Iranian Journal of Neurology

Original Paper

Ir J neurol 2012; 11(2):47-53

Dietary pattern and risk of multiple sclerosis

Received: 12 Oct 2011
Accepted: 15 Jan 2012

Soodeh Razeghi Jahromi[1], Mansoureh Toghae[2], Mohammad Jamal Razeghi Jahromi[3], Mahdi Aloosh[4]

[1] Shefa Neuroscience Research Center, Tehran, Iran
[2] Neurology Ward, Sina Hospital, Tehran University of Medical Sciences, Iranian Center of Neurological Researh, Tehran University of Medical Sciences, Tehran, Iran
[3] Department of Statistics, Islamic Azad University, North Tehran Branch, Tehran, Iran
[4] Research Development Center of Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran

Keywords
Multiple Sclerosis, Dietary Pattern, Factor Analysis

Abstract

Background: It has been suggested that nutrition might play a role in the etiology of multiple sclerosis (MS). However, dietary patterns associated with MS risk are unknown. This study was conducted to compare the dietary patterns of patients with MS and healthy controls to find the relationship between dietary patterns and MS.

Methods: Usual dietary intake of 75 women with relapsing/remitting MS (RRMS) and 75 healthy controls were assessed with a food frequency questionnaire consisting of 168 food items. To define major dietary patterns, we used factor analysis. Multivariate logistic regression was used to assess the relationship between dietary patterns and risk of MS.

Results: Traditional pattern (high in low-fat dairy products, red meat, vegetable oil, onion, whole grain, soy, refined grains, organ meats, coffee, and legumes) was inversely related to the risk of MS [odds ratio (OR) = 0.15; 95% confidence interval (CI): 0.03-0.18; P = 0.028]. A similar inverse relationship was noted between MS risk and lacto-vegetarian (high in nuts, fruits, French fries, coffee, sweets and desserts, vegetables, and high-fat dairy products) and vegetarian (high in green leafy vegetables, hydrogenated fats, tomato, yellow vegetables, fruit juices, onion, and other vegetables) patterns (OR = 0.31; 95% CI: 0.12-0.82; P = 0.018 and OR = 0.42; 95% CI: 0.19-0.90; P = 0.026, respectively). In contrast, the prevalence of MS was higher in those who had high animal fat dietary pattern (high in animal fats, potato, meat products, sugars, and hydrogenated fats and low in whole grains) (OR = 1.99; 95% CI: 1.63-2.94; P < 0.005).

Conclusion: Our findings showed that the risk of RRMS can be affected by major dietary patterns.

Introduction

Multiple sclerosis (MS) is a chronic demyelinating disease of the nervous system which is the most common cause of neurological irreversible disability in young adults[1,2] who are professionally and socially active persons.[3] Assessment of dietary pattern is an approach that has been used to evaluate diet-disease association.[4] Dietary patterns refer to the combined effect of foods and thus may provide insight beyond the impact explained by single foods or nutrients.[5]There have been several studies on single foods or nutrients. However, this study was

Corresponding Author: Mansoureh Toghae,
Email: toghae@sina.tums.ac.ir

performed to evaluate the relationship between MS risk and major dietary patterns recognized by factor analysis.

Materials and Methods

Participants

In this cross-sectional study, a group of 87 female residents of Tehran (Iran) with relapsing/remitting MS (RRMS) was selected from the Iranian MS Association registry by simple random sampling over one year. The cases were newly registered patients that had not made changes in their dietary habits because of the disease. Since 81 cases accepted to participate, 81 healthy controls were recruited from the patients' close relatives or those who matched for age and economic and education level. Overall, 78 controls accepted to participate. The exclusion criteria were following a specific diet during the previous year, consuming food supplements, or leaving more than 70 blank items on the Food Frequency Questionnaire (FFQ). After excluding ineligible participants, 75 cases and 75 controls (mean age: 32.9 ± 8.0 and 30.0 ± 5.7 years, respectively) were included in the study. The study was approved by the ethics committee of Tabriz University of Medical Sciences (Tabriz, Iran). In addition, written informed consents were obtained from all participants.

