



Determination of Lipid Profile and Anthropometric Measurements of Multiple Sclerosis Patients: A Controlled Descriptive Study

Multipl Skleroz Hastalarının Yağ Profilleri ve Antropometrik Ölçümlerinin Belirlenmesi: Kontrollü Tanımlayıcı Çalışma

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Abstract

Objective: Multiple sclerosis (MS) is a neurodegenerative disease of the central nervous system. Lipid profile and anthropometric measurements might differ for patients with MS and healthy people. This study aimed to compare the lipid profiles and anthropometric measurements of patients with MS and healthy participants.

Materials and Methods: The study was designed as a controlled descriptive study, consisting of 392 people (196 patients in the MS-MS group, and 196 healthy volunteers in the control group) who presented to a state hospital in Turkey. Blood samples were collected and lipid profiles (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides) were analyzed. Body mass index (BMI), waist-to-hip and waist-to-height ratios were calculated, and the parameters were compared between the groups. The relationship between the parameters and the presence of MS was investigated.

Results: The weights, heights, hip circumferences, waist-to-hip and waist-to-height ratios of the people differed statistically significantly between the groups ($p < 0.05$). There were no statistically significant differences between the groups in terms of the considered lipid profiles. The difference between the BMI values of males in the control and MS groups was statistically significant ($p = 0.006$).

Conclusion: The obtained results indicate that anthropometric measurements of patients with MS differ significantly from healthy individuals, although no significant difference could be observed in terms of lipid profiles. Most of the findings of this study are consistent with the literature and suggest that the anthropometric changes in individuals should be followed regularly to prevent a possible MS risk.

Keywords: Multiple sclerosis, lipid profile, anthropometric measurement

Öz

Amaç: Multipl skleroz (MS), merkezi sinir sisteminin nörodejeneratif bir hastalıdır. Yağ profili ve antropometrik ölçümler, MS hastaları ve sağlıklı insanlar için farklılık gösterebilmektedir. Bu çalışmada MS hastalarının lipid profilleri ile antropometrik ölçümlerinin sağlıklı bireylerle karşılaştırılması amaçlanmıştır.

Gereç ve Yöntem: Türkiye'deki bir devlet hastanesine başvuran 392 kişiden (MS grubu-196 hasta, kontrol grubu-196 sağlıklı gönüllü birey) oluşan bu çalışma kontrollü tanımlayıcı bir çalışma olarak tasarlanmıştır. Her bir bireyden kan örnekleri toplanmış ve lipid profilleri (toplam kolesterol, yüksek yoğunluklu lipoprotein kolesterol, düşük yoğunluklu lipoprotein kolesterol ve trigliseritler) analiz edilmiştir. Vücut kitle indeksi (VKİ), bel-kalça ve bel-boy oranları hesaplanmış ve bu gruplar arasında bu parametreler açısından önemli bir farkın olup olmadığı test edilmiştir. Ayrıca, çalışmada ele alınan parametreler ile MS varlığı arasındaki ilişki de araştırılmıştır.

Bulgular: Bireylerin ağırlık, boy, kalça çevresi, bel-kalça ve bel-boy oranları gruplar arasında istatistiksel olarak anlamlı farklılık göstermiştir ($p < 0,05$). Çalışmada ele alınan lipid profilleri açısından gruplar arasında istatistiksel olarak anlamlı bir fark bulunamamıştır. Kontrol grubundaki erkekler ile MS grubundaki erkeklerin VKİ değerleri arasındaki farkın istatistiksel olarak anlamlı olduğu tespit edilmiştir ($p = 0,006$).

Sonuç: Elde edilen sonuçlar, MS hastalarının antropometrik ölçümlerinin sağlıklı bireylerden önemli ölçüde farklı olduğunu, ancak yağ profilleri açısından gruplar arasında anlamlı bir farkın bulunmadığını göstermektedir. Bu çalışmadan elde edilen bulguların çoğu literatürdeki sonuçlarla eşleşmektedir ve olası bir MS riskinden korunmak için bireylerdeki antropometrik değişikliklerin düzenli olarak izlenmesi gerektiğini önermektedir.

Anahtar Kelimeler: Multipl skleroz, yağ profili, antropometrik ölçümler

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Introduction

The World Health Organization (WHO) defines multiple sclerosis (MS) as a chronic, inflammatory, demyelinating state of the central nervous system (CNS). MS is one of the most common neurologic diseases, there are 2.5 million people known to be affected by MS around the world (1). MS attacks the myelinated axons in the CNS, destroying the myelin and the axons to varying degrees (2). In MS, active leukocytes can pass the blood brain barrier (BBB). The flow of mononuclear cells to the CNS occurs through a deteriorated BBB pathway. The secretion of various inflammatory cytokines and chemokines from glial cells leads to loss of myelin, deterioration of oligodendrocyte integrity, and axonal loss. These events greatly affect progressive neural atrophy (3). The chronic inflammatory processes that characterize MS pathology interfere with immune mechanisms that regulate and confine the inflammatory cascade to prevent irreversible tissue damage (4).

