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Original Article

Cardiometabolic risk parameters of individuals with lower extremity amputation: What is the effect of adherence to DASH diet and Mediterranean diet?

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ABSTRACT

Objectives: The aim of our study was to investigate the relationship between nutrition (adherence to Mediterranean Diet [MD] and Dietary Approaches to Stop Hypertension [DASH] diets) and cardiovascular disease risk factors in patients with traumatic lower limb amputation (LLA).

Patients and methods: A total of 35 male patients (mean age 36.9±9.3 years; range, 21 to 54 years) with unilateral traumatic LLA between April 2019 and November 2019 were included. Data including age, education status, clinical data, level of amputation, time of amputation, comorbidities, physical activities, medications including nutritional supplements were collected. Blood pressure and anthropometric measurements including weight, height, waist, hip, and upper median arm circumferences were measured. Three-day food records were evaluated to determine daily nutrient intake of each patient. The patients were divided into groups according to their diet scores.

Results: The DASH scores showed a moderate, negative correlation with the body mass index (BMI), hip circumference, waist circumference, waist-to-hip ratio, waist-to-height ratio, serum total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL-C). The MD scores showed a moderate, negative correlation with the BMI, waist circumference, hip circumference, waist-to-height ratio, serum TC, TG, and LDL-C.

Conclusion: Patients with traumatic LLA should be monitored closely for accompanying conditions such as cardiovascular diseases, and it is necessary to encourage them for healthy nutrition habits.

Keywords: Cardiometabolic risk, dietary approaches to stop hypertension diet, mediterranean diet, traumatic lower limb amputation.

Traumatic lower limb amputation (LLA) commonly affects young and active individuals who have a long life-expectancy.[1] It is associated with an increased risk for low back pain, degenerative arthritis, and cardiovascular disease which can reduce overall health quality and physical condition of the wounded persons[2] Rose et al.[3] and Kurdibaylo[4] reported that pain, psychological illness, insulin resistance, blood hypercoagulability, and metabolic syndrome were the most frequent handicaps after LLA.

Considering cardiovascular and metabolic consequences, to date, majority of studies investigating preventive dietary interventions are about LLA due to dysvascular etiologies and, to the best of our knowledge, there is no study in traumatic LLA. Both Mediterranean diet (MD) and Dietary Approaches to Stop Hypertension (DASH) diets are known to improve cardiovascular health.[5] The MD is defined by rich consumption of fruits, vegetables, nuts, non-refined whole grains, leguminous plant and poor consumption of red flesh, dairy farm and domestic

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fowl productions, fish, alcohol, and sugar and is known to decrease risk factors of metabolic syndrome, cardiovascular event incidence, and type 2 diabetes mellitus.[6-8] The DASH is a diet model which mainly aims to specify diet factors impacting blood pressure. It contains high amounts of fruits, veggies, whole-cereal products, nuts, low-fat dairy products, poultry and fish which are rich in blood pressure-decreasing nutrients like fat-free proteins, calcium, potassium, minerals, and fiber.[9] It also limits consumption of sweets, red and refined meats, tropical oils, and full-fat dairy foods; therefore, it is low in sodium, cholesterol, saturated fats, and total fats.[9] The DASH diet provides higher amounts of fiber, protein and minerals such as magnesium, potassium, calcium, lower amounts of total and saturated fat and dietary cholesterol. This type of diet is thought to reduce cardiovascular risk factors such as high blood pressure, high low-density lipoprotein cholesterol (LDL-C), oxidative stress, inflammation, and insulin resistance.[10] Considering associated factors, a healthy and balanced diet may be beneficial in patients with LLA.

In the present study, therefore, we aimed to investigate the relationship between nutrition (adherence to MD and DASH diet) and cardiovascular disease risk factors in this patient group.

