$ g/L; solution 2, NaCl, 0.04 mol/L: $58.5 \times 0.04 = 2.34$ g/L.

Each participant and their legal guardian were provided with an informed consent form. Personal data analysis in this study was carried out under the knowledge and compliance of the Protección de Datos de Carácter Persona (LOPD) law, established by Organic Law 15/1999, December 13, on Personal Data Protection and its complementary regulations.

### Data Analysis

Analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Frequency, percentage, and other descriptive statistics were used to describe and summarize data. Data are presented either as means and 95% confidence intervals for continuous variables or as numbers and percentages for dichotomous variables. We compared the distribution of the selected characteristics between the groups using $\chi^2$ tests for categorical variables or Student $t$ tests or analysis of variance, as appropriate, for continuous variables. $P$ values < .05 were considered statistically significant.

## Results

Baseline characteristics of the study population are shown in Table 1. There were no statistically differences in gender ($P$ = .784), but in age ($P$ < .001), between cases with AD and controls; 41.4% and 58.6% of patients presented normal weight (BMI < 27) and overweight (BMI $\geq$ 27), respectively. Cases with AD presented lower BMI, being the statistically significant the difference between cases and controls ($P$ = .02). A similar situation occurred with weight ($P$ = .001). Another

**Table 1.** Information on Demographics Factors, Sleep, and Exercise by StudyG.

| | AD Cases n (%) | Controls n (%) | Total n (%) | *P* Value |
|---|---|---|---|---|
| Gender[a] | | | | |
| Masculine | 18 (11.3) | 68 (25.5) | 86 (25.1) | .784 |
| Feminine | 53 (33.1) | 184 (68.9) | 237 (69.3) | |
| | Mean (SD) | Mean (SD) | Mean (SD) | |
| Age, years | 77.5 (7.7) | 73 (7.1) | 73.9 (7.4) | <.001[b] |
| Height, cm | 154.6 (10.1) | 157.1 (8.1) | 156.6 (8.6) | .063 |
| Weight, kg | 66 (12.9) | 71.7 (12.5) | 70.6 (12.8) | .001[b] |
| BMI | 27.5 (3.9) | 29 (4.7) | 28.7 (4.6) | .020[b] |
| Body fat (%) | 36.1 (8.8) | 38.3 (7.5) | 37.9 (7.8) | .096 |
| Visceral fat (%) | 12.3 (3.7) | 13.1 (3.9) | 12.9 (3.9) | .247 |
| Muscle, kg | 39.6 (9) | 41.5 (8.1) | 41.2 (8.3) | .175 |
| Waist circumference, cm | 95.5 (15.6) | 96.8 (12.7) | 96.5 (13.4) | .588 |
| Basal metabolic rate, kcal | 1972.7 (394.1) | 2058 (335.7) | 2041.8 (348.2) | .149 |
| Sleep, hours/d | 7.03 (1.9) | 6.2 (1.7) | 6.3 (1.8) | .001[b] |
| Exercise, minutes/week | 370.4 (308.2) | 423.1 (353) | 411.5 (344) | .242 |

Abbreviations: AD, Alzheimer's disease; SD, standard deviation; BMI, body mass index.
[a]Missing data.
[b]Statistically significant differences, *P* Value < .05.

**Table 2.** Frequency and habits of dietary food intake as measured with the 14-point MEDAS.

| | Cases | Controls | *P* Value |
|---|---|---|---|
| MEDAS score, mean (SD) | 8.12 (2.5) | 8.65 (2.4) | .103 |
| ≥9 (good adherence; %) | 48 | 53.2 | .472 |
| ≤8 (bad adherence; %) | 50.7 | 46.4 | |
| PREDIMED test (% of participants scoring 1 on the MEDAS) | | | |
| Olive oil as the principal source of fat for cooking | 94.7 | 96.6 | .869 |
| 4 or more tablespoons of olive oil/d | 68 | 74.9 | .314 |
| 2 or more servings of vegetables/d | 49.3 | 37.8 | .053 |
| 3 or more pieces of fruit/d | 50.7 | 61 | .148 |
| <1 serving of red meat or sausages/d | 77.3 | 86.9 | .105 |
| <1 serving of animal fat/d | 77.3 | 77.5 | .817 |
| <1 cup of sugar-sweetened beverages/d | 77.3 | 77.2 | .764 |
| 7 or more servings of red wine/week | 16 | 24.3 | .098 |
| 3 or more servings of pulses/week | 32 | 28.8 | .533 |
| 3 or more servings of fish/week | 61.3 | 59.2 | .606 |
| <2 commercial pastries/week | 37.3 | 53.6 | .017[a] |
| 3 or more servings of nuts/week | 34.7 | 45.7 | .104 |
| Preferring white meat over red meat | 73.3 | 77.9 | .544 |
| 2 or more servings/week of a dish with sauté sauce | 52 | 59.9 | .315 |

Abbreviations: MEDAS, Mediterranean Diet Adherence Screener; SD, standard deviation; PREDIMED, Prevención con Dieta Mediterránea.
[a]Statistically significant differences, *P* Value < .05.

statistically significant difference was found for sleep hours ($P = .001$). In this case, cases with AD showed better sleep habits than controls, adhering themselves to the National sleep foundation's recommendations, as they slept a mean of $7.03 \pm 1.9$ versus $6.2 \pm 1.7$ hours/day, respectively; 43.7% of patients with AD napped versus 46.9% of controls, and only 9.5% self-considered having a bad quality of sleep versus 14.1%. Physical activity level recommended by the WHO (>150 minutes/week) was more than fulfilled in both the groups, showing a slightly lower adherence the patients with AD.