There are different forms of MS. The most common form of the disease is relapsing-remitting MS (RRMS). The more progressive form of MS is secondary progressive MS (PMS), and there is also a primary progressive type of the disease (5). The cause of the disease is unknown, but it appears to involve a combination of genetic susceptibility and a nongenetic triggers, such as a virus, metabolism or environmental factors (6).

The nutritional status of the individual can be evaluated when anthropometric measurements are used constantly and regularly (7). Anthropometry is an indicator of muscle and fat deposition in determining nutritional status. In all patients with chronic illnesses, evaluation of nutritional status is important. If it is performed by trained personnel, it could recognize patients who are at nutritional risk and need detailed nutritional assessment (8). Reports suggest that comprehensive nutritional assessment in patients with MS should be comprise (9) evaluation of nutritional status, which includes medical history (dietary, medical, and medication); physical examinations (anthropometric, body composition measurements, and laboratory tests); calculation of nutritional and energy needs; evaluation of potential dysphagia; scheduling nutritional intake; and planning for the eventual occurrence of complications.

Despite the chronic inflammatory character of MS, it is still unclear if and how lipoprotein levels are altered in patients with MS, and whether changes in feeding habits and body composition influence disease progression. This topic has been investigated in many studies in the literature (10,11,12,13,14,15,16,17,18). Weinstock-Guttman et al. (10) investigated the associations of serum lipid profile variables [triglycerides (TG), high and low-density lipoproteins (HDL, LDL), and total cholesterol (TChol)] with disability and magnetic resonance imaging measurements in MS. They found that higher LDL-C and TC and HDL-C levels were associated with more inflammatory activity in patients with MS. Çomoğlu et al. (11) reported that TG and cholesterol levels of patients with MS were higher compared with healthy subjects of similar age and sex. Moreover, mean plasma HDL-C and LDL-C levels of the patients with MS were not statistically different from the healthy controls. Newcombe et al. (12) showed that localized accumulation of LDL and oxidation products in early demyelinating lesions might play a pathogenic role in MS.

The etiology of MS is unknown, but many factors have been associated with its prognosis to date. It is believed that the alteration in the plasma lipid profile may be a causative factor for the progression of MS. The current controlled descriptive study aimed to determine the lipid profile and the anthropometric measurements of patients with MS, and to compare them with healthy subjects. The relationship between the existence of MS and certain parameters was also investigated.

Materials and Methods

Study Design

This study was designed as a controlled descriptive study. The output was the presence of MS. Two groups, one including patients having the outcome of interest (MS) and one without it, were compared in terms of the lipid profiles and anthropometric measurements.

Participants

The study group consisted of patients who presented to a state hospital in Turkey between June 28th, 2016, and January 5th, 2017. All individuals with the following characteristics were included in the study group: (1) Willing to participate, (2) age between 19 and 65 years, (3) no disease other than MS, (4) no change in eating habits after being diagnosed as having MS. There were 196 patients who met these requirements. In order to constitute the control group, a list of patient names who presented to the internal medicine or the endocrinology outpatient clinics of the hospital in the aforementioned time period was recorded. Among these patients, individuals who were aged 19-65 years and had no chronic health problems were identified and were asked to be a volunteer for the current study. One hundred ninety-six of the patients who accepted to volunteer were randomly selected. These participants were requested to give blood samples when they had no health problems. Thus, the control group was established.

Measurements

The demographic characteristics and disease histories of the patients with MS were collected through face-to-face interviews using a questionnaire survey. Blood samples were collected for biochemical evaluation and the anthropometric measurements were taken by the researcher.

The body weight, height, waist circumference, mid-upper-arm circumference, and hip circumferences were measured. [Body mass index (BMI)=body weight (kg)/height (m²)], waist-to-hip ratio [waist circumference (cm)/hip circumference (cm)] and waist-to-height ratio [waist circumference (cm)/height (cm)] were calculated. BMI was grouped as underweight (<18.5 kg/m²), normal-weight (18.5-24.9 kg/m²), overweight (25-29.9 kg/m²), and obese (>30 kg/m²) by using the WHO classification standards (19). Waist-to-hip ratios (<0.85: chronic disease risk is low for females, <0.90: chronic disease risk is low for males) and waist circumferences (<94 cm and <80 cm are safe levels for females and males, respectively) were classified using WHO standards (20). Waist-to-height ratios were evaluated as "caution" (<0.4), "appropriate" (0.4-0.5), "think of action" (0.5-0.6), and "take action" (>0.6) (21). Lipid profiles (HDL-C, LDL-C, TG, TChol)

of all individuals were analyzed using an spectrophotometric enzymatic method (22).

Ethical Aspect of the Research

Approval for the study was obtained from the Ethics Committee of Karadeniz Technical University (decision no: 2016/82). A privacy statement was signed for the patients in the study and permission was received for the use of the patients' data.

Statistical Analysis

Descriptive statistics were presented in terms of frequencies and percentages. Group statistics were expressed as mean (\bar{x}) \pm standard deviation (SD). Pearson's chi-square test was used to determine if the presence of MS had a statistically significant relationship with the lipid profile or anthropometric measurements. Depending on whether the Shapiro-Wilk test was significant, the Mann-Whitney U test or Student's t-test was conducted for the main analysis.

All statistical calculations were performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). For all tests, the statistical significance level was taken as 0.05.

