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Association of dietary patterns with systemic inflammation, quality of life, disease severity, relapse rate, severity of fatigue and anthropometric measurements in MS patients

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ABSTRACT

Background: Multiple sclerosis (MS) is associated with changes in quality of life, disability, fatigue and anthropometric measurements. The important relationship of dietary patterns with such clinical manifestations was not completely investigated.

Aims: The goal of this study was to define the dietary patterns and their association with systemic inflammation, Health-Related Quality Of Life, disease severity, Relapse Rate, severity of fatigue and anthropometric measurements in MS subjects.

Methods: This cross-sectional study was conducted in 261 MS patients (mean age 38.9 ± 8.3). Dietary patterns were explored by a Food Frequency Questionnaire. Serum hs-CRP, Multiple Sclerosis Quality Of Life-54 item questionnaire, Extended Disability Status Scale, Fatigue Severity Scale and Visual Analog Fatigue Scale, Relapse Rate, Height, Weight and Deurenberg Equation were also used as tools. Data were analyzed by SPSS24, and using ANOVA, Tukey, Chi-square and ANCOVA tests.

Results: Fruits, Vegetables, Low fat dairy-based pattern and Mediterranean-Like pattern were associated with lower serum hs-CRP ($F = 6.037$, $P_{\text{adjusted}} < 0.01$), higher Physical and Mental Health Composite Scores ($P_{\text{adjusted}} < 0.001$), lower attacks ($F = 4.475$, $P_{\text{adjusted}} < 0.05$), lower acute and chronic fatigue ($F = 5.353$ and $F = 7.011$, respectively, $P_{\text{adjusted}} < 0.01$), lower BMI ($F = 7.528$, $P_{\text{adjusted}} < 0.01$) and Percent Body Fat ($F = 6.135$, $P_{\text{adjusted}} < 0.01$); but no difference was observed about EDSS across the patterns.

Conclusions: Adherence to healthy dietary patterns may reduce systemic inflammation, severity of fatigue, MS attacks, improved quality of life and balance weight especially body fat in MS patients.

KEYWORDS

Dietary pattern; inflammation; quality of life; fatigue; relapse; multiple sclerosis

1. Introduction

Multiple sclerosis (MS) is an autoimmune disease of the CNS with unknown etiology and complex Pathogenesis characterized by chronic inflammation, demyelination, gliosis, and neuronal loss [1]. MS is expressed in four different subtypes including relapsing-remitting MS (RRMS), primary-progressive MS (PPMS), secondary-progressive MS (SPMS), and progressive-relapsing MS (PRMS); RRMS involves about the 85% of patients and subtypes of RRMS&PPMS accompanying with MS attacks [2]. Approximately 2.5 million individuals worldwide are affected by this disease [3]. Iran is now well-known for its high prevalence of MS; The prevalence of MS in Iran ranged from 7.4 to 89 per 100,000 in different provinces with an average prevalence and incidence of 54.51 and 5.87 per 100,000 people, respectively [4,5]. MS symptoms depend on the location and severity of the damage in the CNS, however, fatigue is the most common and annoying symptom that occurs between attacks [6]. Recent studies suggest an overall increase in the incidence of MS that can be explained by environmental risk factors [7] such as incorrect lifestyle; especially unhealthy dietary habits [8–10] and obesity [11]. Obese patients with MS have higher chance of disability and lower QOL [12]. However, dietary patterns in MS patients have not been extensively studied.

At present, there are at least 10 DMTs (Disease-Modifying Treatments) that prevent disease progression but are only useful in RRMS cases [13] and in some cases they are ineffective and generally expensive [14]. Instead, correcting dietary factors and lifestyle modification (avoiding Western lifestyle) by controlling the inflammatory state of the disease and correcting the microbial flora of the gastrointestinal tract can control the symptoms of both RRMS and PPMS [7,10].

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The assessment of dietary patterns is a method to examine the relationship between diet and disease and determines the effect of total food intake (no single foods or nutrients) on the disease [15–17].

