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THE RELATIONSHIP BETWEEN ADHERENCE TO A MEDITERRANEAN DIET AND COGNITIVE IMPAIRMENT AMONG THE ELDERLY IN MOROCCO

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SUMMARY

Background: The Mediterranean Diet has long been regarded as one of the promising strategies for the prevention of cognitive impairment and Alzheimer's disease. Aim: This study aimed to determine the association between adherence to a MedDiet and the risk of cognitive impairment (CI) among the elderly in Morocco.

Material/ Methods: Due to their complete data, a sample of 172 (56.4% men) from 237 subjects were included in our study. Cognitive functions were assessed by the MMSE test (Mini-Mental State Examination). Adherence to a MedDiet was assessed using a validated questionnaire based on weekly consumption of the seven main MedDiet foods: non-refined cereals, potatoes, fruits (whole or in juice), vegetables (cooked or as salad), legumes, fish, olive oil, and three foods consumed less frequently in a MedDiet: red meats, poultry, and full-fat dairy products. A binary logistic regression was performed, with cognitive function as the dependent variable MedDiet adherence score as well as the aliment consumption frequency associated with CI in the bivariate analysis as an independent variable.

Results: The binary logistic regression adjusted for confounding variables revealed that adherence to a MedDiet is not associated with a lower risk of cognitive impairment (ORa= 0.928; 95% CI; [0.831-1.037]) (ORa: Adjusted Odd Ratio; 95% CI: 95% of Confidence Interval). However, only Olive Oil consumption was a protective factor against CI (ORa= 0.882; 95% CI; [0.815-0.953]).

Conclusions: These findings highlight the importance of sensitizing older adults, whether normal or cognitively impaired, to regular consumption in order to prevent the development of Alzheimer's disease later in life.

Key words: Cognitive impairment, Mediterranean Diet, Alzheimer's disease, dietary behavior, older adult

INTRODUCTION

Aging has been associated with the progression of cognitive decline, which could induce Alzheimer's disease (AD) in 8.3% of cases per year [1,2]. AD is a neurodegenerative disease characterized by memory loss, cognitive and behavioral disorders with repercussions on the daily life of the patient [3]. Some factors contribute to (AD), an abnormally phosphorylated tau protein and a neurofibrillary protein that causes intracellular accumulation. Another accumulation in the extracellular area is β-amyloid peptide (Aβ) at the senile plaques [4]. Extracellular formation of senile plaque and intracellular accumulation causes lesions that preferentially affect the limbic system responsible for memory loss and the neocortex [5]. Memory deficit or mild cognitive impairment (MCI) is one of the earliest and most pronounced AD symptoms [6]. At this stage, the population may constitute a particularly suitable population for preventive approaches and clinical trials of drug therapies [2]. Cognitive impairment (CI), including MCI, is expected to affect 115 million people worldwide by 2050 [7]. The CI can be screened with a brief test that takes only a few minutes to administrate, called MMSE (the Mini-Mental State Examination). This instrument, developed by Folstein et al. 1975, represents the most widely used tool for assessing global cognitive impairment with a specificity and sensitivity of 82% and 87%, respectively [8]. It includes a series of questions grouped into seven subtests. The questions are related to orientation in time, orientation in space, immediate recall of three words, attention, delayed recall of three words, language, and constructive praxis [9].

A traditional Mediterranean diet (MedDiet) is characterized by its high consumption of plant foods (vegetables, fruits, legumes, and cereals), olive oil as the primary source of monounsaturated fats, and low saturated fat consumption of meat and poultry. Fish and dairy products are usually eaten in moderation [10]. A Mediterranean diet combines several foods and nutrients potentially protective against cognitive dysfunction, such as fish, olive oils, vitamins B12 and B9, antioxidants, and flavonoids, which may have a protective effect against cognitive decline in the elderly, similar to its protective role against cardiovascular disease, diabetes, and cancer [11-16].

Actually, in the absence of a successful curative approach to Alzheimer's disease, adherence to a MedDiet may be one of the effective strategies for preventing AD. In cognitively normal individuals, greater adherence to a MedDiet was associated with alleviated risk of cognitive impairment (OR = 0.73, 95% CI, 0.56-0.96, P = 0.02), and Alzheimer's (OR = 0.64, 95% CI, 0.46-0.89, P = 0.007) [17]. Therefore, this study aimed to determine the association between adherence to a MedDiet and the risk of cognitive impairment (CI) among the elderly in Morocco. To our knowledge, this is the first study to investigate this correlation until now.