Results

As seen in Table 1, this study consisted of 229 female and 163 male participants. In the control and MS groups, the percentages of female participants were 48.5% and 68.4%, respectively. The mean age was 39.66 ± 11.25 years for the healthy volunteers and 39.09 ± 10.20 years for the patients with MS. The average duration of education of the control group (13.14 ± 3.92 years) was significantly longer than in the MS group (9.08 ± 4.36 years, $p < 0.001$).

For the patients with MS, the disease duration ranged from 6 months to 27 years. The rate of those diagnosed in less than 1 year was 25.5%. The average disease duration for the participants of the MS group was on average 11.36 ± 5.26 years.

TChol, TG, and HDL-C levels of the survey participants were within normal ranges. In contrast, the LDL-C values of the samples were higher than the normal range. As shown in Table 2, there were no significant differences between the groups in terms of lipid profiles ($p > 0.05$). These results were confirmed when adjusted for sex.

The anthropometric measurements of all individuals are presented in Table 3. Body weights, heights, hip circumferences, waist-to-hip and waist-to-height ratios were significantly different between the groups ($p < 0.001$, $p < 0.001$, $p < 0.001$, $p = 0.003$, and $p = 0.017$, respectively). When the participants were divided regarding to sex, there were statistically significant differences between the control and MS groups in terms of mid-upper arm

circumference, waist-to-hip ratio, and BMI of the males. For females, the measurements that differed between the groups were the hip circumference and waist-to-height ratio. Underweight status was ascribed to 1.5% of the healthy controls and 4.6% of the patients with MS. One hundred fifty-five participants were in the normal BMI ranges. Seventy-five healthy controls and 55 patients with MS were overweight. The percentage of obese patients with MS was 25%. As can be seen from Table 4, although the average BMI value of the healthy controls (27.01 ± 4.98 kg/m²) was higher than in patients with MS (26.41 ± 5.28 kg/m²), this difference was not statistically significant ($p = 0.189$).

The mean waist-to-hip ratio was 0.90 ± 0.11 in healthy controls and 0.87 ± 0.09 in patients with MS. The waist-to-hip ratio was less than 0.85 for 37.3% of women and less than 0.90 for 32.3% of men in the MS group. As presented in Table 4, 57.6% of the women and 75.5% of the men were at chronic disease risk according to the waist-to-hip ratio.

The waist-to-height ratios of the healthy controls (0.54 ± 0.09) were significantly lower than in patients with MS (0.56 ± 0.09). Based on the waist-to-height ratios, 26.5% and 16.8% of the participants were within the standard range in the control and MS groups, respectively. It can be seen from Table 4 that 45.7% of the total participants should be aware of the fact that they were on the verge of obesity, and 29.1% should take action against android obesity.

In order to investigate a possible relationship between the presence of MS and the considered anthropometric measurements, categorical variables were converted into dichotomous variables by using some threshold values. It can be seen in Table 5 that 104 of the 196 patients with MS had a BMI higher than 25 kg/m². Only 38.3% of the healthy subjects had a BMI less than 25 kg/m². Among 225 individuals with a BMI of ≥ 25 kg/m², the percentage of individuals with MS was 53.1%. On the other hand, 46.9% of 167 individuals were patients with MS with a BMI of < 25 kg/m². The existence of MS had no statistically significant relationship with BMI ($p = 0.082$). In terms of waist-to-hip circumference ratio, in the study and control groups, there were equal number of individuals whose measurements were greater than or equal to 0.8. Based on this, no significant relationship could be detected between the waist-to-hip ratio and the presence of MS ($p > 0.05$). Nevertheless, cross-table analysis revealed a significant relationship between the presence of MS and the waist-to-height ratio ($p = 0.045$); 66.3% of 196 patients with MS had a waist-to-height ratio less than 0.6. Among 278 individuals with a waist-to-height ratio value of < 0.6 , the percentage of individuals with MS was 66.3%. Of the 196 healthy individuals, 75.5% had a waist-to-height ratio less than 0.6.

Table 1. Demographic characteristics of the survey individuals

Variable	Females (n=229)				Males (n=163)			
	Control (n=95)		MS (n=134)		Control (n=101)		MS (n=62)	
	Mean \pm SD	Median	Mean \pm SD	Median	Mean \pm SD	Median	Mean \pm SD	Median
Age (years)	38.0 \pm 10.4	38.0	38.6 \pm 10.1	39.0	41.2 \pm 11.9	42.0	40.2 \pm 10.3	38.5
Education (years)	13.6 \pm 4.4	14.0	8.8 \pm 4.6	8.0	12.8 \pm 3.5	13.0	9.7 \pm 3.9	11.0

SD: Standard deviation, MS: Multiple sclerosis

Discussion

Summary of Main Findings

Studies in the literature are generally based on either the biochemical information or the anthropometric measurements

of patients with MS, regardless of the parameters affecting the existence of disease. The current study focused on designating the lipid profile and the anthropometric measurements of patients with MS and identifying the relationship between the disease and these parameters.

