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ORIGINAL

Effects of nutrition education given to persons with multiple sclerosis and their families on diet quality and anthropometric and biochemical measurements

Efeito da educação nutricional dada a pessoas com esclerose múltipla e suas famílias em relação a qualidade da dieta, medidas antropométricas e bioquímicas

Zeynep UZDİL[1] 0000-0002-8152-5858
Perim Fatma TÜRKER[2] 0000-0002-4254-3711
Murat TERZİ[3] 0000-0002-3586-9115

ABSTRACT

Objective

In this study, it was aimed to investigate the effects of nutrition education given to persons with multiple sclerosis and their families on anthropometric and biochemical measurements and diet quality.

Methods

Data from 51 persons with multiple sclerosis were analysed in this intervention study. The study was conducted with 3 groups. The education group consisted of only persons with multiple sclerosis, the family education group consisted

[1] Ondokuz Mayıs University, Faculty of Health Sciences, Department of Nutrition and Dietetics. Körfez Neighbourhood, 55270, Atakum/Samsun, Turkey. Correspondence to: Z UZDİL. E-mail: <zuzdil1010@hotmail.com>.
[2] Başkent University, Faculty of Health Sciences, Department of Nutrition and Dietetics. Ankara, Turkey.
[3] Ondokuz Mayıs University, Faculty of Medicine, Department of Neurology. Samsun, Turkey.

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of persons with multiple sclerosis and a family member living with them, and the control group consisted of persons with multiple sclerosis who had not received an education. Anthropometric and biochemical measurements and dietary quality assessments were made before (T1) and immediately after education (T2) and also 3 months after education (follow-up, T3).

Results

The distribution of family education group diet quality scores showed a significant increase from "poor" to "needs improvement" at T3 compared to T1. The upper middle arm circumference measurements of the female control group were decreased at T2 and T3 [from 29.0 (23-34) cm to 28.0 (22-31) cm and to 27.5 (22-31) cm]. Women in family education group, levels of serum haemoglobin and haematocrit were higher than in control group at T2 and T3. Also, men in family education group, levels of alanine aminotransferase were lower than those in education group at follow up. Levels of total cholesterol and low-density lipoprotein cholesterol in education group were higher than those control group at T1, T2, and T3.

Conclusion

This study indicates that nutrition education affects some biochemical and anthropometric measurements in persons with multiple sclerosis. Diet quality improved when receiving education together with families.

Keywords: Diet quality. Multiple sclerosis. Nutrition education.

RESUMO

Objetivo

Objetivou-se investigar os efeitos da educação nutricional dada a pessoas com esclerose múltipla e seus familiares, avaliação de medidas antropométricas, bioquímicas e da qualidade da dieta.

Métodos

Dados de 51 participantes com esclerose múltipla foram analisados neste estudo de intervenção. O estudo foi dividido em 3 grupos, sendo o primeiro composto por indivíduos que obtiveram educação nutricional, o segundo, composto por indivíduos mais um membro da família que morava com eles e obtiveram educação nutricional, e o terceiro, grupo controle, composto por indivíduos que não obtiveram educação nutricional. Medidas antropométricas, bioquímicas e avaliações da qualidade da dieta foram feitas antes (T1) imediatamente após a educação nutricional (T2) e também 3 meses após a educação nutricional (T3).

Resultados

A distribuição dos escores de qualidade da dieta do grupo de educação familiar mostrou um aumento significativo de "ruim" para "precisa melhorar" no T3 em comparação ao T1. As medidas da circunferência do braço médio do grupo controle feminino foram menores em T2 e T3 [de 29,0 (23-34) cm para 28,0 (22-31) cm e para 27,5 (22-31) cm]. Nas mulheres do grupo família, os níveis séricos de hemoglobina e hematocrito foram maiores do que no grupo controle em T2 e T3. Também nos homens do grupo família, os níveis de alanina aminotransferasa foram mais baixos do que os do grupo educação no seguimento. Os níveis de CT e LDL-C no grupo educação foram superiores aos do grupo controle em T1, T2 e T3.

Conclusão

Este estudo observou que a educação nutricional afeta algumas medidas bioquímicas antropométricas em pessoas com esclerose múltipla. A qualidade da dieta melhorou quando recebeu educação junto com as famílias.

Palavras-chave: *Qualidade da dieta. Esclerose múltipla. Educação nutricional.*

INTRODUCTION

Multiple Sclerosis (MS) is a chronic and progressive neurological disease involving the central nervous system, with demyelination and axonal degeneration [1]. It often occurs in women and young adults [2]. Immunological factors, genetic, epigenetic and environmental factors are effective in its etiology [3].

The effects of nutrition on the etiology, pathogenesis, and treatment of this disease have been investigated over the course of the last 50 years [4]. Allostatic load, which evaluates cardiovascular markers, anthropometric measures, inflammatory markers, glucose homeostasis, and lipids levels, was found to be higher in persons with MS compared to healthy individuals [5]. Also, problems related to nutritional status, such as weight loss, obesity, constipation, dysphagia, cardiovascular risks, and loss of bone-mineral density can be seen in these patients [6]. Good nutrition, which includes high diet quality and healthy eating habits, positively affects the physical and mental health of patients and reduces disability [7,8]. Also, a study showed that health-related quality of life in Persons With Multiple Sclerosis (PWMS) is another factor that positively affects them [8]. It is known that high quality diet reduces mortality risk in cases of diabetes, cardiovascular diseases, neurodegenerative diseases, and cancer [9]. Diet scores and physical and mental health were positively affected by education given to PWMS based on healthy lifestyle behaviours and fatigue levels decreased with activity-oriented education [10,11]. Educational intervention for a Mediterranean diet leads to reductions in fatigue and disability in patients [12]. In addition, when families of PWMS and patient caregivers participate in the education, the quality of life of the patients is positively affected [13,14]. However, no study in literature has evaluated the effects of nutrition education on diet quality in PWMS, leading us to conduct the present research. In this study, we sought to evaluate the effects of nutrition education given to PWMS and their families on diet quality and anthropometric and biochemical measurements.

