

Relationship between dietary patterns and mild cognitive impairment (MCI) in elderly women

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Summary. *Context:* Mild cognitive impairment (MCI) is a transitional stage in cognitive performance between changes seen in normal aging and those observed in dementia. Early diagnosis and intervention during the initial stages of mild cognitive impairment can delay or prevent the onset of dementia. Preventive behavioral interventions, for instance changes in dietary patterns, can play a major role in reducing the burden of this disease. *Aim:* The aim of this study was to determine the association between dietary patterns and MCI in the elderly. *Methods and material:* The present case-control study was performed on 82 cases and 163 controls constituted by 60 year-old or older women. We conducted interviews and completed a general questionnaire, IPAQ, FFQ, and MMSE. We used factor analysis and principal component analysis to derive dietary patterns and the chi-square test, independent t-test, and logistic regression to analyze the data. *Results:* There were significant differences between the two groups in terms of educational level ($P = 0.033$), employment ($p = 0.001$), and the number of minutes of study ($P = 0.020$). We identified three dietary patterns including unhealthy, Western, and healthy dietary patterns. There was a statistically significant difference between the two groups only in terms of the healthy dietary pattern ($P = 0.004$). The odds ratio of developing MCI in people who were in the highest tertile of the healthy dietary pattern was 50% lower than those in the first tertile ($OR=0.496$, 95%CI: 0.261, 0.943). *Conclusion:* Our present study demonstrated that only the healthy dietary pattern was significantly associated with MCI and reduced the risk of the disease. It is recommended that further prospective studies be conducted to find more robust relationships.

Key words: dietary patterns, mild cognitive impairment (MCI), the elderly

Introduction

Mild cognitive impairment (MCI) is a transitional stage in cognitive performance between changes that are seen in normal aging and those observed in dementia; it provides an opportunity to identify and prevent Alzheimer's disease in advance (1,2). The prevalence of MCI in people aged over 65 years is between 10% and 20% (3-7). Early diagnosis and intervention during the initial stages of mild cognitive impairment can delay or prevent the

onset of dementia (10). Up to now, no medication has been introduced for the treatment of mild cognitive impairment (11). Therefore, current studies are mainly focused on preventive behavioral intervention or medicine.

Dietary intake, the modifiable lifestyle factor, may affect cognitive function as well as the development and/or prevention of Alzheimer's. However, the epidemiological data on the relationship between diet and the disease have been contradictory (12, 13-16) and the impact of diet on cognitive decline has not been studied

extensively (17). On the other hand, most of the available studies in this context have examined the effect of a single food or nutrient on cognitive disorder, while it is recommended that meals with multiple nutrient combinations be assessed. Indeed, due to synergistic or antagonist interactions between nutrients, the performance of the food network is different from that of a single nutrient or food item (18). Probably, the effect of a single nutrient may be too small and insignificant; in addition, there may be found some accidental relationships caused due to an increase in the Type I error which is itself generated by correlations and interactions between large numbers of nutrients (19). Therefore, instead of studying the components and ingredients of a diet, studies should be focused on dietary patterns or a combination of nutrients together.

Previous epidemiological studies have found an inverse association for Alzheimer's disease and its early symptom, amnesic MCI, with dietary patterns rich in fruits and vegetables, soybean products, legumes, dairy products, unsaturated fatty acids, and fish, but low in saturated fat and simple carbohydrates (20–25). In addition, higher intake of processed foods is associated with some level of cognitive impairment, whilst whole foods and healthy dietary patterns are associated with better cognitive performance (21, 26). Generally, because of the increasing prevalence of dementia, further studies are needed to identify preventive strategies in the early MCI stage.

To the best of our knowledge, only a few studies have been conducted to explore the link between dietary pattern and cognitive impairment, and there is considerable inconsistency in their findings. In addition, most of the information in this context comes from developed Western countries, and little is known about the Middle Eastern and developing nations, the dietary intake of which is considerably different in comparison. Therefore, the aim of this study was to determine the relationship between dietary patterns and MCI in retired elderly women in Tehran.

Materials and method

Study design

The present research is a case control study carried out in Tehran, Iran, in May 2015 which was approved by

the Ethics Committee of Tehran University of Medical Sciences (Project code: 9111468003). This case-control study was conducted on 245 retired elderly women 60 years of age or above who were referred to retirement and health centers in Tehran, Iran. Using a public announcement and direct phone calls to individuals, we invited those who were interested in participating in the study. Eighty two patients with mild cognitive impairment were chosen from among the volunteers and enrolled in the case group and 163 healthy women, who were matched in terms of age and place of residence, were chosen as the control group. All 245 participants were Iranian and had lived in the city of Tehran since birth. Based on our inclusion criteria, only women aged 60 years or above with at least fifth grade education were included. The exclusion criteria were the following: consumption of supplements, being on special diets, taking psychotropic and hypnotic drugs, having been affected by psychiatric diseases, having a history of dementia among family members, having a history of brain surgery or severe trauma to the brain, and addiction to smoking. Samples were voluntarily selected from women who were referred to two retirement centers and the health centers of district six of Tehran Municipality. All participants expressed their willingness to participate in the study with informed written consent.