PATIENTS AND METHODS

This cross-sectional study was conducted at Physical Medicine and Rehabilitation Unit of Gaziler Training and Research Hospital between April 2019 and November 2019. A total of 49 patients with unilateral traumatic LLA who were admitted to our clinic were screened. The patients aged between 18 and 65 years with an at least one year and maximum three years of amputation history were included. Those with chronic diseases such as diabetes mellitus, hypertension, thyroid dysfunction, or amputees due to vascular problems were excluded. Finally, a total of 35 male patients (mean age 36.9±9.3 years; range, 21 to 54 years) were included. A written informed consent was obtained from each patient. The study protocol was approved by the Gülhane Training and Research Hospital Ethics Committee (No. 19/173, Date: 30.04.2019). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Demographic data including age and education status and clinical data including level of amputation, time of amputation, comorbidities, and medications including nutritional supplements were collected. Blood pressure and anthropometric measurements consisting of height, body weight, waist, hip and upper median arm circumferences were measured. The body weight was measured using digital wheelchair scales in the sitting position without prosthesis. The wheelchair was, then, measured alone and difference being the body mass of the patient. The body mass index (BMI) was calculated as mass (kg)/height (m^2). The waist circumference was evaluated at 2-cm distal from the umbilicus, hip circumference was measured at the widest perimeter of the hip. The waist-to-hip ratio (WHR) was calculated by dividing the individual's waist circumference to the hip circumference. The ratio equal to or higher than 0.90 was classified as abdominal obesity.[11] The waist circumference higher than 102 cm was defined as an increased risk.[12] The waist-to-height ratio was calculated by the waist circumference divided by height in cm, and the maximum result was equal to one. A waist-to-height ratio higher than 0.50 was accepted as a high risk.[13] Arm circumference was evaluated at the widest perimeter of the upper median arm. Blood pressure was evaluated after 15-min resting in the sitting position by a standard sphygmomanometer of the right arm. Blood specimens were taken after 8-h fasting. Fasting blood glucose (FBG), hemoglobin, total cholesterol (TC), triglyceride (TG) levels, high-density lipoprotein cholesterol (HDL-C), and LDL-C were noted.

Three-day food records were evaluated by the investigator to determine daily nutrient intake of each patient. Portion sizes and volumes were estimated with a picture book of portion sizes including 120 photographs of different foods, each with three to five different portion sizes.[14] The BeBiS version 7.2 software (Bebispro for Windows, Stuttgart, Germany; Turkish Version, 2010) was used to calculate daily intake of macronutrients, micronutrients, and energy.[15]

Focusing on eight components of diet (i.e., vegetables, legumes, rich fruit intake, nuts, low-fat dairy products, whole grains, low sodium intake, sweetened drinks, processed and red meat), the DASH diet score was constructed.[16] For each of the constituents, the patients were classified into quintiles according to their intake obtained by three-day dietary record. For vegetables, fruits, legumes, nuts, low-fat, and whole grains, quintile 1 was assigned 1 point and quintile 5 was assigned 5 points. For red and processed meat, sweetened drinks and sodium due to low intake were assigned to the lowest quintile as 5 points and the highest quintile was assigned 1 point.[17] Each constituent scores were summed, and a total DASH score was calculated ranging between 8 to 40, in which increasing scores indicate better adherence to the DASH diet. The patients were divided into tertiles according to the DASH scores as ≤18 low, 19 to 22 medium, and ≥23 high.

Adherence to MD was assessed using the Mediterranean Diet Adherence Screener (MEDAS).[18] This tool includes a total of 14 items (12 items for habitual frequency of consumption or amount consumed, and two items for nutritional habits related to MD). According to MD adherence, if the condition in each item is met, one point is given and, if it is not met, 0 point is given. The highest score is 14 points and higher scores indicate better adherence to MD. This tool is validated for the Turkish language.[19] The MD scores were classified into three groups according to MD adherence as ≤5 low, 6 to 9 medium, and ≥10 high.[20]

Physical activities of the patients were also recorded. The physical activity level (PAL) was calculated with dividing the sum (activity durations [min] multiplied by physical activity ratio for each activity) by 1,440 min. The calculated PAL values were classified as ≤1.4 for sedentary, ≥1.55 to - ≤1.6 for limited activity, and >1.75 for physically active.[12]