MATERIAL AND METHODS

Participants

This cross-sectional study was conducted between March 2017 and May 2018, with 172 Moroccan elderly subjects chosen due to their complete data

from a total of 237. All participants were recruited from three nursing homes in Rabat, Kenitra, and the city of Sidi Kacem, as well as one health center in the city of Sidi kacem. The three cities are located in the northwest of Morocco.

The four exclusion criteria were: (1) Subjects who cannot stand up for body composition measurement, (2) age <60 years, (3) Subjects with renal insufficiency, which could confounder and overestimate the body mass index, and (4) Persons with acute pain that could influence their performance on MMSE test. At the beginning, 237 subjects were recruited for this study. Nevertheless, after excluding 56 subjects for MMSE, five subjects for mini nutritional assessment (MNA), 20 subjects for body compositions, and five subjects for physical activity (PA) missing data, 151 subjects were included in our study as a result of their complete data.

Demographic data and medical conditions were gathered from social and medical assistance in nursing homes, as well as direct interviews with patients visiting Sidi Kacem city health center.

Nutritional status and body composition assessment

MNA, a tool developed by Guigoz et al. and recommended by the European Society for Clinical Nutrition and Metabolism [11,12], was used to assess the nutritional status of our sample [11,12]. It consists of 18 items divided into four sections: Anthropometric assessment (weight, height, and weight loss), general assessment (living situation, amount of medicines used, and mobility), dietary assessment (number of meals, food and fluid intake, and autonomy of feeding), and subjective assessment (self-perception of nutritional status and health) [13]. A total score ranging from 24 to 30 reflects good nutritional status, whereas a score between 17 and 23 5 indicates a risk of malnutrition. A MNA score <17 points indicates malnutrition [14].

The participants were referred to a body compositions evaluation using bioelectrical impedance analysis (BIA) (Rossmax, Glass Body Fat Monitor with Scale, model: WF 260, Swiss). The BIA is widely used to study body composition since it is noninvasive, simple, applicable, safe, inexpensive, and requires little patient cooperation [2,15]. The limitation of this tool is that it only provides Fat Mass (FM) in the entire body and not in a specific part of the body. Consequently, another parameter measured in our study was waist circumference (WC), which is utilized as an indicator of body fatness and abdominal body fat [16]. On the exhale, the participants were asked to stand up and measure a flexible non-elastic tape across the belly button between the lower rib margin and the iliac crest at the nearest 0.5 cm of the WC. Fat-Free Mass (FFM) was calculated by subtracting the FM from total body weight.

Evaluation of physical activity

The most commonly used tool for assessing physical activity is the Global Physical Activity Questionnaire (GPAQ). This questionnaire, composed of 16 items, was developed in 2002 within the framework of the WHO "STEPwise approach for Surveillance of risk factors for chronic disease" (STEPS) [9,10]. It was de-

signed to combine the short and long International Physical Activity Questionnaire (IPAQ) strengths by including different domains: work, walking or cycling, leisure, and sitting time [11]. The GPAQ's properties were primarily evaluated in Asia, Africa, and South America.9 Subsequently, the GPAQ was validated against objectively assessed PA in Malaysia [12], Vietnam [13,14], the USA [15], and accelerometers in a recent study in Great Britain [16]. The PA of our sample was evaluated using the GPAQ. The weekly mean and standard deviation of hard and moderate activity was measured by adding the number of minutes in a week of hard work and leisure activities and moderate work and leisure activities. The weekly mean and standard deviation of walking or cycling activities were separately provided. For a sitting time, the mean was calculated by the number of minutes in a typical day of sitting times.

Cognitive function assessment

The MMSE was used to assess the cognitive function, with a cut-off of 24, while the elderly were classified into two categories: normal or cognitive impairment.