METHODS

In this educational intervention study, individuals who had been diagnosed with relapsing-remitting type MS according to the McDonald criteria were included from the Ondokuz Mayıs University Health Application and Research Centre of Neurology's outpatient clinic in the Samsun province between October 2018 and March 2019. These PWMS were divided into 3 groups. In the Education Group (EG), only PWMS received nutrition education. In the Family Education Group (FEG), PWMS and family members living with them received nutrition education. The Control Group (CG) comprised PWMS who did not receive nutrition education. A total of 162 PWMS who had applied to the neurology outpatient clinic were evaluated. The number of PWMS in each group was of 15 PWMS with a 95% confidence interval, margin of error of 0.05, and power of 99.5% in power analysis based on previous work [15]. Considering the losses that may occur during the study, the sample size was determined as 20 participants in each of the 3 groups, for a total of 60 participants. Sixty PWMS were randomly assigned (ensuring equal age and disability) to a control group or one of two intervention groups who met the inclusion criteria and agreed to participate in the research. Individuals who developed a disability received another nutrition education. The ones who were diagnosed with a psychiatric disorder by a physician, had a hearing or vision impairment or liver and kidney failure, and were pregnant/lactating were not included in the study. Sociodemographic characteristics [age, gender, marital status, occupation, duration of MS, and Expanded Disability Status Scale (EDSS) score] and physical activity levels of the individuals were determined using a face-to-face interview method. Nutritional status was evaluated through anthropometric and biochemical measurements. Diet quality was determined using the Healthy Eating Index (HEI)-2010. Diet quality, biochemical measurements and anthropometric measurements were performed before nutrition education (T1), immediately after nutrition education (T2), and 3 months after nutrition education (follow-up, T3) by the responsible researcher. The flow diagram of the study is given in Figure 1. The EDSS was developed by Kurtzke to evaluate the functional status of PWMS [16]. In this study, EDSS scores were determined by a neurologist.

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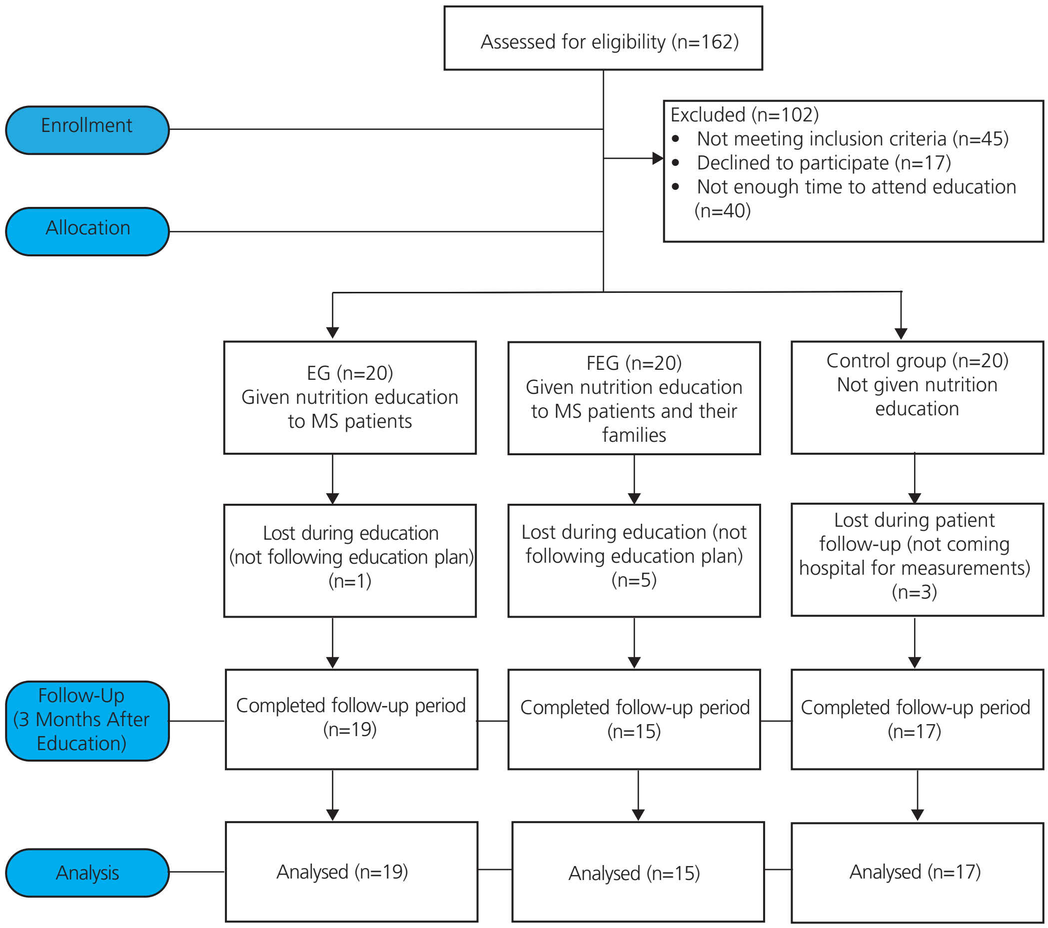

Figure 1 – Study Flow Diagram.
Note: EG: Education Group, FEG: Family-Attended Education Group, MS: Multiple Sclerosis.