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 20.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were represented in mean ± standard deviation (SD) or median (min-max), and categorical variables were represented in number and frequency. Spearman correlation analysis was used to assess the relationship between DASH, MD scores and laboratory findings, blood pressure measurements, and anthropometric measurements. The patients in low, medium, and high score groups according to the DASH and the patients in low, medium, and high score groups according to the MD scores were compared for inter-group differences using the Kruskal-Wallis test. The post-hoc Bonferroni-corrected Dunn test was used for pairwise comparisons. A p value of <0.05 was considered statistically significant.

TABLE 1
Baseline demographic characteristics and amputation level of patients

	n	%	Mean±SD
Age (year)			36.9±9.3
Education			
Primary school	1	2.9	
Secondary-High school	22	62.9	
University or higher	12	34.3	
Amputation level			
Below knee	20	57.1	
Above knee	15	42.9	

SD: Standard deviation.

RESULTS

The majority of the participants (57.1%) had below-knee amputation. The mean disease duration was 24.1±7.4 (range, 12 to 34) months. Baseline demographic characteristics and amputation level of the patients are presented in Table 1.

Laboratory findings and blood pressure levels of the patients are summarized in Table 2. The mean FBG

TABLE 2
Laboratory findings and blood pressure levels of patients

Variable	Mean±SD	Min-Max
Laboratory findings (units, range)		
Fasting blood glucose (mg/dL, 74-106)	91.0±20.7	70.0-186.0
Total cholesterol (mg/dL, 0-200)	201.8±40.5	132.0-291.0
Triglyceride (mg/dL, 0-150)	205.7±149.1	63.0-714.0
LDL-C (mg/dL, 0-130)	126.1±37.5	55.6-221.0
HDL-C (mg/dL, >45)	40.7±7.2	28.0-56.0
Blood pressure		
Systolic (mmHg)	116.3±10.5	90.0-150.0
Diastolic (mmHg)	77.7±7.3	60.0-100.0

SD: Standard deviation; Min: Minimum; Max: Maximum; LDL: Low-density lipoprotein; HDL, High-density protein.

TABLE 3
Anthropometric measurements of the patients

Variable	Mean±SD	Min-Max
Body weight (kg)	81.7±18.5	58.0-138.0
Height (cm)	175.1±5.3	165.0-184.0
Body mass index (kg/m^2)	26.5±5.7	18.1-47.7
Waist circumference (cm)	98.8±13.5	67.0-140.0
Hip circumference (cm)	104.9±8.9	90.0-135.0
Upper arm circumference (cm)	32.6±4.2	24.5-42.0
Waist/hip ratio	0.9±0.1	0.7-1.1
Waist-to-height ratio	0.6±0.1	0.41-0.82

SD: Standard deviation; Min: Minimum; Max: Maximum.

TABLE 4
Daily energy and nutrients intake of the patients

Variable	Mean±SD	Min-Max
Total energy intake (kcal)	2326.7±759.5	1101.3-4820.4
Carbohydrates (g/day)	233.6±102.4	78.2-565.2
Protein (g/day)	89.4±29.9	42.8-179.1
Fat (g/day)	111.8±37.3	63.3-200.8
MUFA (g/day)	42.5±14.2	19.5-65.3
PUFA (g/day)	28.1±14.4	5.6-71.1
SFA (g/day)	33.3±11.7	17.0-63.2
Cholesterol (mg/day)	349.0±123.1	105.1-610.1
Fiber (g/day)	26.9±15.2	10.3-93.6

SD: Standard deviation; Min: Minimum; Max: Maximum; MUFA: Monounsaturated fatty acid; PUFA: Polyunsaturated fatty acid; SFA: Saturated fatty acid.

and HDL-C levels were normal, while TC, TG, and LDL-C levels were above the normal range in 57.1%, 48.6%, and 57.1% of the patients, respectively.