Table 2. Descriptive statistics along with the lipid profiles of the samples (n=392)

Variable	Sex	Group	Mean	SD	Median	p
TG, (mg/dL)	Female	Control	111.6	66.7	101.0	0.163
		MS	123.3	69.7	104.5	
		Total	118.5	68.6	101.0	
	Male	Control	159.9	98.3	144.0	0.828
		MS	163.7	115.9	128.0	
		Total	161.4	105.0	140.0	
	Total	Control	136.5	87.7	113.0	0.936
		MS	136.1	88.7	112.5	
		Total	136.3	88.1	112.5	
TChol, (mg/dL)	Female	Control	190.6	45.2	185.0	0.764
		MS	191.3	42.1	187.0	
		Total	191.0	43.3	186.0	
	Male	Control	196.3	40.6	194.0	0.882 ^a
		MS	197.3	43.8	200.0	
		Total	196.7	41.7	195.0	
	Total	Control	193.6	42.9	189.5	0.855
		MS	193.2	42.6	187.5	
		Total	193.4	42.7	189.0	
LDL-C, (mg/dL)	Female	Control	111.2	29.4	108.0	0.200
		MS	119.1	38.9	110.0	
		Total	115.8	35.4	108.0	
	Male	Control	121.2	36.5	120.0	0.483 ^a
		MS	125.6	41.1	125.5	
		Total	122.9	38.3	120.0	
	Total	Control	116.4	33.6	114.0	0.362
		MS	121.1	39.6	117.0	
		Total	118.7	36.7	115.3	
HDL-C, (mg/dL)	Female	Control	54.2	12.0	54.0	0.082
		MS	51.5	12.3	51.0	
		Total	52.6	12.2	52.0	
	Male	Control	46.3	12.7	45.0	0.121
		MS	43.3	8.7	41.0	
		Total	45.2	11.5	44.0	
	Total	Control	50.1	12.9	50.0	0.303
		MS	48.9	11.9	47.0	
		Total	49.5	12.4	48.3	

^aStudent's t-test was used to compare the groups. All the p values not indicated with superscript "a" were calculated using Mann-Whitney U test, SD: Standard deviation, TG: Triglyceride, TChol: Total cholesterol, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol, MS: Multiple sclerosis

Table 3. Anthropometric characteristics of the participants (n=392)						
Variables		Group	Mean	SD	Median	p
Body weight (kg)	Female	Control	68.60	13.59	65.00	0.903
		MS	67.89	13.44	67.50	
		Total	68.18	13.48	67.00	
	Male	Control	85.63	13.91	85.00	0.001 ^{a*}
		MS	77.93	12.75	77.00	
		Total	82.70	13.95	81.00	
	Total	Control	77.37	16.16	76.00	<0.001*
		MS	71.07	14.00	72.00	
		Total	74.22	15.42	75.00	
Height (m)	Female	Control	1.62	0.06	1.63	0.005*
		MS	1.60	0.07	1.60	
		Total	1.61	0.07	1.60	
	Male	Control	1.76	0.09	1.75	0.372
		MS	1.73	0.07	1.73	
		Total	1.75	0.09	1.73	
	Total	Control	1.69	0.10	1.68	<0.001*
		MS	1.64	0.09	1.63	
		Total	1.67	0.10	1.66	
Mid-upper arm circumference	Female	Control	29.23	4.21	28.00	0.067
		MS	29.91	3.72	30.00	
		Total	29.63	3.94	29.00	
	Male	Control	33.24	3.88	33.00	0.001*
		MS	31.16	2.73	31.00	
		Total	32.45	3.62	32.00	
	Total	Control	31.29	4.51	31.00	0.068
		MS	30.31	3.48	30.00	
		Total	30.80	4.05	30.00	
Hip circumference (cm)	Female	Control	102.05	12.67	100.00	0.002*
		MS	106.04	10.47	105.00	
		Total	104.39	11.57	103.00	
	Male	Control	101.89	12.51	103.00	0.216
		MS	104.31	8.65	103.00	
		Total	102.81	11.23	103.00	
	Total	Control	101.97	12.55	101.00	0.001*
		MS	105.49	9.94	105.00	
		Total	103.73	11.44	103.00	
Waist-to-hip ratio	Female	Control	0.85	0.10	0.85	0.328
		MS	0.86	0.09	0.87	
		Total	0.85	0.10	0.86	
	Male	Control	0.96	0.08	0.95	0.001*
		MS	0.92	0.07	0.93	
		Total	0.94	0.08	0.94	
	Total	Control	0.90	0.11	0.91	0.001*
		MS	0.87	0.09	0.89	
		Total	0.89	0.10	0.90	

Table 3. Continued						
Variables		Group	Mean	SD	Median	p
Waist-to-height ratio	Female	Control	0.54	0.10	0.52	
		MS	0.57	0.10	0.56	0.004*
		Total	0.56	0.10	0.54	
	Male	Control	0.55	0.07	0.55	
		MS	0.55	0.07	0.54	0.921
		Total	0.55	0.07	0.54	
	Total	Control	0.54	0.09	0.53	
		MS	0.56	0.09	0.55	0.017*
		Total	0.55	0.09	0.54	
BMI (kg/m ²)	Female	Control	26.23	5.42	25.28	
		MS	26.63	5.78	25.46	0.514
		Total	26.47	5.62	25.39	
	Male	Control	27.74	4.43	26.79	
		MS	25.93	4.00	24.97	0.006*
		Total	27.05	4.35	26.03	
	Total	Control	27.01	4.98	26.11	
		MS	26.41	5.28	25.39	0.189
		Total	26.71	5.13	25.81	