Patients with chronic diseases such as MS face difficulties related to their illness. These problems restrict health-related activities of patients and have a negative effect on their quality of life (QOL) [18]. In addition to impaired QOL, individuals with MS consistently exhibit acute and chronic fatigue [19]. On the other hand, nutritional status may affect fatigue [20] and it can be exacerbated by an imbalanced diet [21].

Although several observational studies have demonstrated a relationship between specific dietary patterns and the prevalence of MS, very few have shown a correlation of diet with fatigue, quality of life (QOL), and anthropometric indices such as BMI and Percent Body Fats. The purpose of this cross-sectional study was to identify dietary patterns and their relation with systemic inflammation, Percent Body Fat, BMI, and clinical manifestations such as QOL, fatigue, disability and Relapse Rate in a large, diverse sample of adults with MS.

2. Materials and methods

2.1. Subjects and recruitment procedure

In this cross-sectional study, 261 MS patients were selected by stratified randomization from two MS outpatient (between 22 June 2017 and 21 November 2017), based on the referral frequency of four subtypes of MS patients (RR, PP, SP and PRMS) to the clinics.

The inclusion criteria were: writing ability and memory strength, and aged between 20 and 60 years. It must be noted that all RRMS cases received Dimethyl Fumarate 240 mg twice daily in the last year. However, exclusion criteria were: having allergy and other autoimmune diseases, patients with viral infections such as Epstein Barr, patients with disease duration of less than 1 year, consuming special food supplements regularly or fatigue modulating drugs, leaving more than 40% blank items on the Food Frequency Questionnaire (FFQ), other major medical illnesses, and current smokers. We also excluded patients with high dose corticosteroid therapy (greater than 30 mg/day Methylprednisolone) for more accurate result in hs-CRP estimation. For each approached patient, the study objectives were explained, and voluntary cooperation was emphasized. Then, a signed informal consent was provided prior to involvement in the study.

2.2 Data collected and tools used

Private face-to-face interview was conducted by a trained professional questioner. Then we used a self-administered questionnaire contained participant’s socio-demographic and clinical characteristics (age, education level, weight, height, duration of the disease, family history). It should be noted that the Food Frequency Questionnaire (FFQ) was also completed by the researcher; the Multiple Sclerosis Quality Of Life-54 items (MSQOL-54), Fatigue Severity Scale-9 items (FSS-9) and Visual Analog Fatigue Scale (VAFS) questionnaires by the participants; the Extended Disability Status Scale (EDSS) and the Relapse Rate (number of attacks in recent year) by the neurologist. These questionnaires and measurements will be explained below.

2.2.1. Dietary intake assessment

Usual dietary intake was measured by a validated 168-item semi-quantitative FFQ [22] including a list of foods with standard serving size commonly consumed by Iranians [23–25]. The frequency of consumption for each food item was collected on a daily, weekly, or monthly basis; the portion sizes were then converted to grams using household measures [26].

2.2.2. Anthropometric measurements

The subjects were asked to take off their heavy clothes (to the extent allowed by culture) and standing straight without shoes on digital scales. Next, the weight displayed on the screen was recorded to the nearest 100 g. Height was recorded using a non-stretchable tape to the nearest 0.1 cm. BMI was determined by dividing the weight (kg) by the square of height (m2) and classified into four subgroups:

Underweight: BMI < 18.5; normal weight:18.5 ≤ BMI < 25; Overweight:25 ≤ BMI < 30; obese: BMI ≥ 30

Then, using the Deurenberg Equation (27), Percent Body Fat was calculated:

\[ \text{Deurenberg Equation:} \]

\[ \% \text{body fat} = (1.2 \times \text{BMI}) + (0.23 \times \text{Age in yrs}) - (10.8 \times G) - 5.4 \]

\[ G \text{ for male} = 1 \quad G \text{ for female} = 0 \]

2.2.3. Systemic inflammation

In order to evaluate the systemic inflammation, the serum level of circulating hs-CRP was measured. CRP (C-Reactive Protein) is one of the most sensitive proteins in the acute phase of inflammation, which is predominantly synthesized and secreted by hepatocytes in response to proinflammatory cytokines such as TNF-α, IL-1 and IL-6. In a healthy person, its serum level is less than 1 mg/L [28]. In previous studies, obesity and
cigarette smoking have been shown to increase its serum level; whereas physical activity and a diet enriched by vegetables and fruits reduce serum levels [29].