Evaluation of Mediterranean diet adherence

Adherence to a Mediterranean diet was assessed using a validated questionnaire of weekly consumption based on the seven main foods of a Mediterranean diet: non-refined cereals, potatoes, fruits (whole or in juice), vegetables (cooking or salad), legumes, fish, olive oil, and three foods consumed less frequently in a Mediterranean diet: red meats, poultry, and full-fat dairy products. The principles of a Mediterranean diet indicate that alcohol should be moderately consumed (less than 300 ml per day), which was already included as a dichotomous question (Yes or No) in the socio-demographic and medical questionnaires. Since there are only five subjects, and none have stated that they consume it more than once a month, all yes responses received a score of 5.

With the exception of Olive Oil, the frequency of weekly consumption of each food was multiplied by 4 to obtain the frequency of monthly consumption. A score of 0, 1, 2, 3, 4, 5 (from lowest adhesion to the highest adhesion) was assigned when a participant reported consumption of 0, 1 to 4, 5 to 8, 9 to 12, 13 to 18, and> 18 servings/month, respectively of the main foods of a Mediterranean diet (non-refined cereals, potatoes, fruits, vegetables, legumes, and fish). In contrast, a score of 5, 4, 3, 2, 1, 0 was attributed to the monthly consumption of 0, 1 to 4, 5 to 8, 9 to 12, 13 to 18, and> 18 portions of red meat, poultry, and full-fat dairy products. With respect to olive oil, a score of 0 to 5 was assigned to a frequency of consumption: never, rarely, <1 time/week, 1-3 times / week, 3-5 times/week, and 7 times/week, respectively [19]. People who do not consume alcohol received a score of 0, while those who consume alcohol received a score of 5 (five people).

Statistical analysis

The statistical analysis was performed using software SPSS version 24. The Chi-square test was used to investigate the association between two categorical

variables. For all quantitative variables, the Mann-Whitney test was utilized to compare normal and cognitively impaired subjects because of their non-normal distribution. The normality distribution of each variable was determined by the Kolmogorov Smirnov and Shapiro Wilk test.

Binary logistic regression was performed, taking the cognitive function as the dependent variable. The MedDiet adherence score, as well as the aliment consumption frequency associated with CI in bivariate analysis, were entered as independent variables and all other outcomes associated with CI in the bivariate analysis as covariate factors. The adequacy of the logistic regression was verified using the Hosmer–Lemeshow test. A P-value <0.05 was considered significant for all analyses.

RESULTS

Baseline characteristics according to gender and cognitive function

Table.1 shows that women in our sample, when compared to men, were more likely to have low education (P=0.034), never had a profession (P=0.000), or a pension (P=0.042), suffer from chronic disease (P=0.037), and depression (P=0.014). Subjects with cognitive impairment were more likely to have a low education (P=0.000), never practice a profession (P=0.01), and be without a pension (P= 0.014). Cognitive impairment is more frequent among women than men (P<0.002).

Nutritional status and body composition according to gender and cognitive function

Table 2 demonstrates that women were in the high tertile of FM (P=0.010), high BMI (P=0.005), and lower sterile of FFM (P=0.000). The women were more likely to have abdominal obesity (P=0.000). The elderly in high tertile of FFM and high class of CC and normal nutritional status were more likely to have a normal cognitive function (P=0.000; P=0.041; P=0.002, respectively).

Physical activity according to gender and cognitive function

Compared to men, women engage in more moderate PA than men (P=0.001). In contrast, men practice more walking or cycling PA (P=0.024). Subjects with cognitive impairment exercise less walking or cycling PA (P=0.027) (Table 3).

MedDiet and its component adherence scores according to gender and cognitive function

Table.4 depicts a significant difference between cognitive impaired and normal subjects for the olive oil component score (p<0.001) and the MedDiet adherence score (p=0.007). However, men and women were comparable for MedDiet and its component scores, with no significant difference detected by the Mann-Whitney test (p>0.05).