Assessment of dietary intake

Usual dietary intake was evaluated by a validated 168-item semi-quantitative FFQ including a list of foods with standard serving size commonly consumed by Iranians.[6] Participants reported their frequency of eating a given portion size of each food item during the previous year, on monthly (e.g. legumes), weakly (e.g. egg) or daily manner (e.g. bread). Then, the recorded frequency for each food item was converted to daily intake and serving sizes of eaten foods were converted to grams using household measures.

MS diagnosis

The participants were 75 RRMS cases (based on McDonald's criteria). Therefore, they had Expanded Disability Status Scale (EDSS) scores of 0-2 and had been diagnosed with the disease for less than three years. A neurologist was asked to assess the eligibility of patients. We selected RRMS cases in order to have one pathology to study. There are hypothesis that different types of MS have different pathologies and may also have different etiologies.

Statistical analysis

We allocated each food item into one of 44 delineated food groups (Table 1). The logic behind assigning a food item into a certain food group was the resemblance of nutrients. We considered some food items as individual food groups because their nutrient content was inimitable or their consumption reflected a definite dietary pattern [e.g. doogh (an Iranian yogurt drink with a consistency comparable to that of whole milk), garlic, and pizza].

We used factor analysis to define major dietary patterns based on 44 food groups. The factors were rotated by orthogonal transformation. We used a scree plot and the factors with eigenvalues more than 1.2 were obtained. The scree plot is a plot of eigenvalues of identified factors. The eigenvalues declined after the 7th factor and remained similar to each other. The defined dietary patterns (factors) were labeled based on our interpretation of the content and the previous manuscripts. The amount of food group consumption was weighted by load factor. Factor score of each pattern was obtained by summing up the load factors. Each participant was given a factor score for each defined dietary pattern. We categorized participants by tertiles of pattern scores. We used multivariate logistic regression to assess the relationship between dietary patterns and risk of MS. We considered the first tertile of dietary pattern score as reference. We used the Mantel-Haenszel chi-square test to assess the overall trend of odd ratios (ORs) over the increasing tertiles.

As using cutoffs in factor scores involves some information loss, we also performed Spearman correlation test on RRMS risk and dietary pattern scores as a continuous variable. All analyses were adjusted for age. SPSS for Windows 14.5 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

Results

We identified 7 major dietary patterns using factor analysis. The patterns included:

1. Traditional dietary pattern: high in low-fat dairy products, red meats, vegetable oils, onion, whole grains, soy, refined grains, organ meats, coffee, legumes and butter;
2. Western-like dietary pattern: high in processed meats, pickles, pizza, garlic, butter, sugars, refined grains, organ meats, and soft drink and low in olive, yellow vegetables, and dried fruits;
3. High animal fat: high in animal fats, potato, other meat products, sugars, hydrogenated fats and low in whole grains, spices, and poultry without skin;
4. Vegetarian-like pattern: high in green leafy vegetables, hydrogenated fats, tomato, yellow vegetables, fruit juices, onion, and other vegetables;
5. Lacto vegetarian-like pattern: high in nuts, fruits, French fries, coffee, sweets and desserts, other vegetables, high fat dairy products, and sugars;
6. Mixed: high in hydrogenated fats, fish, other meat products, vegetable oils, vegetables, and whole grains;