Body height (m), Waist Circumference (WC, cm), Hip Circumference (HC, cm), Upper Middle Arm Circumference (UMAC, cm) and Triceps Skinfold Thickness (TST, mm) measurements were taken by the researcher. Body weight (kg), Body Fat Mass (BFM, kg), and Fat-Free Mass (FFM, kg) were measured with a Tanita BC-418 bioelectrical impedance analyser. Height was measured in the Frankfurt plane with patients facing straight ahead, toes touching the wall. Body Mass Index (BMI) was calculated with the following formula: body weight (kg)/height (m^2). WC was measured by finding the midpoint of the lowest rib and iliac bone and measuring the circumference passing through that point using an inelastic measuring tape. UMAC was measured by finding the midpoint between the acromial protrusion of the shoulder and the olecranon protrusion of the elbow and measuring the circumference with an inelastic measuring tape. TST was measured with a Holtain calliper while the right arm was bent 90° from the elbow; the midpoint between the acromion of the shoulder and the olecranon protrusions of the elbow was determined, and the calliper was used at the back of the arm [17]. Hand grip strength measurements were made with a digital hand dynamometer by taking four measurements, two each for the right and left hands. The average of those two measurements was evaluated as hand grip strength for the respective hands.

Biochemical measurements were evaluated in the routine follow-up of the participants in this centre and were obtained from hospital records. Blood samples were taken following at least 8 hours of fasting.

Serum Haemoglobin (Hb), Haematocrit (Htc), Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), iron, ferritin, Total Cholesterol (TC), Triglyceride (TG), Low-Density Lipoprotein Cholesterol (LDL-C), High-Density Lipoprotein Cholesterol (HDL-C), and vitamin B12 were evaluated. The analysis of these biochemical parameters was performed with a Roche Diagnostic Cobas 8000 device.

The HEI was developed by the U.S. Department of Agriculture to measure the quality of diet in line with daily food and nutrient consumption recommendations and consists of 12 criteria (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories) [18]. Evaluations are performed according to the following cut-off points: 0-50 points, "poor"; 51-80 points, "needs improvement"; ≥80 points, "good" diet quality [19]. In this study, diet quality was calculated based on prospective 3-day food consumption records. Food consumption records were taken prospectively. Participants were asked to write down all the food and beverages they ate from morning to evening for 3 days and 24 hours on food consumption registration forms by specifying kitchen measures (such as cups, spoons) and quantities. The data of these records were entered into the Turkish Nutrition Information System Program (Bebis) by the responsible researcher and the necessary nutrients were analyzed for HEI calculation.

An accepted dietary approach in the treatment of MS has not yet been accepted nowadays. Studies in the literature show that PWMS have unhealthy eating behaviors that are not based on scientific evidence [20,21]. For this reason, in this study, nutrition education based on healthy nutrition and nutritional recommendations that PWMS can apply for complications such as obesity, gastrointestinal system problems, and cardiovascular risks which are common were given [22,23]. While preparing the nutrition education topics, we have used Turkey-Specific Nutrition Guide [24] and MS related reference [25]. Nutrition, nutrients, correct food preparation and cooking methods, important points to be considered when buying food, specific problems related to nutrition in MS and nutritional recommendations for those problems were the subjects of the nutrition education. The same nutrition education was given to individuals in both of the nutrition Education Groups (EG and FEG) one day per month for 3 months, and each educational session lasted approximately 40 minutes (25 minutes for nutrition education, 15 minutes for questions and answers). Individuals in the CG did not receive nutrition education during the study, but to ensure that these PWMS were not unethically deprived of nutritional information, they received nutrition education in one session upon completion of the study. At the end of each nutrition education session, PWMS in the EG and FEG were given a brochure about the relevant information and were asked to read it before the next session.

Written consent was obtained from all individuals who participated in this study and the Declaration of Helsinki was followed. This study was approved by Baskent University Institutional Review Board and Ethics Committee (dated 19/09/2018 and numbered 18/70).

Qualitative variables were expressed as number (n) and percentage (%), parametric quantitative variables were expressed as Mean±Standard Deviation (SD), and non-parametric quantitative variables were expressed as median (minimum-maximum) values. Fisher's exact test for qualitative variables, Friedman's test with Bonferroni correction for non-parametric analysis, and analysis of variance in repeated measures for repetitive measurements of quantitative variables with three groups were used. The Kruskal-Wallis test was used for the comparison of three non-parametric independent groups, and when parametric test conditions were met, ANOVA testing was applied. For this analysis, IBM SPSS Statistics 21.0 and the R program (for marginal homogeneity testing) were used. Values of $p<0.05$ were considered statistically significant.

RESULTS

A total of 60 PWMS were included in this study, but 9 PWMS (EG: 1, FEG: 5, CG: 3) were excluded from the study because they did not complete the nutrition education or the follow-up process, and analyses were thus conducted with 51 patients [10 men (19.6%) and 41 women (80.4%)]. Table 1 shows the distribution of these individuals' sociodemographic characteristics. Gender, age, EDSS score, education level, marital status, and occupations of the individuals in the three groups were all found to be similar before the start of the study. The physical activity levels of the individuals at the beginning of the study were also similar (p=0.93).

Anthropometric measurements of individuals during the study are given in Table 2. The BMI, WC, HC, and FFM values of the education groups and the CG did not change during the study (p>0.05). At T2 and T3, the UMAC of women decreased in the CG [from 29.0 (23-34)cm to 28.0 (22-31)cm and to 27.5 (22-31)cm, p<0.001]. The TST of the women in the FEG decreased at T2 compared to T1 (15.3±2.5mm

Table 1 – Distribution of Individuals' Sociodemographic Characteristics (n=51).