Five milliliter of blood samples were taken from the elbow vein of fasting patients in the early morning after completing questionnaires. Blood samples were further centrifuged 15 min at the speed of 3000 r/min, and the separated serums were stored in a refrigerator at \(-70^\circ\text{C}\), and tested in batches. Finally, the hs-CRP\(s\) stored in kits (Diagnostic Systems, Germany) were measured by Chemi Luminescent ImmunoAssays (CLIs) with AU640 Chemistry Analyzer (Olympus Diagnostic Systems, Melville, New York). It should be noted blood sampling was performed at relieving stage in which RR\&PRMS cases have not any attack on that time.

### 2.2.5. Fatigue
Fatigue was described as a lack of physical or mental energy or a feeling of tiredness [32]. Chronic fatigue was quantified by the FSS [33] and Acute fatigue was measured with the VAFS [34]. VAFS is a 100-mm scale on which the participants draw a mark indicating the current degree of fatigue. The minimum and maximum score of this scale are 0 and 10; The lower this score, the higher the Acute fatigue. The FSS is a 9-itemized questionnaire; each item was ranged from one (strongly disagree) to seven (strongly agree), with higher scores, indicating more severe fatigue [35–37]. The minimum and maximum total score of this scale are 9 and 63. It has been found to be reliable and valid in Iranian MS patients (Cronbach’s \(\alpha = 0.96\)) [38].

### 2.2.6. Disease severity
EDSS was applied by a neurologist to assess gait disability and disease severity [39,40]. Scales for the total EDSS are from 0 (no disability at all) to 10 (death due to MS). This scale is usually used as inclusion criteria in various studies.

### 2.2.7. Number of attacks in recent year (relapse rate)
At the first, Relapses were defined for subjects in two subtypes of RRMS\&PRMS: new or recurrent neurological symptoms localizing to the CNS, lasting for at least 24 hours after a remission of 30 days or more since the previous attack in the absence of an infection or fever [41]. Then the average frequency of their relapses (or attacks) was asked, as controlled objectively by a neurologist.

### 3. Results

#### 3.1. Demographic information

The sample was consisted of 51 males and 210 females (\(F/M = 4.12\)) with the mean age of 38.9 ± 8.3 years and mean disease duration of 9.7 ± 6.6 years. Only forty
patients (15.3%) reported a family history of MS. Of the total subjects, 216 of them (82.8%) had RRMS, nine (3.4%) had PPMS, twenty-five (9.6%) had SPMS and eleven (4.2%) had PRMS. Mean Height, Weight and BMI were 1.63 ± 0.07 m, 64.9 ± 10.8 kg and 24.3 ± 4.2 kg/m², respectively. Further characteristics of the subjects are shown in Tables 2 and 3 in details.

3.2. Dietary patterns

We discovered three major dietary patterns for the study population. These factors accounted for 94.028% of the cumulative variance in food items. The Kaiser–Mayer–Olkin (KMO; measure of sampling adequacy) was more than 0.6, indicating an effective factor analysis [43] (KMO = 0.840, \( P < 0.001 \)).

- Fruits, Vegetables, Low fat dairy-based dietary pattern (FVLf.patt) characterized by fruits (dried and fresh, juices), vegetables (especially cruciferous and onions, peppers and curry, tomato, squash) and low-fat dairy products.
- Mediterranean-Like dietary pattern (MedL.patt) identified by whole cereals, white meats, beans, nuts, omega 3,6-contained oils and moderate intakes of coffee (2 cups per day).
- Western-Like dietary pattern (WestL.patt) described as high salt intake, refined cereals, red meats, high-fat dairy, sweets, processed and fast foods, and saturated fat-contained oils.