In general, cases with AD had a slightly lower adherence to the Mediterranean diet as shown by the average MEDAS score ($8.12 \pm 2.5$ vs $8.65 \pm 2.4$; Table 2). PREDIMED score was positively correlated with physical activity ($P = .001$) and hours of sleep ($P = .043$) but not with BMI ($P = .055$). A higher percentage (55.9%) of overweight individuals (BMI ≥ 27) than normal weight individuals (44.1%) had a good adherence to the Mediterranean diet. Statistically significant differences were only found for consumption of commercial pastries ($P = .017$). *P* value of the MEDAS score was not statistically significant.

As shown in Table 3, both the detection and the recognition of sweet and salty favors were reduced in patients with AD compared to controls, being significant in the detection of salty flavor

**Table 3.** Sensory Analysis of Taste by Gender and Group.

| | AD Cases | | | Controls | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Men M (SD) | Women M (SD) | Total M (SD) | Men M (SD) | Women M (SD) | Total M (SD) | Men | Women *P* Value | Total |
| Detects salty flavor (threshold 1 to 5) | | | | | | | | | |
| | 2.5 (0.91) | 2.54 (1.1) | 2.28 (0.64) | 2.25 (0.7) | 1.97 (0.75) | 1.96 (0.62) | .301 | .003[a] | .004[a] |
| Detects sweet flavor (threshold 1 to 5) | | | | | | | | | |
| | 1.88 (0.99) | 2.46 (1.2) | 2.32 (1.14) | 2.3 (1.1) | 1.98 (0.86) | 2.06 (0.94) | .312 | .053 | .205 |
| | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | | $\chi^2$ | |
| Guess salty correctly | | | | | | | | | |
| Yes | 9 (15) | 30 (16.3) | 40 (15.7) | 43 (71.7) | 133 (72.3) | 185 (72.8) | .601 | .553 | .406 |
| No | 2 (3.3) | 5 (2.7) | 7 (2.8) | 6 (10) | 16 (8.7) | 22 (8.7) | | | |
| Guess sweet correctly | | | | | | | | | |
| Yes | 8 (13.1) | 28 (15.2) | 38 (14.8) | 43 (70.5) | 129 (70.1) | 180 (70.3) | .282 | .154 | .096 |
| No | 3 (4.9) | 8 (4.3) | 11 (4.3) | 7 (11.5) | 19 (10.3) | 27 (10.5) | | | |
| Guess different glass | | | | | | | | | |
| Yes | 11 (16.2) | 31 (15.7) | 44 (15.8) | 44 (64.7) | 139 (70.2) | 190 (68.3) | .704 | .089 | .199 |
| No | 2 (2.9) | 9 (4.5) | 12 (4.3) | 11 (16.2) | 19 (9.6) | 32 (11.5) | | | |
| Guess different flavor | | | | | | | | | |
| Yes | 7 (10.4) | 19 (9.7) | 28 (10.2) | 34 (50.7) | 111 (56.6) | 151 (54.9) | .545 | .009[a] | .014[a] |
| No | 6 (9) | 20 (10.2) | 27 (9.8) | 20 (29.9) | 46 (23.5) | 69 (25.1) | | | |

[a]Statistically significant differences, *P* Value < .05.

($P = .004$), specifically in women ($P = .003$), and the recognition of the different taste ($P = .014$), also in women ($P = .009$).

No statistically significant differences were found for "Guess salty correctly" and "Guess sweet correctly" between sexes ($\chi^2 = 0.406$ and $\chi^2 = 0.096$, respectively). According to Pearson's correlation, there is a total positive linear correlation ($\rho = 1$) between "detects salty flavor" and "detects sweet flavor" and age.

## Discussion

A growing body of evidence suggested that particular diets have been linked to a lower incidence of AD and late-life cognitive disorders.[29] The Mediterranean diet is characterized by the use of olive oil as the main culinary fat and high consumption of plant-based foods (fruits and nuts, vegetables, legumes, and minimally processed cereals). It also includes moderate to high consumption of fish and seafood and low consumption of butter or other dairy products and meat or meat products. Regular but moderate intake of alcohol, preferentially red wine during meals, is customary.[30]

In several recent population-based studies,[29,31] higher levels of accordance with a Mediterranean-type diet has been linked to slower cognitive decline, reduced risk of AD, transition from mild cognitive impairment (MCI) to AD, and decreased mortality in patients with AD. Furthermore, the results of these population-based studies were confirmed by very recent systematic reviews and meta-analyses[32,33] showing that adherence to the Mediterranean diet was related to a reduced risk of cognitive impairment and decline, MCI, AD, and progression from MCI to AD.