Cognitive status assessment

Cognition impairment was confirmed by an expert psychologist and using the mini mental state examination (MMSE) (28). The translated version of this questionnaire has been developed and validated by the Elderly Science Department of the University of Welfare and Rehabilitation Sciences, Tehran, Iran (29). The possible scores for this questionnaire range from 0 to 30. Participants were categorized into the three following groups: dementia, if their score was less than 21, mild cognitive impairment, if it was ≥ 21 and ≤ 26 and healthy if it was higher than 26.

Dietary intake assessment

A validated semi-quantities food frequency questionnaire (FFQ), including 168 food items, was used

to assess usual dietary intake over the past year (30). Daily nutrients and energy intake were estimated using an application designed with Excel software; the application was developed by the Institute of Endocrinology and Metabolism of Shahid Beheshti University of Medical Sciences, Tehran, Iran. To identify dietary patterns and reduce data complexity, we classified the 168 food items into 24 food groups based on the similarity of food nutrient profiles, culinary usage, and previous study results (31). In addition, some food items with a unique nutrient profile (such as eggs) or

the use of which could represent a special diet (such as French fries, high energy drinks) were classified as a separate food group (Table 1).

Anthropometric assessments

The height of each subject in standing position without shoes was measured using a wall stadiometer with an accuracy of 0.5 cm. Subjects were weighed without shoes, with minimal clothing, using a digi-

Table 1. Food groups used for the factor analysis

Food groups	Food items
1. Condiments and pickles	Ketchup, lemon juice, pickles
2. Mayonnaise	Mayonnaise
3. Refined grains	White bread, baguette bread, rice, pasta, soup and stew noodle
4. French fries	French fries
5. Non-refined grains	Dark bread (Barbari, Sangak, Taftoon), wholemeal breads, barley, bulgur
6. Full-fat dairy products	Full-fat milk, strained yogurt, full-fat yogurt, cream cheese, cottage cheese and cream, ice cream, curd, chocolate milk
7. Visceral meat	Heart, liver, kidney, tongue, brain, head, legs, tripe & bungs
8. Red meat	Beef and veal, lamb meat, mince meat
9. Processed meats	Sausage, salami, hamburger
10. Egg	Egg
11. High energy drinks	Soft drinks, Non-natural juice
12. Vegetables	Cabbage, carrots, tomatoes, spinach, lettuce, cucumbers, eggplant, onions, stewed vegetables, raw vegetables, green beans, green peas, stewed zucchini, mushrooms, green peppers and bell peppers, turnip, corn, garlic, cooked potatoes, squash, celery, etc.
13. Legumes	Lentils, split peas, beans, peas, lima beans, mung bean, soybean, etc.
14. Fruits and Juices	Cantaloupe, watermelon, melon, prunus, apple, apricot, yellow and red plums, cherries, cherries, sour cherry, nectarines, peaches, pears, fresh figs, dates, grapes, kiwi, pomegranate, strawberry, banana, persimmon, fresh berries, pineapple, citrus, dried fruits, natural juices, etc.
15. Liquid oils	Liquid oils other than olive oil
16. Olive group	Olives, olive oil
17. Fish and poultry	Any fish, canned fish, poultry
18. Low-fat dairy products	Low-fat milk, low fat yogurt and regular yogurt, white cheese, yogurt drink (dough), etc.
19. Solid Oils	Solid vegetable oils, animal fats, butter, margarine
20. Salt	Salt
21. Junk Food	Snacks, chips, crackers
22. Sweets and desserts	Cookies, sweeter, Gaz, Sohan, chocolate, cakes and pastries, honey, jam, sugar, candy, pudding, Halva Shekari, biscuits, fruit compote
23. Tea and coffee	Tea, coffee, espresso
24. Nuts	Almonds, peanuts, walnuts, pistachios, hazelnuts, seeds, etc.

tal scale with an accuracy of 0.1 kg; the subjects were weighed by a trained nutritionist.

Assessment of other variables

To assess the physical activity of the subjects, the short version of the international physical activity questionnaire (IPAQ) (27) was used. General characteristics were determined using the demographic questionnaire.

Statistical analysis

Dietary patterns were identified with the factor analysis method (principal component analysis). The

chi-square test was used to compare qualitative variables and the independent t-test was used to compare the quantitative variables between case and control subjects.