3.3 Relationship of dietary patterns with qualitative variables (sex, education level, type of MS, family history, BMI classification)

Distribution of three dietary patterns among different sexes was not significant difference (\( \chi^2 = 0.484, P = 0.78 \)). Similar results were obtained for education level, type of MS and family history; which were not statistically significant. Unlike these, the frequency of subjects among BMI subgroups and dietary patterns was significantly different (\( \chi^2 = 44.7, P < 0.001 \)). As seen in Table 1, the percentage of obesity, overweight, and even underweight in participants with WestL.patt was significantly higher than the other dietary patterns.

3.4. Relationship of dietary patterns with qualitative variables

3.4.1. Age and duration of the disease

There was no significant difference about age (\( F = 0.062, P = 0.940 \)) and for duration of the disease (\( F = 0.251, P = 0.778 \)) among different dietary patterns (Table 2).

3.4.2. Systemic inflammation

In MS participants, the serum concentration of hs-CRP was significantly lower (\( F = 10.348, P < 0.001 \)) in both FVLf.patt (1, 95% CI 0.5–1.6) and MedL.patt (0.8, 95% CI 0.2–1.4) compared to those with WestL.patt (3, 95% CI 2.5–3.5) (Table 2). The mean of hs-CRP

Table 1. Association between three dietary patterns and sex, education level, type of MS, family history and BMI*.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Subgroups</th>
<th>Dietary patterns</th>
<th>Dietary patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FVLf.patt n (%)</td>
<td>WestL.patt n (%)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>11 (21.6)</td>
<td>36 (70.6)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>39 (18.6)</td>
<td>158 (75.2)</td>
</tr>
<tr>
<td></td>
<td>Illiterate</td>
<td>1 (14.3)</td>
<td>6 (85.7)</td>
</tr>
<tr>
<td></td>
<td>Elementary</td>
<td>5 (22.7)</td>
<td>16 (72.7)</td>
</tr>
<tr>
<td></td>
<td>Junior school</td>
<td>4 (11.4)</td>
<td>29 (82.9)</td>
</tr>
<tr>
<td></td>
<td>Diploma</td>
<td>24 (17.8)</td>
<td>101 (74.8)</td>
</tr>
<tr>
<td></td>
<td>University</td>
<td>16 (25.8)</td>
<td>42 (67.7)</td>
</tr>
<tr>
<td>Type of MS***</td>
<td>RRMS</td>
<td>39 (18.1)</td>
<td>160 (74.1)</td>
</tr>
<tr>
<td></td>
<td>PPMS</td>
<td>3 (27.3)</td>
<td>8 (72.7)</td>
</tr>
<tr>
<td></td>
<td>SPMS</td>
<td>7 (28.0)</td>
<td>18 (72.0)</td>
</tr>
<tr>
<td></td>
<td>PRMS</td>
<td>1 (11.1)</td>
<td>8 (88.9)</td>
</tr>
<tr>
<td>Family history</td>
<td>Yes</td>
<td>8 (20.0)</td>
<td>29 (72.5)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>42 (19.0)</td>
<td>165 (74.7)</td>
</tr>
<tr>
<td>BMI classification</td>
<td>Normal</td>
<td>36 (26.9)</td>
<td>82 (61.2)</td>
</tr>
<tr>
<td></td>
<td>Underweight</td>
<td>9 (42.9)</td>
<td>12 (57.1)</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>5 (6.6)</td>
<td>70 (92.1)</td>
</tr>
<tr>
<td></td>
<td>Obese</td>
<td>0 (0.0)</td>
<td>30 (100.0)</td>
</tr>
</tbody>
</table>

Abbreviations: FVLf.patt, Fruits, Vegetables, Low fat dairy-based pattern; WestL.patt, Western-Like pattern; MedL.patt, Mediterranean-Like pattern; RRMS, Relapsing-Remitting Multiple Sclerosis; PPMS, Primary-Progressive MS; SPMS, Secondary-Progressive MS; PRMS, Progressive-Relapsing MS; BMI, Body Mass Index.