Variables	Intervention				Control		Total (n=51)		*p*
	EG (n=19)		FEG (n=15)		CG (n=17)				
	n	%	n	%	n	%	n	%	
Gender									0.20
Men	5	26.3	4	26.7	1	5.9	10	19.6	
Women	14	73.7	11	73.3	16	94.1	41	80.4	
	M±SD		M±SD		M±SD				
Age (year)	39.7±11.1		35.6±13.1		33.5±7.1				0.21
Duration of illness (year)	(9.6±6.2)[a]		(4.1±5.1)[b]		(6.2±5.4)[ab]				0.02*
EDSS score	0.8±1.1		0.3±0.6		1.1±1.3				0.16
	n	%	n	%	n	%			
Education level									0.25
Primary school	7	36.8	2	13.3	8	47.1			
High school	9	47.4	8	53.4	5	29.4			
Undergraduate	3	15.8	5	33.3	3	17.6			
Postgraduate	-	-	-	-	1	5.9			
	n	%	n	%	n	%			
Occupation									0.21
Student	2	10.5	3	20.0	2	11.8			
Self-employment	3	15.8	2	13.3	-	-			
Housewife	8	42.2	3	20.0	13	76.4			
Worker	2	10.5	4	26.7	-	-			
Civil servant	2	10.5	1	6.7	1	5.9			
Retired	2	10.5	2	13.3	1	5.9			
	n	%	n	%	n	%			
Marital status									0.64
Married	15	78.9	10	66.7	11	64.7			
Single	4	21.1	5	33.3	6	35.3			
	Yes	No	Yes	No	Yes	No			
Physical activity (%)									
T1	35.3	64.7	31.6	68.4	26.7	73.3			0.93
T2	11.8	88.2	26.3	73.7	20.0	80.0			0.55
T3	5.9	94.1	26.3	73.7	6.7	93.3			0.13

Note: $^{*}p$<0.05. [a-b]: There is no difference between groups with the same letter on the same row. CG: Control Group, EDSS: Expanded Disability Status Scale, EG: Education Group, FEG: Family-Attended Education Group, T1: before education, T2: after education, T3: 3 months after education (follow-up). Values are expressed as n (%), mean±standard deviation.

and 15.9±2.8mm, *p*=0.03). The BFM of men in the EG increased at T3 compared to T1 (18.0±17.1kg and 17.5±17.4kg, *p*=0.04). The strength of the right and left hands of women in the FEG decreased at T3 compared to T1 [for the right hand 19.7 (9-28)kg and 17.3 (9-23)kg; for the left hand 17.3 (7-27)kg and 15.9 (7-23)kg, respectively *p*=0.02 and *p*=0.006]. The strength of the right hand decreased in men of the FEG at T2 compared to T1 [33.6 (23-46)kg and 31.2 (25-58)kg, *p*=0.04]. The strength of the left hand of women in the CG had decreased at T3 compared to T1 [19.6 (6-30)kg and 17.1 (0-26)kg, *p*=0.001)].

Table 2 – Anthropometric Measurements of Individuals During the Study According to Groups (n=51).

1 of 2

Variables	EG (n=19)		FEG (n=15)		CG (n=17)	
	Men (n=5)	Women (n=14)	Men (n=4)	Women (n=11)	Men (n=1)	Women (n=16)
BMI						
T1	24.7(20.4-41.6)	26.0(20.7-41.3)	25.2(21.9-31.2)	25.6(18.9-38.2)	24.0	26.2(18.9–32.3)
T2	24.8(20.6-41.3)	26.1(21.7-42.3)	25.3(22.4-31.7)	26.4(19.3-39.6)	24.9	26.0(18.8-32.2)
T3	24.8(20.6-41.3)	26.6 (20.3-42)	25.1(22.2-31.7)	26.1(19.3-39.6)	24.0	26.2(19–32.6)
p	0.29	0.43	0.63	0.12		0.15
WC						
T1	89.0(75-125.5)	92.0 (87-97)	90.0(70-113)	83.0 (68-104)	89.0	86.0(66-102)
T2	87.0(75-123)	94.5 (87.5-96)	87.5(75-111)	87.0 (69-107)	91.0	83.5(64-100)
T3	87.0(76-123)	93.0 (85-96)	88.0(72-111)	84.5 (68-107)	89.0	84.0(65.5-100)
p	0.82	0.66	0.37	0.52		0.73
HC						
T1	98.0(94-130)	103.0(100- 108)	101.5(91-135)	103.0 (91-122)	103.0	104.0(91-119)
T2	102.0(94-125)	102.5(100- 106)	102.0(90-130)	103.0 (92-118)	106.0	103.5 (88.5-122.5)
T3	106.0(94-125)	104.5(101- 106)	102.5(89-130)	104.0 (88-118)	103.0	104.0(88.5-118)
p	0.78	0.23	0.22	0.57		0.11
UMAC						
T1	28.0(24-36.5)	28.0 (23-40)	30.5 (27-33)	28.0(21.5-37)	28.0	29.0(23-34)[a]
T2	28.5 (23-36)	27.5 (25-41)	30.0 (26.5-32)	29.0(21-34)	28.5	28.0(22-31)[b]
T3	29.0 (24-36)	27.5 (24-41)	30.0 (26-32)	28.0(20.5-34)	28.0	27.5(22-31)[b]
p	0.305	0.4	0.06	0.81		<0.001*
TST						
T1	9.8±6.0	17.5±2.8	11.4±2.4	(16.6±2.7)[a]	6.0	16.7±3.0
T2	10.3±6.7	16.7±3.9	11.3±2.6	(15.3 ± 2.5)[b]	8.0	15.8±3.3
T3	11.0±6.8	16.8±3.5	11.3±2.8	(15.9 ± 2.8)[ab]	6.0	16.7±3.6
p	0.13	0.28	0.96	0.03*		0.17
BFM						
T1	(16.9±17.2)[a]	27.2±13.6	16.3±6.8	23.6±9.9	8.6	21.2±7.1
T2	(18.0±17.1)[ab]	28.2±13.9	17.1±7.4	24.5±9.9	12.7	21.5 ± 7.3
T3	(17.5±17.4)[b]	27.9±14.2	16.7±7.7	24.5±9.9	8.6	21.4 ± 7.3
p	0.04*	0.12	0.28	0.13		0.78
FFM						
T1	64.2±14.0	46.8±8.0	62.8±3.3	44.1±4.5	66.7	46.3 ± 4.5
T2	63.7±13.3	46.5±8.3	63.0±3.9	44.2±4.1	69.2	45.8±4.1
T3	64.7±12.8	46.7±8.1	62.9±4.0	44.7±4.6	66.7	46.7±5.0
p	0.19	0.74	0.94	0.26		0.26
Hand strength						
Right						
T1	34.8(13-37)	18.1(11-37)	35.6(29-59)[a]	20.9(8-30)[a]	35.6	20.9(7-31)
T2	23.3(9-40)	18.1(9-35)	33.6(23-46)[b]	19.7(9-28)[ab]	33.6	18.9(6-34)
T3	30.8(9-40)	17.9(8-35)	31.2(25-58)[ab]	17.3(9-23)[b]	31.2	17.4(5-31)
p	0.21	0.35	0.04*	0.02*		0.10