Anthropometric measurements of the patients are shown in Table 3. The mean BMI of the patients were 26.5 (range, 18.1 to 47.8) kg/m^2. A total of 37.1% of the patients were overweight, while 8.6% of the patients were obese Class I, 5.7% were Class II, and 2.9% were Class III. The WHR of 65.7% of the patients were higher than 0.9 and waist circumference of 28.6% of the patients were higher than 102. The mean waist-to-height ratio was 0.56, and 91.4% of the patients were classified as high-risk.

Daily nutrition intakes of the patients are summarized in Table 4. Energy intake of 17 patients were higher than energy requirements. Energy percentage from fat was higher than recommended level in 97.1% of the patients and energy percentage from saturated fat was higher than the recommended level in 88.6% of the patients. Cholesterol intake

TABLE 5
Correlation analysis results

	DASH score		Mediterranean diet score	
	r	*p*	r	*p*
Laboratory findings				
Fasting blood glucose	-0.469	0.004	-0.408	0.015
Total cholesterol	-0.322	0.059	-0.408	0.015
Triglyceride	-0.268	0.119	-0.361	0.033
Low-density lipoprotein	-0.418	0.012	-0.469	0.005
High-density protein	-0.068	0.700	-0.183	0.292
Blood pressure				
Systolic	-0.240	0.165	-0.212	0.222
Diastolic	-0.207	0.233	-0.166	0.341
Anthropometric measurements				
Body mass index (kg/m^2)	-0.491	0.003	-0.497	0.002
Waist circumference (cm)	-0.506	0.002	-0.478	0.004
Hip circumference (cm)	-0.478	0.004	-0.522	0.001
Upper arm circumference (cm)	-0.255	0.139	-0.132	0.450
Waist/hip ratio	-0.347	0.041	-0.206	0.236
Waist to height ratio	-0.501	0.002	-0.401	0.017

DASH: Dietary Approaches to Stop Hypertension.

TABLE 6
Comparisons of low, medium, and high score groups

	DASH score							Mediterranean diet score						
	Low		Medium		High			Low		Medium		High		
	Median	Min-Max	Median	Min-Max	Median	Min-Max	*p*	Median	Min-Max	Median	Min-Max	Median	Min-Max	*p*
Laboratory findings														
Fasting blood glucose (mg/dL)	89.0	81.0-186.0[a]	93.0	75.0-143.0[a]	80.5	70.0-92.0[b]	0.007	90.0	74.0-143.0	87.0	75.0-186.0	81.5	70.0-88.0	0.023
Total cholesterol (mg/dL)	217.5	155.0-291.0	216.0	132.0-245.0	171.5	152.0-244.0	0.246	219.0	159.0-291.0	198.5	132.0-245.0	166.5	152.0-244.0	0.056
Triglyceride (mg/dL)	219.5	72.0-714.0	159.0	63.0-344.0	124.5	88.0-306.0	0.457	199.0	72.0-714.0	158.0	63.0-397.0	116.0	88.0-232.0	0.242
LDL-C (mg/dL)	142.5	55.6-221.0	135.0	76.8-156.0	107.5	80.0-122.0	0.043	137.0	80.0-221.0	116.0	55.6-156.0	107.5	90.0-137.6	0.025
HDL-C (mg/dL)	40.0	28.0-56.0	41.0	35.0-55.0	37.5	30.0-56.0	0.473	40.0	28.0-56.0	42.0	28.0-56.0	37.0	30.0-49.0	0.180
Blood pressure														
Systolic blood pressure (mmHg)	120.0	90.0-150.0	120.0	100.0-130.0	115.0	100.0-120.0	0.209	1200	90.0-150.0	115.0	100.0-130.0	120.0	100.0-120.0	0.661
Diastolic blood pressure (mmHg)	80.0	60.0-100.0	80.0	60.0-80.0	80.0	70.0-80.0	0.436	80.0	60.0-100.0	75.0	60.0-80.0	80.0	70.0-80.0	0.149
Anthropometric measurements														
Body mass index (kg/m^2)	27.5	21.3-47.7	25.2	18.1-31.1	24.6	19.6-27.6	0.104	28.1	20.1-47.8	25.0	18.1-29.4	24.1	19.6-27.6	0.032
Waist circumference (cm)	102.0	67.0-140.0	100.0	81.0-112.0	93.5	87.0-98.0	0.064	100.0	83.0-140.0	97.0	67.0-109.0	925	87.0-103.0	0.045
Hip circumference (cm)	108.5	93.0-135.0	104.0	90.0-113.0	100.5	92.0-110.0	0.074	108.0	95.0-135.0	103.0	90.0-113.0	100.0	92.0-110.0	0.020
Upper arm circumference (cm)	34.5	26.0-42.0	31.0	24.5-38.0	30.5	27.0-39.0	0.221	33.0	25.0-42.0	33.0	24.5-38.0	32.0	27.0-39.0	0.858
Waist-to-hip ratio	0.9	0.7-1.0	0.9	0.8-1.0	0.9	0.8-1.0	0.334	0.9	0.8-1.1	0.9	0.7-0.9	0.9	0.8-1.0	0.599