We used varimax rotation to obtain a matrix of simple and interpretable table components and to classify separate and non-correlated dietary patterns. The number of dietary patterns (factors) was determined based on the Eigen value > 1.5, scree plot and their feasibility. A factor loading of 0.3 was considered to determine the food groups in each dietary pattern. Using factor analysis, three major dietary patterns were identified: an unhealthy dietary pattern (loaded with eggs, processed meat, sweets and desserts, high energy drinks, visceral meat, French fries, solid oils, snacks, and mayonnaise), a Western dietary pattern (loaded with French fries, liquid oil, salt, refined cereals, con-

Table 2. Food groups and their loading factors in each dietary pattern

Food groups	Unhealthy dietary pattern	Western dietary pattern	Healthy dietary pattern
Egg	0.607		
Processed meat	0.592		
Sweets and desserts	0.581		
High energy drinks	0.549		
Visceral meat	0.492		
French fries	0.462	0.309	
Natural Oils	0.344		
Junk Food	0.326		
Mayonnaise	0.308		
Liquid oils		0.683	
Salt		0.556	
Refined grains		0.511	
Whole grains		-0.413	
Condiments and pickles		0.370	
Fish and poultry		-0.358	0.318
Tea and coffee		-0.340	
Red meat		0.333	
Vegetables			0.707
Fruits and Juices			0.528
Low-fat dairy products			0.528
Nuts			0.449
Full-fat dairy products			-0.353
Olive group			0.338
Legumes			0.334
% of total variance explained	12.535	8.309	7.206

Loading factors less than 0.3 are deleted to simplify the table.

diments, pickles, and red meat), and a healthy dietary pattern (loaded with poultry and fish, vegetables, fruits, low-fat dairy products, nuts, the olive group, and legumes) (Table 2). The last pattern was responsible for 28.050% of the total variance. The scores of the dietary patterns were computed by summing up the intakes of the food groups weighted by their factor loadings, and a factor score was given to each participant for each recognized pattern (54). The general characteristics of the case and control subjects were compared using the independent sample t-test for continuous variables or the Chi-square test for categorical variables. We categorized the subjects based on the tertiles of the dietary patterns. To examine the differences in age- and energy-adjusted dietary intake across the tertiles of the dietary patterns, we used covariance analysis (ANCOVA). Multiple logistic regression was performed to estimate the ORs and 95% of the CIs for the presence of cognitive impairment across the tertiles of the dietary patterns in crude and multivariable-adjusted models. We used SPSS V. 160 software for data analysis and set the P-value < 0.05 as the significant level.

Results

The relative and absolute frequency of the qualitative characteristics in the case and control groups is shown in Table 3. There was a statistically significant difference between the two groups in terms of the status of their education and employment before retirement ($P < 0.05$); additionally, the controls had better employment and higher levels of education as compared with the case group.

Table 4 presents the mean and standard deviation of the quantitative characteristics of the subjects in terms of their MCI status. There was a significant difference between the two groups in terms of the number of minutes of study ($P = 0.020$). The difference between the two groups in terms of sleep hours per day was not statistically significant; however, the observed difference was important and (Difference = 0.32, $P = 0.098$). The relative and absolute frequencies of the case and control groups in the tertiles of food pattern scores are presented in Table 5. In the highest tertile of the unhealthy dietary pattern as compared with the lowest tertile, the percentage of the patients

Table 3. Comparison of relative and absolute frequency of case and control groups in terms of qualitative characteristics using chi-square test

Variable name		Case	Control	Pvalue*	Total
		N(%)	N(%)		N(%)
Education	Elementary school	10(12.2)	8(4.9)	0.033	18(7.3)
	Middle school	8(9.8)	6(3.7)		14(5.7)
	High school diploma	39(47.6)	89(54.6)		128(52.2)
	University	25(30.5)	60(36.8)		85(34.7)
Employment status before retirement	Worker	23(28)	18(11)	0.001	41(16.7)
	Employee/Expert	58(70.7)	144(88.3)		202(82.4)
	Manager/Boss	1(1.2)	1(0.6)		2(0.8)
Marital status	Married	59(72)	124(76.1)	0.191	183(74.7)
	Single	1(1.2)	5(3.1)		6(2.4)
	Widow	21(25.6)	27(16.6)		48(19.6)
	Divorced	1(1.2)	7(4.3)		8(3.3)
Physical activity level	High	18(22)	29(17.8)	0.321	47(19.2)
	Moderate	56(68.3)	107(65.6)		163(66.5)
	Low	8(9.8)	27(16.6)		35(14.3)

* The P-value < 0.05 is considered significant.