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Table 2 – Anthropometric Measurements of Individuals During the Study According to Groups (n=51).

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Variables	EG (n=19)		FEG (n=15)		CG (n=17)	
	Men (n=5)	Women (n=14)	Men (n=4)	Women (n=11)	Men (n=1)	Women (n=16)
Left						
T1	33.4(13-40)	18.9(8-40)	33.9(31-59)	20.4(6-30)^{a}	20.3	22.7(9-31)^{a}
T2	25.6(9-43)	18.5(7-33)	33.2(27-44)	17.3(7-27)^{ab}	24.9	19.6(6-30)^{ab}
T3	29.1(9-43)	17.1(7-33)	33.8(24-56)	15.9(7-23)^{b}	20.3	17.1(0-26)^{b}
p	0.21	0.73	0.21	0.006*		0.001*

Note: **p*<0.05. $^{a-b}$: There is no difference between groups with letters in the same column. Values are expressed as mean±SD and median (minimum and maximum) values. p: Change with education-Analysis of Variance and Friedman test, CG: Control Group, EG: Education Group, FEG: Family-Attended Education Group, T1: before education, T2: after education, T3: 3 months after education (follow-up), BFM: Body Fat Mass, BMI: Body Mass Index, FFM: Fat-Free Mass, HC: Hip Circumference, TST: Triceps Skinfold Thickness, UMAC: Upper Middle Arm Circumference, WC: Waist Circumference.

Biochemical parameters are shown in Table 3. In men; in the FEG, levels of Hb were higher than those in the EG at T1 and T2 (respectively for the FEG and EG: at T1, 15.2±0.5g/dL and 14.6±0.3g/dL, and at T2, 16.3±0.9g/dL and 14.6±0.7g/dL). In women; in the FEG, levels of Hb and Htc were higher than those in the CG at T2 and T3 (respectively for the FEG and CG: at T2, for Hb 13.3±1.2g/dL and 11.9±1.1g/dL, and for Htc 39.8±4.1% and 36.1±2.9%; and at T3, for Hb 13.3±1.4g/dL and 11.8±1.3g/dL for Htc 40.2±3.9% and 35.7±3.5%). In men; in the FEG, levels of ALT were lower than those in the EG at T3 (*p*<0.05). Levels of TC and LDL-C in the EG were higher than those in the CG at T1, T2, and T3.

Table 3 – Biochemical Measurements of Individuals During Study According to Groups (n=51).

1 of 2

Variables	T1			T2			T3		
	EG	FEG	CG	EG	FEG	CG	EG	FEG	CG
Hb (g/dL)^{1}									
M:13.5-16.9	(14.6±0.3)^{a}	(15.2±0.5)^{b}	13.4^{ab}	(14.6±0.7)^{a}	(16.3±0.9)^{b}	13.7^{ab}	14.9±0.7	15.9±1.3	14.5
W:11.9-14.6	12.6±1.1	12.9±1.3	12.5±1.1	(12.9±1.3)^{ab}	(13.3±1.2)^{a}	(11.9±1.1)^{b}	(12.7±1.2)^{ab}	(13.3±1.4)^{a}	(11.8±1.3)^{b}
Htc (%)^{1}									
M:40-49.4	43.1±1.5	44.1±1.9	41.9	43.6±2.2	46.5±1.5	39.4	43.9±2.5	45.8±2.3	42.1
W:36.6-44	38.3±2.8	38.9±4.7	37.6±2.9	(38.7±3.2)^{ab}	(39.8±4.1)^{a}	(36.1±2.9)^{b}	(38.4±2.7)^{ab}	(40.2±3.9)^{a}	(35.7±3.5)^{b}
TC (mg/dL)									
M/W:0-200	185.0 (133.5-304.7)^{a}	162.6 (127.5-221.5)^{b}	159.6 (101.5-190.7)^{b}	186.4 (138.5-341.7)^{a}	171.8 (117-242.6)^{ab}	152.0 (108.9-201.7)^{b}	181.0 (138.6-340.6)^{a}	175.4 (118-221.7)^{ab}	165.2 (114.6-217.9)^{b}
TG (mg/dL)									
M/W:0-200	112.3 (47.6-312.8)	122.5 (41.7-296.2)	93.3 (46.7-336.3)	112.5 (50-307.7)	142 (41.7-392.4)	87.0 (50.7-354.1)	109.5 (58.5-278.7)	142.3 (41.8-579.2)	91.3 (45.1-323.2)
LDL-C (mg/dL)									
M/W:0-160	109.5 (67.3-241.5)^{a}	82.0 (50.8-133.5)^{b}	78.9 (48.6-117.7)^{b}	100.1 (67.3 –241.8)^{a}	93.9 (50.8-172.6)^{ab}	76.2 (51.1-117.8)^{b}	105.4 (67.3-241.8)^{a}	99.5 (50.8-140.2)^{ab}	71.8 (51.1-109.1)^{b}
HDL-C (mg/dL)									
M/W:35-75	53.0±12.7	49.2±14.5	53.4±11.7	54.0±13.5	50.8±14.7	54.7±11.8	52.7±11.8	52.1±15.8	55.5±12.5
AST (U/L)									
M/W:8-46	19.4 (12.4-69.1)	19.1 (10.9-41)	13.2 (8-30.4)	18.2 (10.3-29.9)	17 (11-34)	15.9 (10.5-29)	19.3 (11.6-26.8)	17.4 (11.8-45.5)	15 (8-41.6)
ALT (U/L)									
M:0-40	21.2 (18.6-24.0)	20.9 (7.2-32.3)	14.8	22.3 (16.1-34.0)	15.6 (8.3-33.2)	14.2	23.8 (20.9-45.9)^{a}	10.3 (4.3-17.2)^{b}	13.3^{ab}