Table 1. Food grouping used in dietary pattern analyses

Food groups	**Food items**
Processed meat	Sausages, hotdog
Red meat	Beef, hamburger, lamb
Organ meat	Beef liver
Other meat products	Kalepache (an Iranian food prepared from beef brain and tongue), beef viscera
Fish	Canned tuna fish, other fish
Poultry with skin	Chicken with skin
Poultry without skin	Chicken without skin
Egg	Eggs
Butter and margarine	Butter, margarine
Margarine	Margarine
Low-fat dairy products	Skim or low-fat milk, low-fat yogurt
High fat dairy products	High-fat milk, whole milk, chocolate milk, cream, high-fat yogurt, cream yogurt, cream cheese, other kinds of cheese, ice cream
Tea	Tea
Coffee	Coffee
Fruits	Pear, apricot, cherry, apple, raisin or grape, banana, cantaloupe, watermelon, orange, grapefruit, kiwi, strawberry, peach, nectarine, tangerine, mulberry, plum, persimmon, pomegranate, lemon, pineapple, fresh fig and date
Fruit juices	Apple juice, orange juice, grapefruit juice, other fruit juices
Cruciferous and yellow vegetables	Cabbage, cauliflower, Brussels sprout, kale and carrots
Tomato	Tomato, tomato sauce
Green leafy vegetables	Spinach, lettuce
Other vegetables	Cucumber, mixed vegetables, eggplant, celery, green pea, green bean, green pepper, turnip, corn, squash, mushrooms
Legumes	Bean, pea, lima bean, broad bean, lentil
Garlic	Garlic
Onion	Onion
Potatoes	Potato
Whole grains	Dark breads (Iranian), barley bread, popcorn, cornflakes, wheat germ, bulgur
Refined grains	White breads (Iranian, baguettes), noodles, pasta, rice, toasted bread, milled barley, sweet bread, white flour, starch, biscuits
Pizza	Pizza
Soy	Soy
Nuts	Peanut, almond, pistachio, hazelnut, roasted seed, walnut
Mayonnaise	Mayonnaise
Dried fruits	Dried fig, dried date, dried mulberry, other dried fruits
Olive	Olive, olive oil
Sweets and desserts	Chocolates, cookies, cakes, confections
Hydrogenated fats	Hydrogenated fats
Vegetable oils	Vegetable oils (except for olive oil)
Animal fats	Animal fats
Sugar	Sugars, candies, gaz (an Iranian confectionery made of sugar, nuts, and tamarisk)
Broth	Broth
Soft drink	Soft drinks
Yogurt drink	Doogh
Condiments	Jam, jelly, honey
Spices	Salt, pepper, saffron, ginger
Pickles	Pickles
Snacks	Potato chips, corn puffs, crackers, popcorn

7. Condiments and dried vegetables pattern: high in condiments, dried fruits, egg, high fat dairy products, fruit juices, and legumes.

Table 2 presents load factor for these dietary patterns. Other negligible dietary patterns were also detected by factor analysis.

The mean age of patients and controls was 32.9 ± 8.0 and 30.0 ± 5.7 years, respectively. While 47 MS patients (63%) reported that they had been under stress two years prior to MS onset, 15 controls (20%) had experienced a stressful life during the previous two years.

Table 2. Load factor matrix for major dietary patterns1

Food groups	Dietary pattern						
	Traditional	Western like	High animal fat	Vegetarian like	Lacto vegetarian like	Mixed	Condiments and dried vegetables
Low-fat dairy products	0.729	-	-	-	-	-	-
Red meats	0.671	-	-	-0.213	-	-	-
Vegetable oils	0.592	-	-0.234	-	-	0.402	-
Onion	0.507	-	-	0.447	-	-0.285	-
Whole grains	0.499	0.224	-0.357	-	-	0.300	-
Soy	0.475	-	-	-	-	-	-
Refined grains	0.469	0.421	-	-0.262	-	-0.281	0.281
Organ meats	0.451	0.390	-	-0.271	-	-	-
Processed meats	-	0.668	-	-	-	-	-
Pickles	-	0.624	-	-	-	-	-
Pizza	-0.260	0.510	-	0.244	-	-	0.241
Garlic	-	0.499	-	-	-	0.200	-
Butter and margarine	0.304	0.492	0.295	-	-	-	-
Sugars	-	0.470	0.341	-	0.343	-0.349	-
Olive	-	-0.426	-0.266	-0.253	-	-0.234	-
Soft drinks	-	0.377	-	-	0.278	-	-
Animal fats	-	-	0.774	0.271	-0.228	-	-
Potato	-	-	0.739	-	-	-	-0.207
Spices	-	-	-0.604	0.205	-0.385	-	-
Poultry without skin	-	-	-0.508	-	-	-	-
Green leafy vegetables	-	-	-	0.738	-	-	-
Hydrogenated fats	-0.296	-	0.331	0.632	0.215	-	-
Tomatoes	-	-	-0.225	0.625	-	0.202	-
Cruciferous and yellow vegetables	0.263	-0.355	-	0.498	-	-	-0.408
Nuts	-	-	-	0.211	0.789	-	-
Fruits	-	-	-	-	0.703	-	-
French fries	-	-	-	-0.430	0.560	-0.333	-
Coffee	0.409	-	-0.228	-	0.478	-0.219	-
Sweets	0.264	-	-0.216	-	0.462	-0.363	-
Other vegetables	-	-	-	0.329	0.428	0.325	-
Broth	-	-	-	-	-	0.720	-
Tea	-	-	-	-	-	-0.666	-
Fish	-	0.275	-0.273	0.212	-	0.451	-
Other animal products	0.272	-	0.425	-	-0.220	0.441	-
Poultry with skin	-	-	-	-	-	-	-
Condiments	-	-	-	-	-0.201	-	0.706
Dried fruits	-	-0.337	-	-	-	-	0.615
Egg	-	0.209	-0.274	-	-	-	0.597
High-fat dairy products	-	-	0.220	-0.218	0.359	-	0.495
Fruit juices	-	-	-0.290	0.455	-	-	0.469
Legumes	0.372	0.270	-	-	0.232	-	0.396
Mayonnaise	-	-	-	-	-	-	-
Yogurt drink	-	-	-	-	-	-	-
Snacks	-	-	-	-	-	-	-
Percentage of variance explained (%)	11.57	8.72	7.58	6.77	6.48.	5.69	4.93