Table 4. Comparison of mean and standard deviation of quantitative characteristics of the subjects in terms of their MCI status using independent T test

Variable name	Case N=82	Control N=163	Pvalue*
Age (years)	63.94±4.72	63.57±4.32	0.551
BMI (Kg/m ²)	26.80±3.52	27.08±3.07	0.543
Family size	2.74±1.28	2.82±1.05	0.661
Sleep hours (h)	6.80±1.45	7.12±1.26	0.098
Study duration (min)	42.23±53.43	59.23±53.56	0.020
MMSE score	25.05±1.21	27.85±0.98	0.00
Total physical activity (MET min/week)	2294.03±1697.21	2083.7±0.98	0.376
Education (%)			0.033
Elementary school	10(12.2)	8(4.9)	
Middle school	8(9.8)	6(3.7)	
High school diploma	39(47.6)	89(54.6)	
University	25(30.5)	60(36.8)	
Employment status before retirement			0.001
Worker	23(28)	18(11)	
Employee/Expert	58(70.7)	144(88.3)	
Manager/Boss	1(1.2)	1(0.6)	
Marital status			0.191
Married	59(72)	124(76.1)	
Single	1(1.2)	5(3.1)	
Widow	21(25.6)	27(16.6)	
Divorced	1(1.2)	7(4.3)	
Physical activity level			0.321
High	18(22)	29(17.8)	
Moderate	56(68.3)	107(65.6)	
Low	8(9.8)	27(16.6)	

* The P-value < 0.05 is considered significant. Abbreviations: BMI: Body Mass Index, MMSE: Mini-Mental State Examination, MET: Metabolic Equivalent of Task

was higher and that of the controls was lower. However, there was no significant difference between the distribution of the cases and the controls in the different tertiles of the unhealthy and Western dietary patterns ($P < 0.05$). Compared with the people who were not affected by the disease, in the first tertile of the healthy dietary pattern, the percentage of people with MCI was higher and in the second and third tertiles, it was lower. There was a significant relationship between the healthy dietary pattern and the risk of MCI ($P = 0.004$).

The adjusted odds ratios and 95% confidence intervals for the risk of MCI in the different tertiles of the healthy dietary pattern are presented in Table 6. To facilitate data analysis and interpretation, educational levels were classified into two more general categories: below high-school diploma, high-school diploma and higher. As shown in Table 6, the relationship between the healthy dietary pattern and MCI was significant and even after adjusting the variables, the effect of education remained significant. Compared with those in the first tertile, the subjects in the third tertile of

Table 5. Comparison of relative and absolute frequency of case and control groups in tertiles of food pattern scores using chi-square test

Dietary pattern	Dietary pattern's tertile	Case N(%)	Control N(%)	Pvalue*	Total
Unhealthy dietary pattern	First tertile	24(29.3)	57(35)	0.170	81(33.1)
	Second tertile	24(29.3)	58(35.6)		82(33.5)
	Third tertile	34(41.5)	48(29.4)		82(33.5)
Western dietary pattern	First tertile	30(36.6)	52(31.9)	0.710	82(33.5)
	Second tertile	27(32.9)	54(33.1)		81(33.1)
	Third tertile	25(30.5)	57(35)		82(33.5)
Healthy dietary pattern	First tertile	38(46.3)	43(26.4)	0.004	81(33.1)
	Second tertile	19(23.2)	63(38.7)		82(33.5)
	Third tertile	25(30.5)	57(35)		82(33.5)

* The P-value < 0.05 is considered significant.

Table 6. Calculation of Adjusted odds ratios and 95% confidence intervals for the risk of MCI in different tertiles of healthy dietary pattern using logistic regression†

Healthy dietary pattern	First tertile (reference)	Second tertile	Third tertile	P-trend
Model 1	1	0.341 (0.174-0.669)‡	0.496(0.261-0.943)	>0.05
Pvalue*		0.002	0.032	
Model 2	1	0.344 (0.173-0.682)	0.513(0.267-0.986)	>0.05
Pvalue		0.002	0.045	

† In model 1, the effects of confounding variable are unadjusted. In model 2, the effect of literacy is adjusted.

* The P-value < 0.05 is considered significant.

‡ The values are reported based on their odds ratio (95% confidence interval).

the healthy dietary pattern had an approximately 50% lower risk of developing MCI ($P < 0.05$). As presented in the Table, the risk of developing MCI in the second tertile of the healthy dietary pattern was less than that in the third. This finding suggests that the relationship between MCI and the healthy dietary pattern does not follow a linear model and those who follow a moderately healthy dietary pattern are less at risk of developing MCI.

Discussion and conclusion

In the present study, we found that a healthy dietary pattern was inversely associated with the risk of MCI. This relationship remained significant even after adjusting for potential confounders. No significant relationship was observed between an unhealthy and a Western dietary pattern with the risk of MCI.