Table 3 – Biochemical Measurements of Individuals During Study According to Groups (n=51).

2 of 2

Variables	T1			T2			T3		
	EG	FEG	CG	EG	FEG	CG	EG	FEG	CG
W:0-35	15.8 (7-129.7)	12.9 (7.3-80.1)	12.4 (7-71.5)	14.7 (10.1-38.9)	11.2 (7-102.6)	12.1 (6.2-39)	15.0 (10.1-37.5)	11.9 (7.9-143.8)	12.1 (7.4-74.2)
Iron (µg/dL)[1]									
M:59-158	75.8 (60.0-127.3)	75.5 (43.6-161.8)	55.7	98.4 (75.4-121.4)	76.4 (65.8-83.7)	94.3	79.2 (69.8-121.5)	81.5 (65.9-118.5)	69.6
W:37-145	61.9 (31.6-143.0)	68.4 (32.0-142.8)	55.7 (16.3-173.6)	69.7 (37.1-161.7)	77.1 (51.0-142.8)	72.9 (22.9-110.2)	65.5 (22.5-96.9)	72.5 (39.0-159.2)	66.0 (28.0-124.0)
Ferritin (ng/mL)[1]									
M:21.8-274.7	66.7±36.3	130.9±92.5	53.0	59.2±27.6	136.8±103.0	67.9	57.6±25.7	137.9±101.7	67.9
W:4.63-204	22.4 (10.7-138.9)	38.8 (5.1-76.9)	21.7 (5.1-101.4)	30.8 (8.8-174.2)	55.5 (5.1-100.7)	17.8 (4.7-81.1)	33.0 (5.2-238.7)	44.4 (4.6-87.0)	16.7 (4.7-81.1)
Vitamin B_{12} (pg/mL)[2]									
M/W:197-866	313.5 (166.7-429.4)	351.5 (305.9-397.0)	326.6 (249.1-404.1)	317.5 (261.2-392.8)	645.9 (397.0-894.9)	308.5 (258.3-358.6)	338.1 (261.3-1113.0)	411.7 (263.4-560.0)	334.1 (327.2-341.0)
Vitamin B_{12} (pg/mL)[1]									
M/W:197-866	322.4 (161.4-730.7)	304.4 (185.4-441.5)	322.1 (213.4-615.9)	302.0 (228.9-572.2)	307.4 (205.4-894.9)	290.3 (171.9-615.1)	303.0 (215.6-504.9)	(195.1-505.7)	306.4 (172.0-938.4)

Note: [1]Not taking iron/vitamin B12 supplement, 2 Taking B12 supplement, [a-b]: There is no difference between groups with the same letter in the same rows. Values are expressed as mean±SD and median (minimum and maximum) values, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, CG: Control Group, EG: Education Group, FEG: Family-Attended Education Group, Hb: Haemoglobin, Htc: Haematocrit, HDL-C: High-Density Lipoprotein Cholesterol, LDL-C: Low-Density Lipoprotein Cholesterol, TC: Total Cholesterol, TG: Triglyceride. T1: before education, T2: after education, T3: 3 months after education (follow-up), M: Men, W: Women. Also in rows with a/b are $p<0.05$.

Figure 2 shows the distribution of HEI-2010 scores. Mean HEI-2010 scores did not significantly differ between the nutrition education groups, but the HEI-2010 scores of only the FEG had increased significantly at T3, from "poor" to "needs improvement" ("poor" at T1, 46.7%, and "poor" at T3, 20% versus "needs improvement" at T1, 53.3%, and "needs improvement" at T3, 80%, $p=0.046$). The mean HEI-2010 score of the FEG had also increased at T2, but that was not a statistically significant change.

DISCUSSION

The importance of nutrition in PWMS has been better understood in recent years and positive effects of healthy nutrition on the treatment of PWMS have been revealed [7]. Consumption of a healthy diet such as the Mediterranean diet has been shown to positively affect disease symptoms, such as fatigue in PWMS [26]. Also, the participation of families in the disease-related processes of MS is very helpful in the course of solving PWMS' problems [14].