Table 1. Baseline characteristics according to gender and cognitive function of Moroccan elderly

	Total N=151	Women N=61	Men N=90	Normal Cognitive function N=49	Impaired Cognitive function N=102	Signification
Gender *n*(%)						
Females	61 (40.4)	40 (48.2)	21 (30.9)	10 (21.3)	51 (49)	**P=0.002**
Age (years) *n* (%)						
]60 to 69]	104(68.9)	43 (70.5)	61 (67.8)	36 (73.5)	68 (66.7)	P=0.929
]70 to 79]	36 (23.8)	14 (23.0)	22 (24.4)	12(24.5)	24 (23.5)	
≥ 80	11 (7.3)	4 (6.5)	7 (7.8)	1 (2)	10 (9.8)	P=0.226
Residence *n* (%)						
Institution care	55 (36.4)	23 (37.7)	32 (35.6)	15 (30.6)	40 (39.2)	P=0.788
Own house	96 (63.6)	38 (62.5)	58 (64.4)	34 (69.4)	62 (60.8)	P=0.304
Education *n* (%)						
Illiterate	89 (58.9)	44 (72.1)	45 (50.0)	11 (22.4)	78 (76.5)	**P=0.034**
< 6 years	41 (27.2)	13 (21.3)	28 (31.1)	26 (53.1)	15 (14.7)	
6 to 9 years	14 (9.3)	2 (3.3)	12 (13.3)	7 (14.3)	7 (6.9)	**P=00.000**
> 9 years	7 (4.6)	2 (3.3)	5 (5.6)	5 (10.2)	2 (2)	
Children's number						
Girls Mean (SD)	1.53 (1.62)	1.54 (1.84)	1.52 (1.32)	1.51(1.36)	1.54 (1.74)	**P=0.040**
Boys Mean (SD)	1.54 (1.44)	1.33 (1.32)	1.79 (1.55)	1.57(1.37)	1.52 (1.48)	
All Mean (SD)	3.07 (2.63)	2.88 (2.75)	3.30 (2.48)	3.09 (2.38)	3.06 (2.75)	P=0.888
Profession *n* (%)						
Never had a profession	35 (23.2)	33 (54.1)	2 (2.2)	4 (8.2)	31(30.4)	**P=0.000**
Farmer	32(21.2)	6 (9.8)	26 (28.9)	11(22.4)	21(20.6)	**P=0.010**
Worker / Artisans	18(11.9)	6 (9.8)	12 (13.3)	6(12.2)	12 (11.8)	
Trader/ Liberal profession	43 (28.5)	12 (19.7)	31 (34.4)	15 (30.6)	28 (27.5)	
Civil servant/ framework	23(15.2)	4 (6.6)	19 (21.1)	13(26.5)	10 (9.8)	
Pension *n* (%)						**P=0.042**
Yes	17 (11.3)	3 (4.9)	14 (15.6)	10 (21.3)	7 (6.7)	**P=0.014**
Alcohol consumption *n* (%)						P=0.150
Yes	3 (2.0)	0 (0.0)	3 (3.3)	1 (2.1)	2 (1.9)	P=0.974
Numbre of Chronique Disease						
None	71 (47.0)	21 (34.4)	50 (55.6)	24 (49)	47 (46.1)	**P=0.037**
1	37 (24.5)	19 (31.2)	18 (20.0)	13 (26.5)	24 (23.5)	
2 or more	43 (28.5)	21 (34.4)	22 (24.4)	12 (24.5)	31 (30.4)	P=0.746
Polymedication						
None	69 (45.7)	25 (41.0)	44 (48.9)	22 (44.9)	47 (46.0)	P=0.583
[1-2]	61 (40.4)	26 (42.6)	35 (38.9)	23 (46.9)	38 (37.3)	
3 or more	21 (13.9)	10 (16.4)	11 (12.2)	8,2 (8.2)	17 (16.7)	P=0,287
GDS-15 score						**P=0.014**
Mean (SD)	7.53 (3.76)	8.43 (3.58)	6.92 (3.79)	6.57(3.75)	7.99 (3.70)	**P=0.033**

Multivariate analysis of the correlation between MedDiet adherence score and cognitive impairment

The MedDiet adherence score was introduced as an independent variable in binary logistic regression adjusted for confounding variables (gender, profession, pension, education, nutritional status, Fat-Free-masse, calf circumference, GDS-15 score, and walking or cycling PA).The result revealed that MedDiet ad-

Table 2. Nutritional status and body composition according to gender and cognitive function of 151 Moroccan elderly