Surprisingly in this study, overweight patients (BMI $\geq$ 27) had a better adherence to the Mediterranean diet compared to normal weight patients. PREDIMED score was not positively correlated with BMI as it was for physical activity or hours of sleep. According to Cova et al,[34] BMI predicts progression of MCI to dementia and AD. In particular, a higher BMI was associated with a lower risk of dementia and AD, and underweight was associated with a higher risk of dementia. Similar results were obtained in Sobow et al's [35] study, where low initial BMI and losing weight on follow-up had a significantly greater risk of developing dementia. In another study of Cova et al,[36] the authors compared anthropometric measurements in healthy controls, patients with MCI, and patients with AD, observing that AD in both sexes showed significantly lower arm and calf circumferences compared to healthy controls, and men with AD had lower waist circumferences than healthy controls and patients with MCI.

According to our results, patients with AD showed a significantly different nutritional status, based on anthropometry, with respect to cognitively healthy controls. Anthropometric measurements, more precisely weight and BMI, were significantly lower in patients with AD; waist circumferences were lower in patients with AD than in controls. Height, body fat, visceral fat, and muscle mass were also lower in cases with AD. Therefore, our results in patients with AD are consistent with available literature. During aging process, reduction in body weight, height, and fat free mass, associated with an increase in fat mass, is well documented.[37] However, body composition of elderly individuals with AD differs from that of cognitively healthy elderly individuals[38]: Anthropometric measurements and bioelectrical differences in patients with AD compared to controls in the present study corroborate this hypothesis.

Accruing evidence has suggested a possible relation between abnormal sleep characteristics and cognitive

impairment due to both cerebral vascular etiologies and AD.[39] The preclinical stage of AD appears to be associated with worse sleep quality but not with changes in sleep quantity.[40] However, our results show a better self-reported sleep quality in those affected by AD but higher sleep quantity than those with no AD. There is a trend toward increased time in bed in those with AD. One possible explanation may be that individuals with poor sleep efficiency may increase their time in bed to compensate and obtain approximately the same amount of total sleep time.[40] We also assessed naps, since frequent napping is a manifestation of sleep–wake disturbance. The group with AD reported less naps per week in their sleep diaries; however, the difference in group averages was not statistically significant. These results are not in accordance with those of Ju et al[40] who reported more naps per week and a higher proportion of frequent (3 or more days/week) nappers.

Common neurologic disorders such as AD often result in smell and secondary flavor impairment. Symptoms of smell and taste alteration may not be reported directly, since patients may not be aware of this but instead may develop weight loss and loss of appetite.[41] There are only a few reports regarding the gustatory function of patients with AD, and the conclusions are inconsistent. The filter paper disk method used in Ogawa et al study[42] demonstrated decreased gustatory function in patients with AD beyond that of aging. Regarding the detection thresholds, significant differences between the AD and the control groups were found for all the taste qualities (sweet, salty, sour, and bitter). Regarding the recognition thresholds for salty, sour, and bitter tastes, there were significant differences between the AD and the control groups. As for the recognition threshold for the sweet taste, the score of the AD group was higher than that for the control groups although the difference was not significant. These results suggest that failure of taste processing in the brain occurs in patients with AD.

Recently, 2 studies[43,44] have demonstrated impairment of the gustatory function in patients with AD, which support the current findings. Steinbach et al[43] reported a significant decline in recognition thresholds of the 4 basic tastants (sweet, salty, sour, and bitter) in patients with AD compared to age-matched controls, using Taste Strips, which were filter paper strips soaked with the basic tastants in 4 different concentrations. Sakai et al[44] investigated the gustatory function of patients with AD using the filter paper disk method. They showed significantly reduced detection in patients with AD of sweet, salty, and bitter tastes and reduced recognition of sweet and sour tastes. However, Koss et al[45] found no impairment of detection thresholds for sweet and sour tastes in a small group of patients with AD, using a method of pipetting a solution containing tastes. In the present study, both the detection and the recognition of sweet and salty favors were reduced in patients with AD compared to controls, being significant the detection of salty flavor and the recognition of the different taste.

## Conclusion

Cognitively intact individuals have increased chance to maintain healthy lifestyle, while more or less mildly cognitively impaired individuals apparently do not.

Patients with AD showed worst outcomes in anthropometric measurements (lower BMI and weight), slightly lower adherence to physical exercise, and slightly lower adherence to the Mediterranean diet as shown by the average MEDAS score. Gustatory function assessed by the threshold and the triangle tests also decreased in patients with AD compared to controls. Patients with AD adhered to the National sleep foundation's recommendations.

### *Limitations*

It is an observational study, so the results cannot be cause and effect, but they allow understanding and finding behavior patterns and habits that relate/associate with symptoms or with the condition. As this was a case–control study, it is possible that dietary intake was affected by an individual's health status and social background. Thus, causal inference cannot be determined.

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