In this study, anthropometric measurements, including BMI, WC, HC, and FFM did not change in either the intervention group or the control group. This may be the result of only informing PWMS about healthy nutrition and not giving them energy-restricted diets. However, there was a decrease in UMAC measurements at T2 and T3 and a decrease in left-hand strength at T3 compared to T1 observed in the CG, comprising PWMS who did not receive nutrition education. Measurements of decreased muscle strength reflected in decreasing UMAC and hand grip CG should suggest that these individuals were malnourished.

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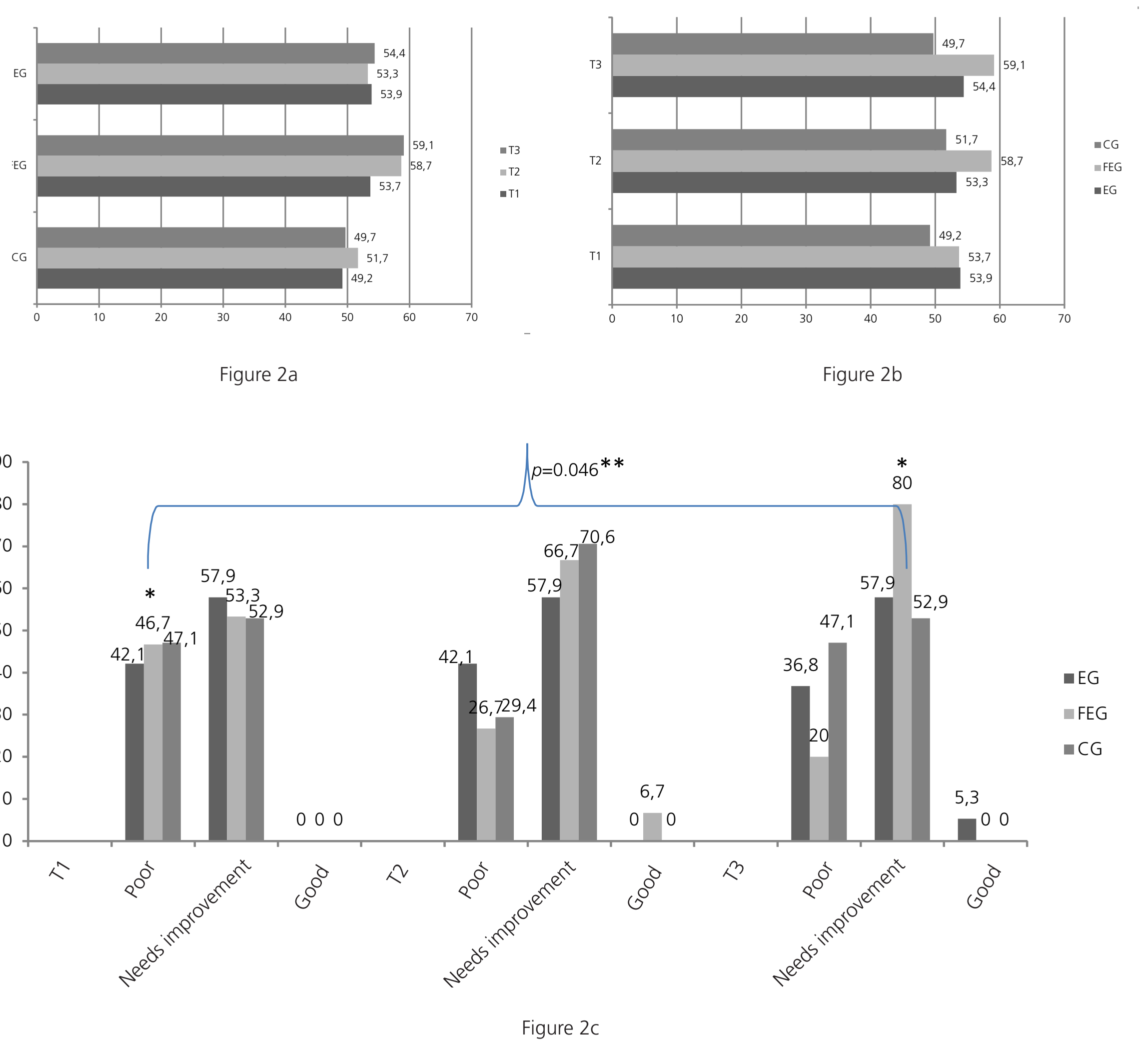

Figure 2 – Distribution of Individuals' HEI-2010 Scores According to Time, Groups and Cut-Off Points (n=51).
Note: 2a: Mean of HEI-2010 scores according to T1, T2, T3, 2b: Mean of HEI-2010 scores according to groups and 2c: Distribution of HEI-2010 cut-off points, *$p<0.05$, **Marginal homogeneity test, CG: control group, EG: education group, FEG: family-attended education group, HEI: Healthy Eating Index, T1: before education, T2: after education, T3: 3 months after education (follow-up).

Among the PWMS who received nutrition education, a decrease in hand grip strength was only detected in the FEG, not in the EG. This result for FEG is unexpected for us and we think that this decrease in hand grip strength in the FEG may have been related to the clinical features of MS such as they could have attack periods. The BFM of men in the EG had increased at T3 compared to T1. Increases in the fat mass of individuals may be caused by decreased activity levels. In another study, it was shown that the activity level of PWMS was low and interventions for increased activity leads to successful results [27]. Also, it was shown that 44.8% of PWMS engaged in regular physical activity [28]. In this study, it is similarly to the other results that fewer than half of the individuals in the EG engaged in physical activity (at T1, T2, and T3, respectively: 35.3%, 11.8%, and 5.9%) [27,28]. This reveals that PWMS are not adequately physically active. Although physical activity levels did not show a statistically significant difference between groups during the study, it was determined that there was a decrease in the proportion of individuals engaged in physical activity in all groups (Table 1). Physical activity levels may have been affected by seasonal characteristics in this study as T1 occurred in autumn when the weather was warm in the Samsun province, and T2 and T3 occurred in winter.