*Obtained from Pearson’s Chi-square test.

**% within subgroups.

***Note: Less than 20% of cells expected to be less than 5, and the minimum expected count was more than 1. To meet these two conditions, the subgroups of education and types of MS were reduced to two subgroups; i.e., types of MS: RRMS, others; education level: diploma and more, Less than diploma.
concentration was significant between two pairwise of dietary patterns including ‘West L. Patt and FVLf.patt (P<0.001), West L. Patt and Med L. Patt (P, B, C < 0.01)’ (Table 2). This difference was observed, even after adjusting for covariates (F = 6.037, Padjusted < 0.01).

### 3.4.3. Anthropometric measurements

There were significant differences about anthropometric variables among dietary patterns: Height (F = 6.068, P < 0.01), Weight (F = 9.797, P < 0.001), BMI (F = 17.969, P < 0.001) and Percent Body Fat (F = 10.094, P < 0.001).

Tukey test showed significant differences between WestL.patt and FVLf.patt (P<0.001). Similar differences were also observed between WestL.patt and MedL.patt, expect for Weight (P = 0.192).

We also realized significant difference about BMI, by the elimination of confounder effects such as age, sex, duration of the disease and type of MS (F = 7.528, Padjusted < 0.01). Similar result was obtained for Percent Body Fat (F = 6.135, Padjusted < 0.01) (adjusted only for type of MS and duration of the disease).

#### 3.4.4. Disease severity

Mean difference of EDSS across three dietary patterns was not significant (FVLf.patt: 1.8, 95% CI 1.4-2.1; MedL.patt: 1.4, 95% CI 1.1-1.8; WestL.patt: 2, 95% CI 1.8-2.1; P = 0.126).

Post-hoc comparisons also did not show any significant difference about EDSS between the WestL.patt and FVLf.patt (P<0.001), and WestL.patt and MedL.patt (P = 0.149) (Table 2).

After controlling for covariates, difference between dietary patterns was not yet significant (F = 1.867, Padjusted = 0.157) (Table 3).

### 3.4.5. Fatigue severity

Participants with MedL.patt and FVLf.patt had lower score for acute (mean for VAFS = 7.5, 6.5) and chronic...
fatigue (mean for FSS = 23.3, 28.1) compared to those with West L. Patt (F for VAFS = 14.581, F for FSS = 21.223, P < 0.001). In addition, mean differences among dietary patterns in both variables was significant (P, B, A, P, B, C < 0.001) (Table 2).

ANCOVA test, after adjustment for age, duration of the disease, type of MS and sex revealed significant differences about VAFS and FSS across the dietary patterns (F for VAFS = 5.353, P_{adjusted} < 0.01; F for FSS = 7.011, P_{adjusted} < 0.01) (Table 3).

### 3.4.6. Quality of life

All scores related to quality of life were significantly higher for those adhered to FVLf. part as well as Med L. Patt (P < 0.001; social function P < 0.05) (Table 2).

Tukey test showed a significant difference between FVLf.patt & WestL.patt, and MedL.patt & West L. Patt (F, B, A, P, B, C < 0.001; except for Social function P, B, A = 0.185, P, B, C = 0.064; Role limitations – emotional P, B, C = 0.881; Cognitive function P, B, C = 0.999; MHCS P, B, C = 0.915) (Table 3).

Two composite scores, including PHCS and MHCS, were controlled for covariates presented in Table 3. Also in this condition, the difference between the dietary patterns was significant (P_{adjusted} < 0.001).

### 3.4.7. Number of attacks in recent years (Relapse Rate)

Among subjects with RRMS and PRMS, there was a significant difference about mean one-year Relapse Rate between three detected dietary patterns (F = 12.185, P < 0.001); it means a healthier dietary pattern like FVLf.patt (0.8, 95% CI 0.6–1) and MedL.patt (0.7, 95% CI 0.4–1) was associated with a lower Relapse Rate, compared to WestL.patt (1.5, 95% CI 1.3–1.6) (Table 2).

Precisely, we found the difference between two healthy patterns and western-like pattern is significant (Table 2).