DASH: Dietary Approaches to Stop Hypertension; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; [a,b] Different letters in same line refers to significant difference in pairwise comparisons.

of 62.9% of the patients were higher and fiber intake of 54.3% of the patients were lower than the recommended level. There was no patient taking nutritional supplements.

The mean DASH score of patients was 19.8±4.3 (range, 12.0 to 28.0) and the mean MD score was 6.4±3.9 (range, 0.0 to 13.0). According to the correlation analysis, the DASH scores showed a moderate, negative correlation with the BMI, waist circumference, hip circumference, WHR, waist-to-height ratio, FBG, and LDL-C. The MD scores also showed a moderate, negative correlation with the BMI, waist circumference, hip circumference, waist-to-height ratio, FBG, serum TC, TG, and LDL-C. However, there was no significant correlation between the other parameters and diet scores (Table 5).

According to the DASH score classification, 40.0% (n=14) of the patients were in low, 25.7% (n=9) of the patients were in moderate, and 34.3% (n=11) of the patients were in the high-score group. Adherence to MD was also classified as low in 42.9% (n=15), medium in 28.6% (n=10), and high in 28.6% (n=10) of the patients. According to the comparisons of low, medium, and high-score groups, FBG was significantly lower in the high DASH score group than the low and medium DASH score groups, while LDL-C levels were significantly lower in the high DASH score group than the low DASH score group. The FBG and LDL-C levels were significantly lower in the high MD score group than the low MD score group. Additionally, in low MD score group, the BMI, hip circumference, and waist circumference were higher than the other groups (Table 6).

The mean PAL was 1.3±0.1 (range, 1.1 to 1.5). A total of 62.8% of the patients were in sedentary level and 37.2% of the patients were in limited activity level. There was no significant correlation between the PAL and DASH, MD scores, laboratory findings, blood pressure measurements, and anthropometric measurements of the patients ($p>0.05$).

DISCUSSION

Individuals with traumatic LLA have increased cardiovascular mortality and morbidity rates, compared to healthy individuals. Hrubec and Ryder[21] and Modan et al.[22] showed that the relative risk of cardiac-related mortality was 1.58 in unilateral above-knee amputees and 3.5 in bilateral above-knee amputees, compared to veterans without limb loss, and 2.2 compared to healthy controls. The reasons of this high-risk cardiovascular disorders still remain unresolved. Long-term follow-up of traumatic LLA has shown excessive proportion of changeable cardiovascular risk factors such as obesity, physical inactivity, smoking, and substance misuse. Irregularities of arterial stream proximal to the amputation area and hemodynamic changes have also effects in the development of cardiovascular problems and bilateral amputation and more proximal levels cause a serious risk of consequent illness.[23] Traumatic limb loss mainly affects young individuals and the mean age of the patients in the current study is in consistent with the literature.[1] It is evident that, with advancing age, cardiovascular consequences of limb loss would affect the whole life of an individual. Therefore, strategies aiming to modulate these risks are of vital importance.