	Total N=151	Women N=61	Men N=90	Normal Cognitive function N=49	Impaired Cognitive function N=102	Signification
FM (Kg)						
First tertile						
[11,69- 22,54]	49 (32.5)	14 (23.0)	35 (38.9)	14 (28.6)	35 (34.3)	[a]**X=9.14;P=0.010**
Second tertile						
[22,68- 31,99]	51 (33.8)	18 (29.5)	33 (36.7)	16 (32.7)	35 (34.3)	[b]X=0.9;P=0.637
Third tertile						
[32,43- 60,89]	51 (33.8)	29 (47.5)	22 (24.4)	19 (38.8)	32 (31.4)	
FFM (Kg)						
First tertile						
[23,91- 39,22]	48 (31.8)	34 (55.7)	14 (15.6)	10 (20.4)	38 (37.3)	[a]**X=34,7;P=0.000**
Second tertile						
[39,31- 46,21]	50 (33.1)	20 (32.8)	30 (33.3)	11 (22.4)	39 (38.2)	[b]**X=15.48;P=0.000**
Third tertile						
[46,44- 80,50]	53 (35.1)	7 (11.5)	46 (51.1)	28 (57.1)	25 (24.5)	
CC (cm) *n* (%)						
< 31	26 (17.2)	10 (16.4)	16 (17.8)	4 (8.2)	22 (21.6)	[a]X=1.85;P=0.174
≥ 31	125 (82.8)	51 (83.6)	74 (82.8)	45 (91.8)	80 (78.4)	[b]**X=4.17;P=0.041**
AC(cm) *n* (%)						
< 23	10 (6.6)	2 (3.3)	8 (8.9)	1 (2.0)	9 (8.8)	[a]X=0.04;P=0.825
≥ 23	141 (93.4)	59 (96.7)	82 (91.1)	48 (98.0)	93 (91.2)	[b]X=2.46;P=0.117
BMI (kg/m2) *n* (%)						
<18,5	2 (1.3)	0 (0.0)	2 (2.2)	0 (0.0)	2 (2.0)	[a]**X=12.93;P=0.005**
18,5 < BMI <24,9	53 (35.1)	15 (24.6)	38 (42.2)	13 (26.5)	40 (39.2)	
25 < BMI < 29,9	52 (34.4)	19 (31.1)	33 (36.7)	20 (40.8)	32 (31.4)	[b]X=3.64;P=0,303
BMI >30	44 (29.2)	27 (44.3)	17 (18.9)	16 (32.7)	28 (27.5)	
Abdominal obesity by WHR *n* (%)						
Yes	115 (76.2)	60 (98.4)	55 (61.1)	36 (73.5)	79 (77.5)	[a]**X=27.7; P=0.000**
No	36 (23.8)	1 (1.6)	35 (38.9)	13 (26.5)	23 (22.5)	[b]X=0.28;P=0.591
Nutritional status *n* (%)						
Normal	74 (49.0)	25 (41.0)	49 (54.4)	33 (67.3)	41 (40.32)	[a]X=2.63;P=0.104
Malnutrition	77 (51.0)	36 (59.0)	41 (45.6)	16 (32.7)	61 (59.8)	[b]**X=9.76;P=0.002**

X: chi-square; [a]association with gender; [b] association with cognitive function

herence was not associated with a lower risk of cognitive impairment (ORa= 0.955; 95% CI; [0.848-1.076]) (p>0.05) (Table.5).

Food consumption frequencies according to gender and cognitive function

Table.6 demonstrates that the mean difference between normal and cognitively impaired subjects was significant only for olive oil consumption (p<0.001). However, no significant difference was found for all other foods. Men and women were comparable for food consumption, with no significant difference revealed by the Mann-Whitney test (p>0.05).

Table 3. Physical activity according to gender and cognitive function for 151 Moroccan elderly