In this study, there was no significant relationship between an unhealthy and a Western dietary pattern and MCI. Consistent with the results of our study, Ashby-Mitchell et al. showed that dietary patterns rich in snacks, processed foods and red meat, as well as the Western dietary pattern were not significantly related to the risk of cognitive impairment (32). Nevertheless, some studies have reported a significant relationship between unhealthy and Western dietary patterns and the risk of cognitive impairment. Direct links between processed foods, dietary pattern and relative risk of cognitive impairment (33), level of cognitive impairment and poor physical function (26) have been shown in epidemiological studies. In a case-control study, people with Alzheimer's were habituated to an unhealthy dietary pattern (34).

The difference between the results of the mentioned studies and those of our study can be attributed to differences in the type of study, sample size,

and characteristics of the studied subjects. In addition, most of the previous studies have combined the features of unhealthy and Western dietary patterns and considered them collectively as a more general dietary pattern called either the unhealthy dietary pattern or the Western dietary pattern. In our study, however, the umbrella term “unhealthy dietary pattern” was itself divided into two categories i.e. the unhealthy dietary pattern and the Western dietary pattern. If in future research these features are combined and put in a more general pattern, the combination of the unhealthy and Western dietary patterns would probably show a relationship with cognitive impairment.

The direct relationship between an unhealthy dietary pattern and MCI can be attributed to different mechanisms. The increment of free radicals and oxidative stress can damage nerve cells and lead to impaired cognitive function (35); moreover, it is well established that higher fat intake is associated with increased oxidative stress (36), atherosclerosis and thrombosis, the conditions which are probably associated with dementia and cognitive impairment (37). Moreover, Apo E gene, involved in the pathogenesis of Alzheimer's disease, has a strong relationship with lipid metabolism and changes in cholesterol concentration in response to dietary fat (38). There is also some evidence suggesting that saturated fat and refined carbohydrates are associated with neurologic changes in the hippocampus and consequently disrupt cognitive function.

According to the results of our study, there was a significant inverse relationship between a healthy dietary pattern and the risk of MCI. The healthy dietary pattern in this study, like the Mediterranean dietary pattern, was loaded with fish, vegetables, fruits, nuts, olives and olive oil, and legumes; as the only difference, the healthy dietary pattern in our study included poultry and low-fat dairy products. In line with the results of our study, many studies have shown a significant inverse association between healthy dietary patterns and cognitive impairments. Several observational studies have reported a negative association between a healthy dietary pattern, which is mainly characterized by high intake of salad dressing, nuts, fish, tomatoes, poultry, cruciferous vegetables, fruits, dark green leafy vegetables, and low intake of high fat dairy products, red and visceral meat and butter, and the risk of Al-

zheimer's disease (23) and cognitive impairment (33), but a positive association with MMSE scores (39) and cognitive function (40). However, other investigators have failed to find any significant association between healthy patterns and MCI (26). Perhaps, due to the small sample size of the mentioned study and the exclusive assessment of patients with MCI, the results did not show any relationship between dietary pattern as a whole and cognitive function (26). In a longitudinal study, higher adherence to the Mediterranean dietary pattern was associated with slower reduction in the MMSE score, but was not associated with other cognitive tests and the risk of dementia (22). In another prospective study by Cherbuin et al, adherence to the Mediterranean dietary pattern had no protective effect against cognitive impairment (41). Generally, the discrepancies between our findings and earlier studies might be related to the differences in study design, the studied samples, or the different methods used to identify dietary patterns. For instance, most of the mentioned studies are prospective studies and use the scoring method of the Mediterranean dietary pattern to examine the relationship between dietary pattern and cognitive function.

The favorable link between a healthy dietary pattern and cognitive function might be related to the higher consumption of fruits and vegetables which prevent oxidative damage (42-44) through their high content of beta-carotene. Vitamin E which has a powerful antioxidant effect can have an impact on Alzheimer's disease (16). Dietary fatty acids which play a role in atherosclerosis, thrombosis, or inflammation can affect the evolution of the brain, the membrane function, and the accumulation of amyloid beta; accordingly, they may have an impact on dementia or cognitive functioning (37). Some studies have reported evidence of the beneficial effects of PUFA fats like fish and MUFA fatty acids (12, 47). Omega-3 fatty acids which have anti-inflammatory, antioxidant, and anti-thrombotic features are useful for brain health (48). Another likely connection between diet and cognitive function is attributed to the presence of high levels of homocysteine, an intermediate component in the methionine metabolic cycle in patients with Alzheimer's disease and cognitive impairment (49). Homocysteine is directly linked to the cognitive function and plays

a role in the occurrence of this disease (49). Vitamins B6, B12 and folate can reduce the amount of circulating homocysteine with methyl transport or deamination with the production of methionine or cysteine and consequently cause a decrease in Alzheimer's disease (16). Inflammation is another factor affected by dietary intake (35, 50) and can mediate the relationship between cognitive problems and diet (51).