Studies investigating cardiovascular risk factors have demonstrated that patients with LLA had a higher BMI, mean body fat, and blood pressure and abnormalities in blood lipid levels.[3,24] In our study, more than half of the patients were overweight or obese according to their BMI values. Immobilization due to lower limb loss results in weight gain and, thus, long-term risks of amputation may be related to metabolic and hemodynamic sequelae.[3,25] In addition, most of the patients were in the high-risk group according to the waist-to-height ratio. Among other anthropometric measurements, the waist-to-height ratio is more advantageous to assess cardiometabolic risk factors.[26,27] On the other hand, significantly lower HDL-C and higher TG levels were reported in previous studies.[24] The mean TC, LDL-C, and TG levels were above normal range in the current study, supporting dyslipidemic consequences of LLA in the literature.

The DASH is a diet model aiming to help blood pressure control and significant benefits have been shown by researchers. In a randomized-controlled trial including 459 adults with untreated diastolic and systolic blood pressure, the DASH diet reduced blood pressure significantly and that could be a possible treatment in hypertension and, may restrain hypertension.[28] In addition to lowering blood pressure, another study showed that DASH diet could reduce LDL-C, HDL-C, and TC concentrations.[29] In the current study, no significant correlation between the blood pressure and DASH diet scores was observed. However, a moderate, negative correlation between the LDL-C and DASH score was found, consistent with the latter study. In addition, lower LDL-C level in high DASH score group among low and median DASH score group also supported this finding.

The relation between adherence to DASH diet and body composition was also another topic in the literature. A meta-analysis reported that adherence to the DASH diet provided significant reduction in body composition based on the BMI.[30] The effect of DASH diet on waist circumference was assessed in two studies and both reported a decrease in the waist circumference.[31,32] In the current study, the BMI, hip, waist, WHR, and waist-to-height ratio showed a negative, moderate correlation with the DASH diet scores. However, some previous studies were unable to show the effect of DASH diet on the body fat percent and lean body mass.[33]

An umbrella review of meta-analyses showed that MD helped to decrease metabolic risk factors involving blood pressure, BMI, glucose and TG levels, glycosylated hemoglobin (HbA1c), TC, and HDL-C, and waist circumference. In addition, it was reported that MD reduced the risk of mortality due to cardiovascular diseases and cancer. However, the evidence was mild or weak for many inflammatory and metabolic parameters.[8] Similar to studies reporting protective effects of MD, a moderate, negative correlation was found between the MD adherence and anthropometric measurements in the current study. Serum TC, TG, and LDL-C were also in the negative correlation with MD. Ambring et al.[34] also found a correlation between MD and serum lipids such as TC, LDL, and TG. In addition, lower LDL-C in high MD score group than low MD score group, and higher BMI and hip and waist circumference in low MD score group among median and high MD score group are also consistent with the aforementioned results.

The possible effect of dietary models to protect from cardiometabolic disease may differ according to different age groups or disabilities. According to the results of a recent study, adherence to the MD or DASH style diet was effective only in the younger age group, proposing that possible dietary intercession to prevent cardiometabolic disorders differ by age group.[35] Another recent study about the advantages of DASH diet on the risk of coronary artery disease among United States veterans showed that DASH diet was associated with a reduced risk of coronary artery disorders.[36] Therefore, there is a need of prospective clinical researches evaluating the effect of MD or DASH diet patterns of post-traumatic lower limb amputee patients to understand more details about the potential benefits from nutrition.

The cross-sectional design and relatively small sample size can be interpreted as the main limitations of this study.

In conclusion, patients with traumatic LLA should be monitored closely for accompanying conditions such as cardiovascular diseases, and it is necessary to encourage them for healthy nutrition habits. The outcomes of our study may be beneficial to remark rehabilitation teams for neglected aspects of amputation.

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