Furthermore, univariate analysis after controlling for age, sex, type of MS and duration of the disease showed mean difference between dietary patterns is still significant (F = 4.475, P_{adjusted} < 0.05) (Table 3).

### 5. Discussion

In this cross-sectional observational study, we tried to find major dietary patterns and then evaluated the association between them and systemic inflammation, Health-Related Quality Of Life (HRQOL), disease severity, Relapse Rate, severity of fatigue and anthropometric measurements in 261 Iranian participants with four subtypes of MS. Using 168 item FFQ and factor analysis...
method, three dietary patterns were identified; two of them were healthy (FVLf.patt, n = 50 and MedL.patt, n = 17) and that one was unhealthy (WestL.patt, n = 194). Subjects adhered to two healthy and one unhealthy pattern showed significant mean differences about the most dependent variables (except for EDSS), even after adjustment for age, sex, duration of the disease and type of MS.

Considering the homogeneity of food intake in Iran, judgement about dietary patterns is very difficult. Although previous studies, mostly have evaluated single foods or nutrients, based on our knowledge, this is a unique study to identify major dietary patterns in four subtypes of Iranian MS patients. Jahromi SR et al., in a case–control study, found seven major patterns and an inverse relationship between traditional, vegetarian and lactovegetarian dietary patterns and MS risk from 75 Iranian woman (new RRMS cases) [44], while in our study, three major patterns with somewhat similar associations were explored. Based on the newest study in Iran, two dietary patterns – healthy and western – on 68 MS case was observed [45]. In other populations, similar results were attained; for example, in Serbia, Pekmezovic et al. discovered that frequent consumption of beef, chicken, meat of the lamb, butter and ice-cream – with dose–response relationship – can contribute to the risk of developing MS [46]. Similarly, in our study, high consumption of these foods is included in WestL.patt. However, in contrast to our results, Fitzgerald KC et al. after comparison of one large MS population with NHANES participants reported: ‘people with MS consume comparable intakes of fruit, vegetables, legumes, whole grains and less added sugar’ [47].

MedL.patt was one of the strong key points of our study. The lowest hs-CRP levels and highest PHCS were seen in this pattern. Riccio et al. showed that a Mediterranean-like diet may improve MS treatment by suppressing inflammation [48]. Some authors reported that adherence to Mediterranean diet (MD) is associated with reduced risk of MS [49]. According to other researchers, MD is the most powerful fighter against diseases like MS [50]. From a practical point of view, the significant presence of omega-3 PUFA and high ratio of omega-3/omega-6 in MedL.patt is greatly responsible for development of clinical manifestations towards an amelioration of inflammatory status [51,52] that we found out too.

Similar to ours, the lower level of QOL in MS patients has been reported in various investigations [53–56], however, the association of dietary patterns with QOL was not fully conducted in any survey. Hadgkiss et al. demonstrated a significant association of healthy dietary habits with better physical and mental QOL and a lower level of disability using a 24-item questionnaire [57], but in our survey, differences among dietary patterns towards all of the QOL subscales were significant. More precisely, Jelinek et al. suggested that – in addition to a healthier diet –, other factors such as moderate and high physical activity, non-smoking and normal BMI are associated with higher PHC and MHC scores [58]. On the contrary, in current study, smokers were excluded and physical activity was not assessed.

Given the important relationship between inflammation and neurodegeneration in MS cases [59,60], the goal of treatment should be focused on controlling the inflammatory processes. First step is to know inflammation and dietary pattern interaction; in fact, this is the most important aim of our study. The serum level of hs-CRP was reported higher than healthy people by Ji et al. [61]. In relation to food items, Montonen et al. revealed that consumption of red meat is associated with higher serum levels of γ-glutamyl-transferase (g-GT) and hs-CRP [62]; as this was shown in WestL.patt (mean, 95% CI for this pattern = 3, 2.5–3.5 mg/L). We also observed the lower levels of this marker in the FVLf.patt and MedL.patt. Similarly, in previous studies, a reverse relationship of vegetables and fruits intake with serum levels of hs-CRP has been reported [63,64]. From the aspect of dietary patterns, various studies have been done on various diseases, but our study is the first attempt to study this feature in MS patients. Detecting a positive relationship between western pattern compliance and hs-CRP was as a result of two separate studies applied by Fung et al. [65] and Lopez-Garcia et al. [66]. In the most similar state to our study, Esmaillzadeh et al. found three patterns; two of them (healthy and western) had significant relationship with CRP level [67].