[1] Values < 0.2 were excluded for simplicity

Table 3 shows ORs for MS across tertile categories of dietary pattern. After adjustment for age, participants in the highest tertile of traditional dietary pattern had lower odds of MS [OR = 0.15; 95% confidence interval (CI): 0.03-0.18; P = 0.028] than subjects in lower tertiles. Individuals in the thirdtertile of lacto vegetarian (OR = 0.31; 95% CI: 0.12-0.82; P = 0.018) and cases in the second tertile of vegetarian-like dietary pattern (OR = 0.42; 95% CI = 0.19-0.90; P = 0.026) had lower odds of MS. Furthermore, those in a higher tertile of high animal fat dietary pattern had higher odds of MS in comparison to those in lower tertiles (OR = 1.99; CI: 1.63-2.94; P = 0.04). The trends of ORs across the tertiles of traditional, high animal fat, vegetarian-like, and lacto vegetarian patterns were also significant.

After adjusting for age in Spearman correlation analysis, traditional, vegetarian, and lacto vegetarian patterns were negatively associated with the risk ofMS. The association was inverse for high animal fat pattern (Table 4).

Discussion

As mentioned above, seven major dietary patterns, including traditional, western-like, high animal fat,vegetarian-like, lacto vegetarian-like, mixed, and

Table 3. Multivariate adjusted odd ratios for multiple sclerosis risk across tertiles of dietary patterns (DP)