	Total N=151	Women N=61	Men N=90	Normal Cognitive function N=49	Impaired Cognitive function N=102	Signification
Hard PA minutes/ week means (SD)	137.2 (562.9)	66.0 (290.3)	184.6 (684.8)	145 .7 (678)	133 (501.4)	[a]Z=-0.93; P=0.352 [b]Z=0.88; P=0.378
Moderate PA minutes/ week means (SD)	572.4 (961.8)	837.4(1179 .2)	395.7 (740.4)	452.1 (765.7)	630,7(1042.3)	**[a]Z=3.4; P=0.001** [b]Z=1.06; P=0.285
Walking or cycling PA minutes/day means (SD)	207.2(316)	143.2 (242.7)	249.9 (351.5)	273.6 (340.8)	175 (299.8)	**[a]Z=-2.25; P=0.024** **[b]Z=-2.21; P=0.027**
Siting times minutes/day means (SD)	400.7(235.2)	421 (227.2)	386.5 (241.0)	369 .5 (198.4)	415.2 (250.1)	[a]Z=1.21; P=0.226 [b]Z=0.86; P=0.386

Z: Mann Whitney test; [a]association with gender; [b] association with cognitive function

Table 4. MedDiet and corresponding component scores according to gender and cognitive function for 151 Moroccan elderly

	MedDiet and corresponding component scores (mean (SD))						
	All N=151	Women N=151	Men N=151	P-value	Normal N=49	Cognitive Impairment N=102	P-value
Non-refinedcereals	2.7 (1.2)	2.8 (1.3)	2.6 (1.4)	0.435	2.5 (1.4)	2.8 (1.3)	0.074
Potatoes	3.3(1.1)	3.2 (1.3)	3.5 (1.1)	0.521	3.5 (1.2)	3.3 (1,0)	0.155
Vegetables	4.7 (1.1)	4.7 (1.1)	4.7 (1.0)	0.249	4.9 (0.7)	4.6 (1.2)	0.090
Fruit	4.1 (1.9)	4.0 (1.9)	4.1 (1.9)	0.939	4.1 (1.9)	4.0 (1.9)	0.944
Legumes	1.6 (1.2)	1.5 (1.3)	1.7 (1.2)	0.318	1.6 (1.2)	1.7 (1.3)	0.475
Olive oil	3.1 (1.8)	3.0 (1.9)	3.2 (1.8)	0.599	3.9 (1.6)	2.7 (1.8)	**0,000**
Fish	1.5 (0.9)	1.5 (1.0)	1.5 (0.9)	0.953	1.5 (1,0)	1.4 (0, 9)	0.757
Redmeats	3.7 (1.1)	3.8 (1.2)	3.6 (1.0)	0.271	3.7 (1,0)	3.6 (1.1)	0.699
Poultry	2.7 (1.1)	2.6 (1.1)	2.8 (1.2)	0.128	2.9 (1.1)	2.7 (1.2)	0.316
Full-fatdairy	4.5 (4.6)	4.5 (4.8)	4.5 (4.6)	0.621	4.4 (4.3)	4.6 (4.4)	0.315
Alcohol	0.1(0.6)	0.1(0.9)	0.0 (0.0)	0.126	0.1(0.7)	0.1(0.6)	0,886
MedDiet total score	28.7 (4.3)	28.2 (3.4)	28.8 (4.8)	0.061	29.9 (4.4)	28.2 (4.1)	**0.007**

All comparisons between subcategories were performed using Mann Whitney test

Table 5. Binary logistic regression between MedDiet adherence score andcognitive impairment

	ORa	CI 95%	P-value
MedDiet total score	0.955	[0.848-1.076]	0.449

Adjusted for gender, profession, pension, education, nutritional status, Fat-Free-masse, calf circumference, GDS-15 score and walking or cycling physical activity; ORa: adjusted odds ratio; CI: confidence interval