This study has some limitations. First, the sample size in this study was small, while in case-control studies on dietary patterns a larger sample size is usually needed. Some variables that may be associated with cognitive performance such as income were not evaluated in this study, so they might have had confounding effects. In this study, dietary patterns were assessed using the FFQ. This is a suitable tool for collecting food data in epidemiological studies but might generate some errors such as over-reporting or under-reporting (19, 52). Another common limitation of dietary pattern analysis is the fact that the results of this method are dependent on the characteristics of the population such as geographic region, race, and culture. In addition, there is no golden standard in factor analysis to determine the number of factors and name the patterns. Finally, the researchers can make discretionary decisions about food groupings and the number of factors; such decisions may affect the findings and their interpretation (53). Another limitation of this study was its exclusive focus on women; consequently, generalizing the results to the entire population of the elderly is not possible.

One of the strengths of this research is that it is the first study examining the relationship between dietary pattern and MCI in Iran. Another strength of the study is that our findings justified a high variance of consumption (28.05 for the three dietary patterns). Moreover, in this study we checked and controlled the effect of many variables that could have acted as confounding factors.

This study showed that only the healthy dietary pattern, characterized by high intake of poultry and fish, vegetables, fruits, low-fat dairy products, nuts, olives, and cereals, was inversely associated with the risk of MCI. No other significant association was found between an unhealthy and a Western dietary pattern and MCI.

It is suggested that further studies be conducted on other factors that can affect cognitive function, such as the age of menopause, hormonal status, income level, welfare, etc. Future studies are recommended to use various cognitive tests to assess the cognitive status of the subjects. We recommend further prospective studies to overcome the mentioned limitations and to find stronger relationships between the related factors.

To summarize, our present study demonstrated that only a healthy dietary pattern was significantly associated with MCI and reduced the risk of the disease. Lower educational levels (less than high-school diploma) were also associated with a higher risk of developing MCI. Additionally, in our study there was a high statistical correlation between employment status, study hours, and level of education; it was concluded that the significant relationship between employment status and MCI, and between study hours and MCI, was under the influence of educational level which was also significant.

Acknowledgement

This study was extracted from an M.sc dissertation which was approved by the Ethics committee of Tehran University of Medical Sciences (code 9111468003).

References:

1. Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, Rabins PV, Ritchie K, Rossor M, Thal L, Winblad B. Current concepts in mild cognitive impairment. *Archives of neurology*. 2001 Dec 1;58(12):1985-92.
2. Morris JC, McKeel DW, Storandt M, Rubin EH, Price JL, Grant EA, Ball MJ, Berg L. Very mild Alzheimer's disease Informant based clinical, psychometric, and pathologic distinction from normal aging. *Neurology*. 1991 Apr 1;41(4):469-.
3. Busse A, Hensel A, Gühne U, Angermeyer MC, Riedel-Heller SG. Mild cognitive impairment long-term course of four clinical subtypes. *Neurology*. 2006 Dec 26;67(12):2176-85.
4. Solfrizzi V, Reiman E, Caselli RJ, Del Parigi A, Capurso A, Panza F. CIND and MCI in the Italian elderly: frequency, vascular risk factors, progression to dementia. *Neurology*. 2007 Dec 4;69(23):2186-7.
5. Plassman BL, Langa KM, Fisher GG, Heeringa SG, Weir DR, Ofstedal MB, Burke JR, Hurd MD, Potter GG, Rodg-