			Before adjustment			Adjusted for age (y)		
Tertile of DP score	**Case**	**Control**	**OR (95% CI)**	**P**	**P for trend**	**OR (95% CI)**	**P**	**P for trend**
Traditional pattern								
T1	38	34	1.00			1.00		
T2	27	23	0.28 (0.08-0.99)	0.058	< 0.005	0.36 (0.10-1.34)	0.129	< 0.005
T3	10	18	0.17 (0.42-0.70)	0.014		0.24 (0.60-0.95)	0.239	
Western-like pattern								
T1	23	18	1.00			1.00		
T2	19	32	1.11 (0.49-2.49)	0.432	0.631	1.07 (0.46-2.46)	0.880	0.767
T3	34	24	2.38 (0.90-5.10)	0.270		2.56 (1.16-5.66)	0.200	
High animal fat pattern								
T1	32	53	1.00			1.00		
T2	22	11	1.23 (0.65-2.34)	0.280	< 0.005	1.21 (0.64-2.31)	0.270	< 0.005
T3	21	11	1.97 (1.57-2.68)	0.001		1.98 (1.59-2.90)	0.002	
Vegetarian-like pattern								
T1	24	38	1.00			1.00		
T2	33	22	0.023 (0.20-0.88)	0.023	0.041	0.44 (0.20-0.93)	0.032	0.024
T3	19	14	0.46 (0.19-1.09)	0.081		0.53 (0.22-1.28)	0.159	
Lacto vegetarian-like pattern								
T1	14	26	1.00			1.00		
T2	35	34	0.12 (0.23-1.20)	0.144	< 0.005	0.66 (0.28-1.52)	0.328	< 0.005
T3	25	14	0.30 (0.12-0.80)	0.011		0.35 (0.14-0.90)	0.030	
Mixed pattern								
T1	17	34	1.00			1.00		
T2	35	28	0.38 (0.12-1.19)	0.099	0.057	0.37 (0.11-1.23)	0.105	0.067
T3	23	13	0.68 (0.24-1.88)	0.466		0.65 (0.22-1.89)	0.426	
Condiments and dried vegetables pattern								
T1	34	37	1.00			1.00		
T2	19	22	0.74 (0.25-2.19)	0.582	0.244	0.76 (0.24-2.45)	0.640	0.229
T3	22	16	0.87 (0.28-2.76)	0.821		0.95 (0.22-3.90)	0.943	

Table 4. Spearman correlation coefficients (r) for the relationship between risk of multiple sclerosis and dietary pattern scores

Dietary pattern scores	**Before adjustment**		**Adjusted for age (y)**	
	r	**P**	**r**	**P**
Traditional pattern score	-0.481	< 0.005	-0.275	< 0.005
Western-like pattern score	-0.049	0.553	-0.042	0.700
High animal fat pattern score	0.311	< 0.005	0.278	< 0.005
Vegetarian-like pattern score	-0.176	< 0.05	-0.181	< 0.050
Lacto vegetarian-like pattern score	-0.213	< 0.005	-0.205	< 0.005
Mixed pattern score	0.422	0.060	0.412	0.060
Condiments and dried vegetables pattern score	0.086	0.293	0.071	0.514

condiments and dried fruits, were identified in the studied population. More analysis showed that four dietary patterns had relationship with the risk of MS. An inverse relationship was observed betweentraditional, vegetarian and lacto vegetarian dietary patterns and MS risk. Besides, a positive relationbetween high animal fat dietary pattern and risk of MS was found. These relationships were independent of age. Although several studies have evaluated single foods or nutrients, based on our knowledge, no study has examined the association between dietary patterns and risk of MS. Ghadirian et al. used an FFQ and found a protective effect for cereal and bread consumption. They suggested pork and hotdog consumption to escalate the risk of MS development. They also showed a positive relation between energy and animal fat intake and MS risk. On the other hand, consumption of vegetable protein, dietary fiber, cereal fiber, vitamin C, thiamin, riboflavin, calcium, and potassium (commonly found in plants including grains, fruits and vegetables) were inversely associated with MS risk.[7] Similarly, the current study revealed that following a diet low in animal fat and high in plant foods (grains in the traditional dietary pattern, nuts and fruits in the lacto vegetarian pattern, and vegetables in the vegetarian pattern) may decrease the risk of developing MS. In another cross-sectional study based on three-day food diary, inadequate intake of carbohydrate, dietary fiber, vitamin E, calcium and zinc and high intake of saturated fatty acids (SFA) were associated with higher risk of MS.[8] Likewise, in the current study, whole grains content of the traditional dietary pattern, vegetable content of the vegetarian pattern, and nuts and fruits content of the lacto vegetarian pattern were good sources of fiber. Furthermore, the inverse relationship between consuming more plant foods and risk of MS and the positive association between SFA and MS risk were also observed in this study.