^a: Student's t-test was used to compare the groups. All the p values not indicated with superscript "a" were calculated using Mann-Whitney U test, *There was statistically significant difference between the compared groups (p<0.05), SD: Standard deviation, BMI: Body mass index, MS: Multiple sclerosis

Even though statistics do not always show the facts, it is believed that under appropriate circumstances, unbiased and sufficient sample selection can lead researchers to the best information about the facts. In this respect, we conducted a large-scale literature search, and efforts were made to increase the validity of the obtained statistics of the current study. MS-based studies in literature were compared in terms of lipid profiles and anthropometric measurements, and the findings of the studies are presented in Table 6 and Table 7, respectively.

Some studies in the literature argue that lipid profiles should show changes in patients with MS. Quintana et al. (13) discussed the use of lipids and the antibody response against them as biomarkers for MS. Jorissen et al. (14) determined whether lipoprotein levels and HDL function were altered in patients with MS. Their data showed that patients with RRMS had lower total LDL compared with healthy controls and with patients with PMS, as a result of the reduced number of large LDL particles. Moreover, in a subgroup of patients with RRMS with a low BMI (BMI \leq 23 kg/m²), a higher level of small HDL particles and increased levels of TG were observed as in the study of Palavra et al. (15) who observed an increase in small HDL particles and TG in the total RRMS patient population. Weinstock-Guttman et al. (10) showed that MS clinical progression was associated with higher baseline TC and LDL-C levels, and higher HDL-C levels were associated with lesser radiologic disease activity. Despite these findings, there are some studies showing contradictory results with regard to the alterations in lipoprotein levels of patients with MS. According to the study of Navarro and Segura (16), the mean concentrations of plasma TChol, HDL-C, and total TG were in the normal range

for both the MS and control groups. There were no significant differences between these groups. Similar results were observed in the study of Çomoğlu et al. (11). Mean plasma TChol levels were slightly higher in patients with MS than in healthy volunteers, but this was not significant. The mean plasma HDL-C and LDL-C levels of patients with MS were not statistically different from the values of the controls. Dogan (17) evaluated the effect of lipoprotein-associated phospholipase A2 (Lp-PLA2) activity and serum lipids in patients with MS. Their findings revealed that the serum lipid concentrations and Lp-PLA2 activity had no significant effect on MS and its progression. There were no statistically significant differences between patients with MS and healthy controls in terms of Lp-PLA2 activity, TChol, TG, HDL-C, LDL-C, atherogenic index of plasma (AIP), non-HDL-C and TChol to HDL-C ratio.

In our present study, findings related to lipid profiles showed that there was no statistically significant difference between the lipid profiles of patients in the MS group and healthy subjects. This result did not change when the groups were compared after adjusting for sex. The boxplots in Figure 1 graphically depict groups of numeric data through their quartiles. In terms of TG, TChol, and LDL, Jorissen et al. (14) and Çomoğlu et al. (11) found similar results supporting the findings of the present study. Taking into consideration that the study groups in the compared literature come from variety of different nations, have different genetic features and nutritional status, and are exposed to different environmental factors, it is likely to observe differences among the studies. As stated in the study of Weinstock-Guttman et al. (10), lifestyle changes including adoption of a healthier diet and

regular exercise in order to improve the serum lipid profile may be beneficial for patients with MS to improve their neurologic condition.

Table 4. Anthropometric measurements of the participants based on the World Health Organization classification

Group	Control (n=196)		MS (n=196)		Total (n=392)		p	
	n	%	n	%	n	%		
BMI (kg/m²)								
<18.5	3	1.5	9	4.6	12	3.1	0.189	
≥18.5 and <24.99	72	36.7	83	42.3	155	39.5		
≥25 and <29.99	75	38.3	55	28.1	130	33.2		
≥30	46	23.5	49	25.0	95	24.2		
$\bar{X} \pm SD$	27.01±4.98		26.41±5.28		26.71±5.13			
Waist-to-hip ratio								
Female								
<0.85	47	49.5	50	37.3	97	42.4	0.003	
≥0.85	48	50.5	84	62.7	132	57.6		
Male								
<0.90	20	19.8	20	32.3	40	24.5		
≥0.90	81	80.2	42	67.7	123	75.5		
$\bar{X} \pm SD$	0.90±0.11		0.87±0.09		0.89±0.10			
Waist-to-height ratio								
<0.4	6	3.1	8	4.1	14	3.6	0.017*	
≥0.4 and <0.5	52	26.5	33	16.8	85	21.7		
≥0.5 and <0.6	90	45.9	89	45.4	179	45.7		
≥0.6	48	24.5	66	33.7	114	29.1		
$\bar{X} \pm SD$	0.54±0.09		0.56±0.09		0.55±0.09			

*: Mann-Whitney U test, p<0.05. BMI: Body mass index, SD: Standard deviation, MS: Multiple sclerosis