- ers WL, Steffens DC. Prevalence of cognitive impairment without dementia in the United States. *Annals of internal medicine*. 2008 Mar 18;148(6):427-34.
6. Manly JJ, Tang MX, Schupf N, Stern Y, Vonsattel JP, Mayeux R. Frequency and course of mild cognitive impairment in a multiethnic community. *Annals of neurology*. 2008 Apr 1;63(4):494-506.
 7. Lopez OL, Jagust WJ, DeKosky ST, Becker JT, Fitzpatrick A, Dulberg C, Breitner J, Lyketsos C, Jones B, Kawas C, Carlson M. Prevalence and classification of mild cognitive impairment in the Cardiovascular Health Study Cognition Study: part 1. *Archives of neurology*. 2003 Oct 1;60(10):1385-9.
 8. Barnes DE, Yaffe K. Predicting dementia: role of dementia risk indices. *Future neurology*. 2009 Sep;4(5):555-60.
 9. Matthews FE, Jagger C, Miller LL, Brayne C, CFAS M. Education differences in life expectancy with cognitive impairment. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. 2009;64(1):125-31.
 10. Gauthier S, Reisberg B, Zaudig M, Petersen RC, Ritchie K, Broich K, Belleville S, Brodaty H, Bennett D, Chertkow H, Cummings JL. Mild cognitive impairment. *The Lancet*. 2006 Apr 21;367(9518):1262-70.
 11. Petersen RC. Mild cognitive impairment. *New England Journal of Medicine*. 2011 Jun 9;364(23):2227-34
 12. Luchsinger JA, Mayeux R. Dietary factors and Alzheimer's disease. *The Lancet Neurology*. 2004 Oct 31;3(10):579-87.
 13. Gillette Guyonnet S, Secher M, Vellas B. Nutrition and neurodegeneration: epidemiological evidence and challenges for future research. *British journal of clinical pharmacology*. 2013 Mar 1;75(3):738-55.
 14. McNeill G, Winter J, Jia X. Diet and cognitive function in later life: a challenge for nutrition epidemiology. *European journal of clinical nutrition*. 2009 Feb 1;63:S33-7.
 15. Shatenstein B, Ferland G, Belleville S, Gray-Donald K, Kergoat MJ, Morais J, Gaudreau P, Payette H, Greenwood C. Diet quality and cognition among older adults from the NuAge study. *Experimental gerontology*. 2012 May 31;47(5):353-60.
 16. Luchsinger JA, Noble JM, Scarmeas N. Diet and Alzheimer's disease. *Current neurology and neuroscience reports*. 2007 Sep 1;7(5):366-72..
 17. Solfrizzi V, Capurso C, D'Introno A, Colacicco AM, Santamato A, Ranieri M, Fiore P, Capurso A, Panza F. Lifestyle-related factors in predementia and dementia syndromes. *Expert Review of Neurotherapeutics*. 2008 Jan 1;8(1):133-58.
 18. Jacobs DR, Gross MD, Tapsell LC. Food synergy: an operational concept for understanding nutrition. *The American journal of clinical nutrition*. 2009 May 1;89(5):1543S-8S.
 19. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Current opinion in lipidology*. 2002 Feb 1;13(1):3-9.
 20. Morris MC, Evans DA, Bienias JL, Tangney CC, Bennett DA, Aggarwal N, Schneider J, Wilson RS. Dietary fats and the risk of incident Alzheimer disease. *Archives of neurology*. 2003 Feb 1;60(2):194-200.
 21. Kim J, Yu A, Choi BY, Nam JH, Kim MK, Oh DH, Yang YJ. Dietary Patterns Derived by Cluster Analysis are Associated with Cognitive Function among Korean Older Adults. *Nutrients*. 2015 May 29;7(6):4154-69.
 22. Féart C, Samieri C, Rondeau V, Amieva H, Portet F, Dartigues JF, Scarmeas N, Barberger-Gateau P. Adherence to a Mediterranean diet, cognitive decline, and risk of dementia. *Jama*. 2009 Aug 12;302(6):638-48.
 23. Gu Y, Nieves JW, Stern Y, Luchsinger JA, Scarmeas N. Food combination and Alzheimer disease risk: a protective diet. *Archives of neurology*. 2010 Jun 1;67(6):699-706.
 24. Scarmeas N, Stern Y, Mayeux R, Manly JJ, Schupf N, Luchsinger JA. Mediterranean diet and mild cognitive impairment. *Archives of neurology*. 2009 Feb 1;66(2):216-25.
 25. Kanoski SE, Davidson TL. Western diet consumption and cognitive impairment: links to hippocampal dysfunction and obesity. *Physiology & behavior*. 2011 Apr 18;103(1):59-68.
 26. Torres SJ, Lautenschlager NT, Wattanapenpaiboon N, Greenop KR, Beer C, Flicker L, Alfonso H, Nowson CA. Dietary patterns are associated with cognition among older people with mild cognitive impairment. *Nutrients*. 2012 Oct 25;4(11):1542-51.
 27. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*. 2011 Oct 21;8(1):1.
 28. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of psychiatric research*. 1975 Nov 30;12(3):189-98.
 29. Rashedi V, Rezaei M, Gharib M. Prevalence of cognitive impairment in community-dwelling older adults. *Basic and clinical neuroscience*. 2014;5(1):28.
 30. Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran Lipid and Glucose Study. *Public health nutrition*. 2010 May 1;13(05):654-62.
 31. Aghapour B, Rashidi A, Dorosti-Motlagh AR, Mehrabi Y. The association between major dietary patterns and overweight or obesity among Iranian adolescent girls. *Iranian Journal of Nutrition Sciences & Food Technology*. 2013 Mar 15;7(5):289-99.
 32. Ashby-Mitchell K, Peeters A, Anstey KJ. Role of dietary pattern analysis in determining cognitive status in elderly Australian adults. *Nutrients*. 2015 Feb 4;7(2):1052-67.
 33. Akbaraly TN, Singh-Manoux A, Marmot MG, Brunner EJ. Education attenuates the association between dietary patterns and cognition. *Dementia and geriatric cognitive disorders*. 2009 Feb 2;27(2):147-54.
 34. Gustaw-Rothenberg K. Dietary patterns associated with Alzheimer's disease: population based study. *International journal of environmental research and public health*. 2009 Apr 1;6(4):1335-40.
 35. Wärnberg J, Gomez Martinez S, Romeo J, Díaz LE, Mar-