The inverse relationship of traditional, vegetarian, and lacto vegetarian-like dietary patterns with MS development risk could be ascribed to these patterns' healthy constituents. The mechanism by which these dietary patterns can protect individuals against MS is not fully understood. Omega-3 poly unsaturated fatty acids (PUFA) content of vegetable oil, soy and nuts can inhibit the production of pro-inflammatory cytokines including interleukin (IL)-1, IL-2, tumor necrosis factor alpha (TNF-α), and interferon-gamma (INF-γ) and thus suppress demyelination.[9-11] Omega-3 PUFAs can also impose their beneficial role by decreasing the proliferation and activation of T-helper lymphocyte 1 (Th-1).[12,13] Low-fat dairy products, which are one of the food items in traditional dietary pattern, are high in calcium and vitamin D. Both of these elements are related with lower risk of MS. Signaling between astrocytes, axons, and oligodendrocytes may have a significant role in myelin maintenance throughout life. Adenosinetriphosphate (ATP), adenosine, and glutamate regulate signaling between oligodendrocytes and axons. Glutamate and ATP signaling is calcium dependent.[14] Auto-reactive T cells may be developed in the absence of vitamin D.[15] One of the constituents of the traditional dietary pattern is organ meats, including liver, which contain high amounts of vitamin B12. Low levels of vitamin B12 have been demonstrated in patients with MS. Recent studies revealed important immunoregulatory roles of vitamin B12 such as modulating TNF-α activity.[16] Onion in the lacto vegetarian and vegetarian-like dietary patterns contains an isoflavonoid named quercetin which can reduce IL-12-induced T-cell proliferation and Th-1 cell proliferation.[17] Additionally, antioxidant content of fruits and vegetables have been found to be useful in decreasing clinical signs of experimental allergic encephalomyelitis.[18] On the other hand, the positive relation between the high animal fat dietary pattern and risk of MS can be ascribed to its high SFA content. One of the transcription factors, cyclic adenosine 3',5'-monophosphate response element binding protein (CREB), promotes the survival of neurons. Prostaglandins are essential for CREB formation. Unlike PUFA, SFA cannot produce prostaglandins.[19] Additional beneficial effects of other components of these foods may protect individuals against MS.

Unlike analyzing individual foods or nutrients, dietary pattern assessment is not limited to interaction among nutrients. The reason behind dietary pattern approach, which offers a complementary viewpoint, is that foods and nutrients are eaten in combination and in the form of identified dietary patterns.[20]

We faced several limitations in interpreting our findings. We identified dietary patterns only by using food intake data, although assessing eating behavior (e.g. snack and meal pattern) has been also suggested.[21] Overmatching in choosing controls might also be an issue in this study. When cases and controls have similar diets, it may decrease the likelihood of finding an association. Associations might have been stronger if we had a sample of controls that represented the general population. Some changes in dietary habits occurred in a number of patients after the onset of the disease. By asking the patients to indicate the changes in their dietary behavior and recruiting patients who were diagnosed with RRMS less than three years prior to the study, we tried to lessen the recall bias. It should be mentioned that some potential confounders, such as Epstein–Barr virus (EBV) infection, stress level, and sun exposure, were not assessed while they could have potentially confounded the associations. Prospective studies are required to clarify the relationship between dietary patterns and risk of MS.

Conclusion

Our findings revealed that dietary patterns described by high amount of low-fat dairy products, red meat, vegetable oil, onion, whole grains, soy, refined grains, organ meats, coffee, legumes, and butter are related to lower risk of RRMS. In addition, dietary patterns characterized by high intake of nuts, fruits, French fries, coffee, sweets and desserts, other vegetables, high-fat dairy products, and sugars are also related with lower risk of MS development. An inverse relationship was observed between high amount of green leafy vegetables, hydrogenated fats, tomato, yellow vegetables, fruit juices, onion, and other vegetables and risk of MS. In contrast, a dietary pattern which is high in animal fats, potato, meat products, sugars, and hydrogenated fats and low in whole grains, spices, and poultry without skin is related to higher risk of RRMS development.

Acknowledgement And Contribiotions

We thank the MS organization staff especially Mrs. Mohseni and Mr. Khosroyar for their enthusiastic support and the patients for their kind cooperation. We are indebted to the Research Development Center of Sina Hospital (Tehran, Iran) for its support. None of the authors had any financial or personal conflicts of the interests.