The serum Hb level was higher in FEG than in EG among men at T1 and T2. Although serum Hb level increased after the nutrition education, the mean value was within the range of the reference values. While serum Hb and serum Htc levels in women were similar before nutrition education, they were higher in FEG than CG at T2 and T3. Although serum Htc level increased after the nutrition education and during the follow-up, the mean value was within the range of the reference values. Also, another effect of nutrition education on serum biochemical measurements is that the ALT level decreased in the follow-up, the median value was within the range of the reference values. Also, levels of serum TC and LDL-C in the FEG and EG were higher than CG at T1, T2, and T3. ALT level is lower in both T3 and FEG in men compared to EG. Independent of nutrition education, the fact that individuals in the EG had higher TC and LDL-C levels before nutrition education may have been effective in these results (Table 3). Another possible explanation for this finding may be the effect of a significant increase in BFM in male participants and an insignificant increase in BFM among female participants, but this effect may be described as very low because no significant change in TG levels was detected. Increasing serum LDL-C levels associated with adiposity in PWMS [29]. Also, an increasing level of Hb and Htc, but a decreasing level of ALT shows positive effects of nutrition education. It was previously determined that nutrition education given to patients with cardiometabolic risk led to positive changes in food consumption compared to those who did not receive nutrition education [30]. There is not enough study to evaluate the effect of nutrition education on biochemical parameters in PWMS but in some diseases such as metabolic syndrome and chronic kidney disease, total cholesterol and serum electrolyte levels are affected by nutrition intervention [31,32].

In a cross-sectional study, the high adherence to the diet quality was determined at 9.6% of PWMS and the level of adherence to the diet was moderate [33]. In this study, mean diet quality as evaluated with the HEI-2010 was determined to be 53.9, 53.3, and 54.3 points for the EG, FEG, and CG at T1, respectively. Also, according to the distribution of HEI cut-off points in all intervention and control groups, the level of diet quality needs improvement (Figure 2). The HEI-2010 score of the FEG had increased at T2 (Figure 2a) and the highest HEI-2010 score was observed in the FEG (Figure 2b) at T3. In addition, the distribution of diet quality scores of the FEG showed a positive increase in the direction of "needs improvement" at T3 (for "poor" diet quality, 46.7% at T1 and 20% at T3, and for "needs improvement", 53.3% at T1 and 80% at T3). It is known that intervention in nutrition education given to the general population, including families, has some conflicts; in school-aged children, nutrition education is not associated with diet quality, but in web-based education, it improves the diet [34,35]. There is not enough study evaluating the effect of nutrition education in PWMS. And in this study, it was determined that the quality of diet increased when PWMS participated in nutrition education with their families similarly.

Significant decreases in BMI, WC, and TG levels were shown in the intervention group when nutrition education was given to patients with schizophrenia [36]. It was also determined that there was a change in BMI with nutrition education given to breast cancer patients [37]. An electronic education program for PWMS addressing problems of the disease was shown to help patients stop smoking, lose body weight, and increase their levels of physical activity [38]. In this study, it was determined that nutrition education given to PWMS affected the diet quality and some anthropometric and biochemical measurements. Anthropometric measurements are important because it was shown that BMI is associated with diet quality in PWMS [33]. Significant and positive changes were found in diet quality among those who received nutrition education together with their families. It was also shown that those who did not receive nutrition education had decreased levels of UMAC, hand grip strength, Hb (both genders), Htc (in women), and increased ALT level (in men).

This study has some strengths worth noting. All data (food consumption records and anthropometric measurements) except the biochemical measurements were obtained by a single researcher and with the same tools. For this reason, the biases that may occur due to differences in researchers and measurement tools were avoided. In addition, all biochemical measurements were performed in the same centre. However, this study also has some limitations. Due to the requirement of participating in the nutrition education program on a regular basis, individuals living close to the Samsun province and those who did not work (often housewives who have more responsibility for shopping and preparing food) were more likely to volunteer to participate in the study. In addition, because MS is more common in women, the number of participating women was higher than the number of men [39]. Another limitation is that, while hand grip strength was measured, PWMS were not asked if they were in attack periods or not. It would be useful to determine whether the PWMS are in the attack period by a specialist neurologist, in intervention studies of PWMS which evaluate muscle strength. We neglected the difference in duration of illness while including participants in this study and PWMS with similar disability levels were included in the groups. Because the disability scores are more effective in determining the physical and mental adequacy of the patients to receive nutrition education PWMS rather than the duration of the disease. The work presented here may serve as a guide for further research evaluating whether decreases in hand grip strength are associated with nutritional status or the clinical progression of MS.

CONCLUSION

In this study, we determined that diet quality improved among the PWMS who received nutrition education together with their families. Anthropometric measurements, including BMI, WC, HC, and FFM did not change, but UMAC and hand grip strength and biochemical measurements including haemoglobin, haematocrit, and ALT levels changed with nutrition education. Physical inactivity in PWMS was another result of this study, so increasing physical activity levels should be a better way to control anthropometric and biochemical measurements. Further studies with larger samples and long-term follow-up are needed to better reveal the possible health effects of nutrition education given to PWMS.

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CONTRIBUTORS

Z UZDİL contributed to the conceptualization, methodology, investigation, writing – original draft. PF TÜRKER contributed to the conceptualization, methodology, writing – review and editing. M TERZİ contributed to the methodology, writing – review and editing.

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