- cos A. Nutrition, inflammation, and cognitive function. *Annals of the New York Academy of Sciences*. 2009 Feb 1;1153(1):164-75.
36. Hardy JA, Higgins GA. Alzheimer's disease: the amyloid cascade hypothesis. *Science*. 1992 Apr 10;256(5054):184.
37. Kalmijn S. Fatty acid intake and the risk of dementia and cognitive decline: a review of clinical and epidemiological studies. *The journal of nutrition, health & aging*. 1999 Dec;4(4):202-7.
38. Cummings JL. Alzheimer's disease. *The New England journal of medicine*. 2004 Jul 1;351(1):56-67.
39. Enomoto M, Yoshii H, Mita T, Sanke H, Yokota A, Yamashiro K, Inagaki N, Goshio M, Ohmura C, Kudo K, Watada H. Relationship between dietary pattern and cognitive function in elderly patients with type 2 diabetes mellitus. *Journal of International Medical Research*. 2015 Aug 1;43(4):506-17.
40. Kesse-Guyot E, Andreeva VA, Jeandel C, Ferry M, Hercberg S, Galan P. A healthy dietary pattern at midlife is associated with subsequent cognitive performance. *The Journal of nutrition*. 2012 May 1;142(5):909-15.
41. Cherbuin N, Anstey KJ. The Mediterranean diet is not related to cognitive change in a large prospective investigation: the PATH Through Life study. *The American Journal of Geriatric Psychiatry*. 2012 Jul 31;20(7):635-9.
42. Burgener SC, Buettner L, Buckwalter KC, Beattie E, Bossen AL, Fick DM, Fitzsimmons S, Kolanowski A, Richeson NE, Rose K, Schreiner A. Evidence supporting nutritional interventions for persons in early stage Alzheimer's disease (AD). *The Journal of Nutrition Health and Aging*. 2008 Jan 1;12(1):18-21.
43. Carter CS, Hofer T, Seo AY, Leeuwenburgh C. Molecular mechanisms of life-and health-span extension: role of calorie restriction and exercise intervention. *Applied Physiology, Nutrition, and Metabolism*. 2007 Sep 7;32(5):954-66.
44. Szekely CA, Breitner JC, Zandi PP. Prevention of Alzheimer's disease. *International Review of Psychiatry*. 2007 Jan 1;19(6):693-706.
45. Grodstein F, Kang JH, Glynn RJ, Cook NR, Gaziano JM. A randomized trial of beta carotene supplementation and cognitive function in men: the Physicians' Health Study II. *Archives of internal medicine*. 2007 Nov 12;167(20):2184-90.
46. Perrig WJ, Perrig P, Stähelin HB. The relation between antioxidants and memory performance in the old and very old. *Journal of the American Geriatrics Society*. 1997 Jun 1;45(6):718-24.
47. Solfrizzi V, Panza F, Capurso A. The role of diet in cognitive decline. *Journal of neural transmission*. 2003 Jan 1;110(1):95-110.
48. Swanson D, Block R, Mousa SA. Omega-3 fatty acids EPA and DHA: health benefits throughout life. *Advances in Nutrition: An International Review Journal*. 2012 Jan 1;3(1):1-7.
49. Seshadri S, Wolf PA. Homocysteine and the brain: vascular risk factor or neurotoxin?. *The Lancet Neurology*. 2003 Jan 31;2(1):11.
50. Granic I, Dolga AM, Nijholt IM, van Dijk G, Eisel UL. Inflammation and NF- κ B in Alzheimer's disease and diabetes. *Journal of Alzheimer's Disease*. 2009 Jan 1;16(4):809-21.
51. Chrysohoou C, Panagiotakos DB, Pitsavos C, Das UN, Stefanadis C. Adherence to the Mediterranean diet attenuates inflammation and coagulation process in healthy adults: The ATTICA Study. *Journal of the American College of Cardiology*. 2004 Jul 7;44(1):152-8.
52. Khani BR, Ye W, Terry P, Wolk A. Reproducibility and validity of major dietary patterns among Swedish women assessed with a food-frequency questionnaire. *The Journal of nutrition*. 2004 Jun 1;134(6):1541-5.
53. Martinez ME, Marshall JR, Sechrest L. Invited commentary: Factor analysis and the search for objectivity. *American journal of epidemiology*. 1998 Jul 1;148(1):17-9.
54. Kim Jae-On, Mueller Charles W. *Factor Analysis: Statistical Methods and Practical Issues*, Sage; 1978, vol. 14.

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