Table 6. Food consumption frequencies according to gender and cognitive function

	Number of servings per week Mean (SD)						
	All N=151	Women N=151	Men N=151	P-value	Normal N=49	Cognitive Impairment N=102	P-value
Non-refinedcereals	7.4(10.8)	8.5(11.7)	6,6 (10.1)	0,384	6.8 (10.5)	7.7 (11.0)	0,084
Potatoes	3.4(0.9)	3,4 (1.2)	3,5 (0,7)	0,826	3.5 (1.0)	3.4 (0.9)	0,324
Vegetables	17.0(8.5)	18.0 (8.9)	16.4 (8.3)	0.249	18.6 (9.0)	16.2 (8.3)	0.152
Fruit	8.7(5.9)	8.5 (5.4)	8.8 (6.2)	0.939	9.3 (6.3)	8.4 (5.6)	0.526
Legumes	1.6(1.3)	1.5 (1.3)	1.6 (1.2)	0.318	1.5 (1.2)	1.6 (1.3)	0.429
Olive oil	4.3 (4.9)	4.2 (5.4)	4.3 (4.7)	0.599	6.1 (4.7)	3.4 (4.9)	**0,000**
Fish	1.4(1.1)	1.4 (1.1)	1,5 (1, 1)	0.953	1.5 (1.2)	1.4 (1.0)	0.905
Redmeats	1.3 (1.1)	1.2 (1.3)	1.3 (1,0)	0.271	1.3 (1.1)	1.3 (1.1)	0.808
Poultry	2.3 (1.3)	2.5 (1.3)	2.2 (1.3)	0.128	2.2 (1.4)	2.3 (1.3)	0.581
Full-fatdairy	1.4 (2.3)	1.4 (1.5)	1.4 (1.2)	0,588	1.4 (1.5)	1.4 (1.2)	0,588

All comparisons between subcategories were performed using Mann Whitney test

Table 7. Binary logistic regression between Olive oil consumption and cognitive impairment

	ORa	CI 95%	P-value
Olive oil consumption	0.906	[0.823-0.997]	**0.043**

Adjusted for gender, profession, pension, education, nutritional status, Fat-Free-masse, calf circumference, GDS-15 score and walking or cycling physical activity; ORa: adjusted odds ratio; CI: confidence interval

Multivariate analysis between Olive oil consumption and cognitive impairment

The binary logistic regression adjusted for gender, profession, pension, education, nutritional status, Fat-Free-masse, calf circumference, GDS-15 score, and walking or cycling PA shows that olive oil consumption was a protective factor against cognitive impairment (ORa=0.906; 95% CI; [0.823-0.997]) (P=0.043) (Table.7).

DISCUSSION

Mild cognitive impairment (MCI) is a transitional stage in which people experience a higher risk of progression to dementia within five years [20]. A MedDiet has long been regarded as one of the promising strategies for the prevention of cognitive impairment and Alzheimer's disease. It is considered a healthier alternative to a Western diet. A MedDiet is a diet with an abundance of plant foods, including fruits, vegetables, bread, other forms of cereals, beans, nuts, seeds, fish, and olive oil as its primary source of monounsaturated fats. In contrast, dairy

foods, red meat, and chicken are consumed in lower quantities, and red wine is consumed moderately with meals [21]. A limited number of research works investigated the association between MedDiet adherence and cognitive function, especially in Morocco.

The objective of the current search was to investigate the association between MedDiet adherence and cognitive function in order to determine if a high adherence to a MedDiet of the elderly could be an effective strategy for preventing cognitive impairment and Alzheimer's disease. A MedDiet presents a valuable source of nutraceutical products including, antioxidants, unsaturated fatty acids, vitamins and phenolic compounds that can control the involved biological mechanisms of cognitive disturbance [35,36]. The current study results suggested that adherence to a MedDiet lifestyle was not a protector factor against cognitive impairment. The benefit of adherence to a Mediterranean-type diet on the evolution of cognitive functions or incidence of dementia has been reported only in three prospective studies [22-24] and one cross-sectional study [25]. In Féart et al.'s [24] study, higher adherence to a Mediterranean-style diet was only mildly associated with a slower decline in the MMSE and not consistent with other cognitive tests, and adherence was not related to the risk of dementia. However, one study investigated the correlation between a Mediterranean-style diet and cognitive decline in women with prevalent vascular disease or more than three coronary risk factors. It has been revealed that following a Mediterranean-style diet was not related to cognitive decline since confounder factors had no significant effect [26].