Table 5. Evaluation of multiple sclerosis existence with some anthropometric measurements of the survey samples (n=392)

Group	Control		MS		Total		p
	n	%	n	%	n	%	
Waist-to-hip ratio							
<0.8	34	17.3	34	17.3	68	17.3	0.999
≥0.8	162	82.7	162	82.7	324	82.7	
Waist-to-height ratio							
<0.6	148	75.5	130	66.3	278	70.9	0.045*
≥0.6	48	24.5	66	33.7	114	29.1	
BMI (kg/m²)							
<25	75	38.3	92	46.9	167	42.6	0.082
≥25	121	61.7	104	53.1	225	57.4	

*Pearson chi-square test, p<0.05. BMI: Body mass index, MS: Multiple sclerosis

Patients with MS are expected to face weight reduction due to the presence of hypermetabolism, decreased physical activity, and a possible obstacle in the process of preparing and cooking food. It is also believed that inflammation in chronic illnesses is generally related with the alteration in body composition including weight loss (23). Moreover, height measures thought to be affected by genetic, physical, and nutritional differences that might have associations with MS. Due to these facts, a significant difference between the anthropometric characteristics of healthy participants and patients with MS was predicted to be found in this study. As expected, healthy controls had significantly higher body weights and body heights than patients with MS (p<0.001). In accordance with our results, the body weights and heights of patients with MS were lower than controls in the studies of Ozgocmen et al. (24) and Ghadirian et al. (25).

As an anthropometric measurement, BMI has been the most commonly investigated measure due to its presumed association with MS. In a study (25) performed in Montreal between 1992 and 1995, the mean age, weight, and height of 197 incident cases and 202 frequency-matched controls were compared, and no statistically significant differences were found. The case patients had a significantly lower BMI than the controls. An inverse association was observed between high BMI and the risk of MS, with an odds ratio of 0.76. In the study of Formica et al. (26), 71 female patients with MS were compared with 71 healthy, age-comparable female controls (45.6±1.1 vs. 47.7±1.2 years). The BMI in patients with MS was found to be statistically less than the BMI of controls (23.6±0.6 vs. 26.0±1.0 kg/m², p<0.05). In a prospective study of over 230,000 women in the United States, being obese in late adolescence/early adulthood (age 18 years) was associated with a 2-fold increased risk of MS (27). In their cross-sectional cohort study linking electronic medical record information to a mailed survey from 1999 to 2004, Khurana et al. (28) reported an increased prevalence of overweight and obesity in a large sample of older veterans with MS (mean age: 59.6±11.9 years),

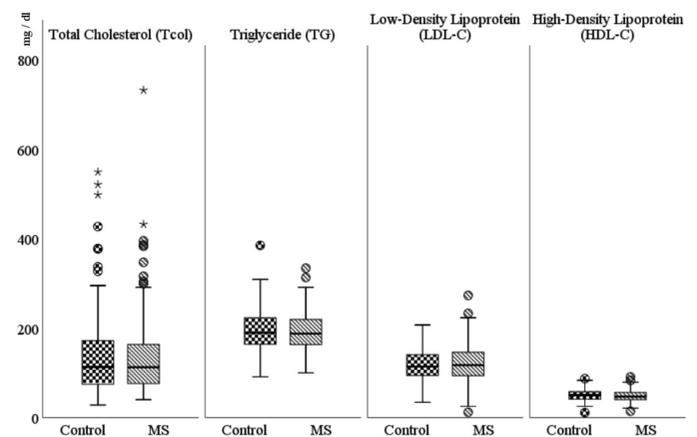


Figure 1. Comparison of the lipid profiles of the participants in the control and multiple sclerosis groups. No statistically significant difference was found in terms of all lipid profiles (each p>0.05)

TChol: Total cholesterol, TG: Triglyceride, LDL-C: Low-density lipoprotein-cholesterol, HDL-C: High-density lipoprotein-cholesterol, MS: Multiple sclerosis

predominantly males (86.7%). According to the findings of a population-based case-control study conducted in Sweden, patients with MS (n=1571) with a BMI over 27 kg/m² at the age of 20 years had a two-fold greater risk of developing MS compared with normal-weight subjects (29). In the prospective study performed by Munger et al. (30) on Danish school children, it was concluded that higher BMI during childhood and early adolescence was associated with an increased risk of MS. Among boys, the association was weaker than for girls, and overall not significant. Although, all these studies suggested a link between obesity and an increased risk of MS, the validity of the findings of these studies were questioned by some experts due to the bias related to the study designs. These studies were generally unable to account for other confounding factors that could have an impact on the results.

Recently, in a Canadian study conducted to investigate the possible causal link between obesity and MS, Mokry et al. (31) used a Mendelian randomization approach, which involved the use of genetic variants as instrumental variables to measure exposures to a risk factor on an outcome. These results of the study provided evidence that genetically elevated BMI was strongly associated with an increased risk of MS, where a 1 SD increase in BMI conferred a 41% increase in the odds of MS. The researchers also found that a genetically determined change in BMI or an increase in BMI caused by other factors increases MS susceptibility. Despite all the findings of the literature, in the current controlled descriptive study, only for males, the difference between the BMI values of

patients with MS and healthy controls was statistically significant (p=0.006). To investigate the association between BMI and the presence of MS, study participants were divided into two clusters according to the defined BMI threshold of 25 kg/m², which is the BMI cut-off value for being considered as overweight according to WHO. The result of the analysis showed that the presence of MS had no significant association with BMI.