References

1. Shaygannejad V, Janghorbani M, Ashtari F, et al. Effects of adjunct low-dose vitamin d on relapsing-remitting multiple sclerosis progression: preliminary findings of a randomized placebo-controlled trial. Mult Scler Int. 2012; 2012:452541.
2. Togha M, Karvigh SA, Nabavi M, et al. Simvastatin treatment in patients with relapsing-remitting multiple sclerosis receiving interferon beta 1a: a double-blind randomized controlled trial. Mult Scler. 2010; 16(7):848-54.
3. Bartosik-Psujek H, Stelmasiak Z. Multiple sclerosis--difficult answers to easy questions. Neurol Neurochir. Pol. 2006; 40(5):441-5. [In Polish].
4. Waijers PM, Ocke MC, Van Rossum CT, et al. Dietary patterns and survival in older Dutch women. Am J Clin Nutr. 2006; 83(5):1170-6.
5. Hodge AM, English DR, O'Dea K, et al. Dietary patterns and diabetes incidence in the Melbourne Collaborative Cohort Study. Am J Epidemiol. 2007; 165(6):603-10.
6. Esmaillzadeh A, Mirmiran P, Azizi F. Whole-grain consumption and the metabolic syndrome: a favorable association in Tehranian adults. Eur J Clin Nutr. 2005; 59(3):353-62.
7. Ghadirian P, Jain M, Ducic S, et al. Nutritional factors in the aetiology of multiple sclerosis: a case-control study in Montreal, Canada. Int J Epidemiol. 1998; 27(5):845-52.
8. Timmerman GM, Stuifbergin AK. Eating patterns in women with multiple sclerosis. J Neurosci Nurs. 1999; 31(3):152-8.
9. Das UN. Is there a role for saturated and long-chain fatty acids in multiple sclerosis?. Nutrition. 2003; 19(2):163-6.
10. Liang X, Nazarian A, Erdjument-Bromage H, et al. Heterogeneous fatty acylation of Src family kinases with polyunsaturated fatty acids regulates raft localization and signal transduction. J Biol Chem. 2001; 276(33):30987-94.
11. Micu I, Jiang Q, Coderre E, et al. NMDA receptors mediate calcium accumulation in myelin during chemical ischaemia. Nature. 2006; 439(7079):988-92.
12. Cantorna MT. Vitamin D and its role in immunology: multiple sclerosis, and inflammatory bowel disease. Prog Biophys Mol Biol. 2006; 92(1):60-4.
13. Tourtas T, Birke MT, Kruse FE, et al. Preventive effects of omega-3 and omega-6 Fatty acids on peroxide mediated oxidative stress responses in primary human trabecular meshwork cells. PLoS One. 2012; 7(2):e31340.
14. Reynolds EH, Bottiglieri T, Laundy M, et al. Vitamin B12 metabolism in multiple sclerosis. Arch Neurol. 1992; 49(6):649-52.
15. Benrashid M, Moyers K, Mohty M, et al. Vitamin D deficiency, autoimmunity, and graft-versus-host-disease risk: Implication for preventive therapy. Exp Hematol. 2012; 40(4):263-7.
16. Birch CS, Brasch NE, McCaddon A, et al. A novel role for vitamin B(12): Cobalamins are intracellular antioxidants in vitro. Free Radic Biol Med. 2009; 47(2):184-8.
17. Van Meeteren ME, Teunissen CE, Dijkstra CD, et al. Antioxidants and polyunsaturated fatty acids in multiple sclerosis. Eur J Clin Nutr. 2005; 59(12):1347-61.
18. Dawson TM, Ginty DD. CREB family transcription factors inhibit neuronal suicide. Nat Med. 2002; 8(5):450-1.
19. Rudnick DA, Perlmutter DH, Muglia LJ. Prostaglandins are required for CREB activation and cellular proliferation during liver regeneration. Proc Natl Acad Sci U S A. 2001; 98(15):8885-90.
20. Esmaillzadeh A, Kimiagar M, Mehrabi Y, et al. Dietary patterns and markers of systemic inflammation among Iranian women. J Nutr. 2007; 137(4):992-8.
21. Tseng M. Validation of dietary patterns assessed with a food-frequency questionnaire. Am J Clin Nutr. 1999; 70(3):422.