Another parameter to consider is the rate of cognitive impairment, which in our sample seems very high. None of the studies above have mentioned the percentage of cognitive impairment in their data to compare. Moreover, Tangney et al. [22] reported fewer servings per week of non-refined cereals, vegetables, and olive oil than those reported in our study. Therefore, the association between cognitive impairment and a MedDiet could be due to some specific components of a MedDiet. The Mann-Whitney test analysis revealed that the difference in averages between normal and cognitively impaired subjects was significant only for olive oil consumption ($p=0.000$). Hence, this variable was included in multivariate analysis to be adjusted for other confounder factors. The findings have revealed that olive oil consumption is a protective factor against CI ($p=0.002$). A one-unit increase in consumption was associated with a 12.6% lower risk of developing a CI. Olive oil is a product of mechanical extraction from the olive fruit. It is composed primarily of glycerol fraction (about 95%) called saponifiable fraction composed mainly of oleic acid and non-glycerol fraction (about 5%). Previous experimental investigations have revealed that olive oil decreased remarkably the 42-residue form of the amyloid β peptide deposits, suppression of pE3-Aβ generation, increase the autophagic markers expression via mTOR inhibition and decreased the oxidative stress products [37,38]. Rather than vitamin E, carotenes, and chlorophyll, the non-glycerol fraction (also known as the unsaponifiable fraction) contains many phenolic compounds with a high biological potential [27]. The effect of consuming an extra virgin olive oil-enriched diet on

amyloid- and tau-related pathological alterations was investigated in a mouse model study [28]. According to these study findings, long-term consumption of an extra virgin olive oil-containing diet starting at an early age induces a protective effect against AD and its related disorders. The monounsaturated fatty acids (MUFAs) in olive oil can reduce cholesterol levels, limit cardiovascular risks, and improve cerebral blood flow. A study by Solfrizzi et al. [29] on subjects aged 65 to 84 years, Mini-Mental State Examination [MMSE] with a cut-off <24 was used to screen the cognitive impairment. The results of this study revealed an inverse relationship between MUFAs energy intake and cognitive decline (MMSE < 24). Furthermore, the same authors had conducted a prospective study with an 8.5-year follow-up among non-demented elderly subjects aged between 65 and 84 years evaluated with MMSE, High MUFA, and PUFA (Polyunsaturated fatty acids) energy intakes, and total energy intake was significantly associated with better cognitive performance [12].

The beneficial effect of olive oil cannot be attributed solely to its monounsaturated fatty acid because the phenolic components found in this food have high bioactive effects as demonstrated in several studies. The senile plaques induce an elevated brain inflammation mediator triggered by Microglia attached to the senile plaques. These inflammatory factors can directly harm neurons or activate neurotoxic astrocytes [30]. In some studies, the inflammation markers such as interleukin-6 (IL-6) and C-reactive protein (CRP) were correlated with cognitive impairment and dementia [31], amyloid charge, and neuronal death in a mouse model [32]. In a clinical study, 28 coronary heart disease subjects during three weeks with high phenolic concentration (161 mg/kg) vs. low phenolic concentration (14.67 mg/kg) olive oil, Interleukin-6 and C-reactive protein decreased after consuming phenol-rich olive oil [33]. Oxidative stress and DNA neuronal damage were also among the triggers of CI, Alzheimer's disease, and dementia. Ten healthy subjects were supplemented with high phenolic concentration (592 mg/kg) vs. low phenolic concentration (147 mg/kg) during eight weeks. Olive oil has demonstrated a reduction in DNA damage with the consumption of a phenol-rich olive oil diet. Nevertheless, no difference was detected in the plasma antioxidant capacity [34].

This study has some limitations: First, it is a cross-sectional study that does not associate cognitive function and nutritional status over time. Our sample size is small, and we did not consider sex, age, and education differences in a cut-off classification, which could result in some normal illiterate persons being classified as having CI. Moreover, the study did not account for energy intake, which could be a determinant covariate. Further research with a larger sample size considering these limitations is required to confirm our results.

CONCLUSION

In conclusion, MedDiet adherence is not associated with a lower risk of cognitive impairment, contrary to three previous studies and other evidence. Non-

etheless, according to our findings, olive oil consumption is protective against CI. These findings highlight the importance of sensitizing elderly people, whether normal or cognitively impaired, to their regular consumption in order to prevent the development of Alzheimer's disease later in life. The importance of conducting further research on this food is to confirm our findings and better understand the physiology of this association.

Statement of Ethics

All participants gave written informed consent to be interviewed and used for research purposes and publication.

The current study was approved by the Ethics Committee of Ibn Tofail University under the responsibility of the Biology and Health laboratory. All procedures carried out in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

Conflict of Interest Statement

The authors declared no conflicts of interest.

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Data Availability Statement

The datasets used and analyzed during the present study are available from the corresponding author on reasonable request

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