Fatigue is one of the most painful complications of MS. Nutrition education program conducted by Rashvand et al. raised FSS score [68]; vitamin B12 and iron [69] and coenzyme Q10 [70] supplementation had positive effects on fatigue. However, in these studies, the current diet of MS patients was not considered. Another study, using 24-hour food record for 3 days, found that the lower magnesium and folate intakes are correlated with higher fatigue scores in MS patients [71]. Differentiation between acute and chronic fatigue has been determined in few investigations [72,73]. But for the first time, we measured the relationship between these two factors with dietary patterns. Fatigue severity was negatively correlated with healthy diets (FVLf.patt and MedL.patt).

MS attack (Relapse Rate in the RR&PRMS cases) was associated with dietary patterns, but disease severity (measured by EDSS) was not significantly different among the patterns. Positive effects of omega-3
supplementation on EDSS and Relapse Rate, and omega-3,6 – on EDSS only – was reported by Rezapour-Firouzi et al. [74]. Similar to our results, Azary et al., after dietary intake assessment of 219 patients with pediatric RRMS or CIS (clinically isolated syndrome) Concluded that saturated fat and vegetables have an amazing effect on Relapse Rate occurrence [75]. Jelinek et al. also reported promotion effects of fish consumption and omega-3 supplementation on Relapse Rate, however, the statistically significant impact was observed for flaxseed oil only [76]. Indeed, in our result, patterns contained all types of omega-3,6 were negatively associated with Relapse Rate.

Association between dietary patterns and anthropometric indices in MS patients has not been studied completely before; however, we evaluated BMI and Percent Body Fat among different dietary pattern in four subtypes of MS for the first time. Both the underweight and the overweight-obesity are related to West L. Patt. Many previous studies have shown a positive association between obesity and hs-CRP [77], though it should be noted that even after BMI adjustment [78], the relationship between this factor and risk of diseases like diabetes mellitus was still stable [79]. However, the BMI and Percent Body Fat was adjusted for covariates mentioned earlier itself. Obese participants had unhealthy pattern and, as a result, worse clinical manifestations.

5.1. Limitations

Regarding the high similarity of food intakes in Iran and lack of some food items in the FFQ-168, it was difficult to identify dietary patterns. Receiving information about food intake was prone to a recall bias; however, we tried to reduce this bias by psychologically supporting patients when answering questions. On the other hand, filling these questionnaires was time-consuming, this could reduce the accuracy of the gathered information. The existence of some items, such as sexuality-related questions in MSQOL-54, created constraints for participants; however, there was no compulsion for the respondents to answer these questions. Managing the patients’ clothing to increase the accuracy of anthropometric measurements was very difficult due to cultural restrictions; however, the maximum effort was made in this challenge. Finally, the causation and direction of relations between variables was not recognizable due to the cross-sectional nature of the study.

6. Conclusion

In short, we found three major dietary patterns; most of the subjects adhered to Western-Like pattern. These patients had higher BMI and Percent Body Fat compared to those with Fruit, Vegetable, Low Fat Dairy-Based and Mediterranean-Like patterns. Lower relapses and higher quality of life (except for social function), as well as fatigue improvement were observed in two healthy patterns; however, disease severity had not any association with different patterns. Lower inflammatory marker ‘hs-CRP’ in the Mediterranean-Like pattern highlighted the important role of omega-3,6 fatty acids. All of these relationships – even after adjusting for age, sex, disease type and duration – remained significant. Further investigations must be conducted to verify this identified relations, especially clinical trials for each component of these two healthy patterns.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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