When the relationship between MS and various anthropometric measurements was examined, it was determined that BMI and waist-to-hip ratio were not related to MS; however, waist-to-height ratio was found to have relation with MS. The anthropometric measurements that differed significantly between the patients with MS and healthy controls were as follows: for males, mid-upper arm circumference, waist-to-hip ratio, and BMI; for females, hip circumference and waist-to-hip ratio; for all participants, hip circumference, waist-to-hip ratio, and waist-to-height ratio. The boxplots in Figure 2 graphically depict the difference in BMI, waist-to-hip ratio, and waist-to-height ratio in terms of the compared groups.

Study Limitations

Due to time constraints, the study could not be designed at MS onset. The results of this study are restricted to the lipid profiles and some anthropometric measurements collected from 392 participants who were all Turkish. Accordingly, it is important to note that the impact of ethnicity could not be observed in this study. For further studies, the sample size might be increased, and studies

Table 6. Comparison of the lipid profiles observed in multiple sclerosis-based studies in the literature

Variable	Study	Healthy controls		Patients with MS	
		Female	Male	Female	Male
Triglycerides	Current study	111.63±66.69	159.93±98.33	123.28±69.70	163.68±115.85
	Jorissen et al. (14)	113.6±6.1		136.6±17.8 (RRMS) 106.2±5.6 (PMS)	
	Çomoğlu et al. (11)	101.0±54.1	118.0±27.93	241.0±121.5*	151.4±37.9†
	Saka et al. (18)	(MS-female vs MS-male, p>0.05)		75.6±30.9	103.6±61.35
TChol	Current study	190.59±45.20	196.32±40.57	191.29±42.05	197.32±43.81
	Saka et al. (18)	(MS-female vs MS-male, p>0.05)		174.4±29.53	159.1±34.71
	Çomoğlu et al. (11)	177.25±21.53	172.5±35.38	192.33±30.06	206.4±20.43
LDL	Current study	111.20±29.43	121.20±36.50	119.07±38.88	125.55±41.14
	Saka et al. (18)	(MS-female vs MS-male, p>0.05)		110.9±28.16	104.6±32.22
	Jorissen et al. (14)	109.8±3.8		96.6±4.8 (RRMS) 115.6±6.3 (PMS)	
	Çomoğlu et al. (11)	101.25±11.03	87.5±23.87	87.67±17.0	118.6±19.03
HDL	Current study	54.15±11.95	46.30±12.68	51.54±12.29	43.29±8.87
	Saka et al. (18)	(MS-female vs MS-male, p<0.001)		48.4±11.41	33.5±5.24
	Jorissen et al. (14)	61.0±1.7		59.3±2.3 (RRMS) 60.8 ±3.5 (PMS)	
	Çomoğlu et al. (11)	51.75±14.22	64.0±16.43	51.67±8.04	57.6±4.93

Values are means±standard deviation. *Versus healthy female controls (*p<0.05), †Versus healthy male controls (†p<0.05), TChol: Total cholesterol, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, MS: Multiple sclerosis, RRMS: Relapsing-remitting multiple sclerosis, PMS: Progressive multiple sclerosis

can be tried on patients from different ethnic groups. We tried to include all patients who satisfied the determined requirements in the study, and the resulting study group involved 134 female and 62 male patients. Therefore, the analyses could not be performed on a sex-matched design. Given that the majority of patients with MS were admitted from surrounding cities and it was difficult to access the medical records of these patients, the identification of subgroups could not be done. Moreover, because the current study was designed as a controlled, descriptive study, causality between the presence of MS and the associated variables could not be investigated. However, descriptive findings of this study can be used to construct a well-organized cohort study. Although Expanded Disability Status Scale (EDSS) scores were not included in the current study, in terms of the quantification of disability in MS, it would be informative to search for a relationship between anthropometric measures and the EDSS scores of people with MS in further studies.

Conclusion

The analyses and the results of this paper aimed to make contributions to the literature in terms of the recognition of MS by comparing lipid profiles and anthropometric measurements of people with and without MS. The results indicated that most of the anthropometric measurements of patients with MS significantly differed from healthy individuals, although no significant difference could be observed in terms of lipid profiles. Most of the findings of this study are consistent with the literature, suggesting that anthropometric changes in individuals should be followed regularly to prevent a possible risk of MS.

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Table 7. Comparison of the anthropometric measurements observed in multiple sclerosis-based studies in the literature

Variable	Study	Healthy controls		Patients with MS	
		Female	Male	Female	Male
Body weight (kg)	Current study	68.60±13.59	85.63±13.91	67.89±13.44	77.93±12.75††
	Ozgocmen et al. (24)	67.6±7.3		64.6±11.6	
	Mohammad Shirazi et al. (32)	-	-	61.38±11.45	69.73±10.6
	Çomoğlu et al. (11)	58.57±9.13	69.14±12.23	61.8±11.1	69.0±12.44
	Ghadirian et al. (25)	62.3±12.5	79.3±14.9	60.0±11.2	77.5±15.5
Height (cm)	Current study	162.0±6.0	176.0±9.0	160.0±7.0**	173.0±7.0
	Ozgocmen et al. (24)	162.6±9.5		163.2±10.7	
	Mohammad Shirazi et al. (32)	-	-	161.0±16.0	173±6.0
	Çomoğlu et al. (11)	159.14±6.79	171.0±9.54	157.6±1.72	170.17±5.71
	Ghadirian et al. (25)	161.5±5.8	175.6±6.6	163.2±6.4	175.4±5.4
Mid-upper-arm circumference (cm)	Current study	29.23±4.21	33.24±3.88	29.91±3.72	31.16±2.73††
Waist circumference (cm)	Current study	86.43±14.52	97.23±11.96	91,11±15.66*	95.63±12.11
	Saka et al. (18)	(MS-female vs MS-male, p<0.05)		76.0±13.39	87.2±13.85
	Palavra et al. (15)	90.0 (median)		86.4 (median)	
Hip circumference (cm)	Current study	102.05±12.67	101.89±12.51	106.04±10.47**	104.31±8.65
Waist-to-hip ratio	Current study	0.85±0.10	0.96±0.08	0.86±0.09	0.92±0.07††
Waist-to-height ratio	Current study	0.54±0.10	0.55±0.07	0.57±0.10**	0.55±0.07
BMI (kg/m ²)	Current study	26.23±5.42	27.74±4.43	26.63±5.78	25.93±4.00††
	Ghadirian et al. (25)	23.9±4.7	25.7±4.2	22.5±4.1**	25.2±4.9
	Palavra et al. (15)	26.48 (median)		23.75 (median)	
	Çomoğlu et al. (11)	23.63±2.97	23.48±2.26	24.85±4.18	23.83±3.77
	Ozgocmen et al. (24)	25.7±3.5		24.4±4.5	
	Barnes et al. (33)	28.7±5.2		26.9±7.4	
	Saka et al. (18)	(MS-female vs. MS-male, p>0.05)		24.8±5.41	25.6±5.32
	Pekmezovic et al. (34)	23.8±3.4		22.6±3.5‡	
	Jorissen et al. (14)	24.9±0.4		25.9±0.7 (RRMS)	24.5±0.9 (PMS)

Values are means±standard deviation. *Versus healthy female controls (*p<0.05, **p<0.01); †Versus healthy male controls (†p<0.05, ††p<0.01); ‡Versus total healthy controls (‡p<0.05, ‡‡p<0.01), BMI: Body mass index, MS: Multiple sclerosis, RRMS: Relapsing-remitting multiple sclerosis, PMS: Progressive multiple sclerosis

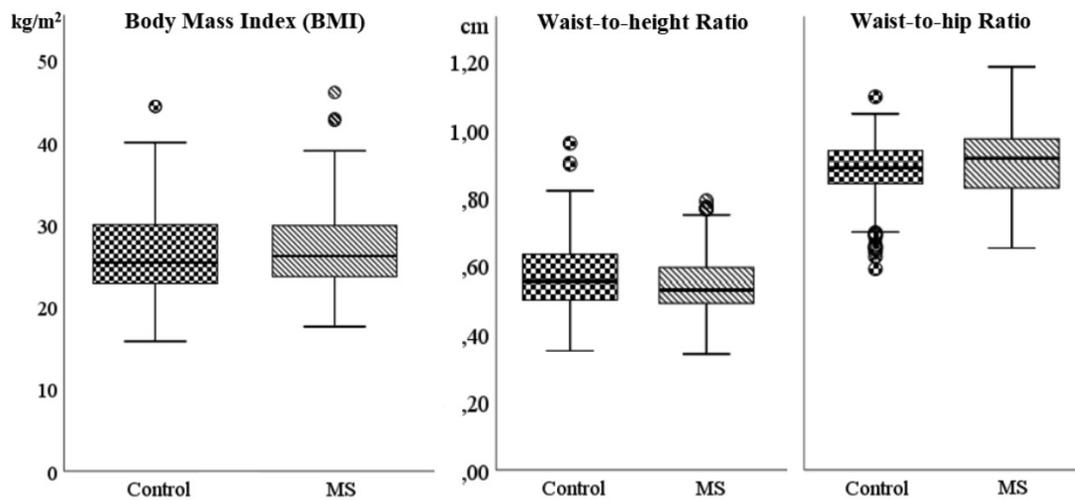


Figure 2. Comparison of the anthropometric measurements of the participants in the control and multiple sclerosis groups. Statistically significant differences were observed in terms of any of the considered measurements (each $p < 0.05$)

MS: Multiple sclerosis

Ethics

Ethics Committee Approval: Approval for the study was obtained from the Ethics Committee of Karadeniz Technical University (decision no: 2016/82).

Informed Consent: Consent form was filled out by all participants.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: G.D.A., A.A.M., H.T.B., Design: G.D.A., E.K., Data Collection or Processing: G.D.A., A.A.M., Analysis or Interpretation: E.K., G.D.A., A.A.M., H.T.B., Literature Search: G.D.A., E.K., Writing: G.D.A., E.K.

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