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Research paper

The relationship between adherence to the Mediterranean diet and body composition in Croatian university students

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ABSTRACT

Introduction: Little is known of how adherence to the Mediterranean diet (MD) is related to body composition, especially in university students. The main purposes of this study were (i) to assess differences in body composition by gender and level of adherence to the MD and (ii) to assess the relationship between body composition and level of adherence to the MD.

Methods: In this cross-sectional study, participants were 198 university students (56.6% women). To assess adherence to the MD, we used the Mediterranean Diet Quality Index Questionnaire (KIDMED). Body composition was assessed by using bioelectrical impedance (BIA). Height (H), weight (W), blood pressure (BP) and heart rate (HR) were assessed according to standardized procedures and physical activity (PA) was assessed by using International Physical Activity Questionnaire (IPAQ).

Results: The rate of normal BMI in men and women was 61.6% and 87.5%. There were no significant differences in adherence to the MD by gender ($p = 0.068$). One-way ANOVA between levels of adherence to the MD showed that participants with the lowest level of adherence had the highest body-mass index (BMI) ($p < 0.001$), fat-mass percentage (% FM) ($p < 0.001$), visceral fat (VF) ($p < 0.001$), HR ($p < 0.001$) and the lowest levels of PA ($p < 0.001$).

Higher adherence to the MD was related to decreased levels of BMI ($p < 0.001$), % FM ($p < 0.001$) and VF ($p < 0.001$), increased levels of fat-free mass (FFM) ($p < 0.001$) and hours of PA ($p < 0.001$) for both men and women.

Conclusions: Higher adherence to the MD shows beneficial effects in body composition parameters in university students.

1. Background

Obesity has become one of the most growing public health problems in the world [1]. Reports suggest that almost 2 billion people over the age of 18 are overweight and of these, 600 million are obese [2].

In 2010, obesity was estimated to cause approximately 3.4 million deaths annually [3]. In general, the higher prevalence of overweight/obesity status is associated with increased risk for many diseases, such as all-cause mortality, high blood-pressure, coronary heart disease, sleep apnea and breathing problems and lower level of quality of life [4]. As for adults, the prevalence of young adults' obesity is increasing worldwide [1]. The prevalence of obesity in the United States was 16.9% [5], South Africa between 11.0% and 24.0% [6], China between 2.9% and 14.3% [7], India between 11.0% and 37.5% [8,9] and Latin America between 12.4% and 31.6% [10].

Higher BMI and greater accumulation of fat mass are often explained by poor diet and physical inactivity. One of the healthiest diets worldwide is the traditional Mediterranean diet (MD) [11]. It is characterized by a high intake of fruits and vegetables, legumes, nuts, cereals and olive oil, a moderately high intake of fish, moderate alcohol intake (that comes primarily from wine), low to moderate intake of dairy products (cheese and yoghurt) and a low intake of meat, poultry, sweets and products rich with saturated fatty acids [11]. The prevalence of adherence to the MD in young adults has often been investigated in countries situated near the Mediterranean region [12–15]. For example, the prevalence of low adherence to the MD in Cyprian

Abbreviations: W, weight; H, height; BMI, Body-mass index; MD, Mediterranean diet; PA, physical activity; % FM, percentage of fat-mass; % FFM, percentage of free-fat mass; VF, visceral fat; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate

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university students was 21.8% [12] and between 3.1% and 9.5% in Spanish university students [13,14]. In one recent study conducted on Croatian university students, the prevalence of poor adherence to the MD was 42.8% [15]. In general, MD has been shown to have beneficial effects against cardiovascular [16,17], metabolic [18], and mental diseases [19,20].

The relations between adherence to the MD and body composition have been investigated in general population [21–25]. The aforementioned studies have shown, that higher adherence to the MD is inversely related with BMI, waist circumference (WC) and waist-to-height ratio (WHR). In children and youth, studies have shown that higher adherence to the MD is associated with lower BMI, WC and other adiposity risk indicators [26–29]. However, two studies conducted on children found no relationship between adherence to the MD and weight (W) or BMI [30,31].

After an extensive literature review, studies are lacking which investigate the relationship between adherence to the MD and body composition in university students. In this specific population, an increment of BMI status and % FM can be explained by the fact that many young adults undergo lifestyle changes, such as leaving home, going to university [32], starting work and as a result they leave their familiar environment [33], and have increased autonomy in decision-making and overall development [34]. Moreover, it has been reported, that university students represent a population with poor dietary habits, often tend to follow a diet accompanied by a high consumption of fast food and high-calorie products, which can potentially lead to increased risk of cardiovascular and metabolic diseases [35,36]. Thus, the main purposes of the present study were (i) to assess differences in body composition by gender and level of adherence to the MD and (ii) to assess relations between the body composition and level of adherence to the MD by gender. We hypothesized, that higher adherence to the MD would be related with lower BMI, % FM, VF and blood pressure, yet with higher % fat-free mass (% FFM) and more physical activity (PA) weekly in university students.

2. Methods

2.1. Participants and study design

In this cross-sectional study, participants were 198 university students (mean height 1.73 ± 0.09 m, mean weight 69.94 ± 14.90 kg, mean BMI 23.12 ± 3.66 kg/m^2, 56.6% of women) of the Faculty of Economics and Business from the University of Zagreb, Croatia. We included students from one faculty, since Faculty of Economics and Business is an appropriate example of the‘average’ student population in our country, where almost 10.0% of the students attend every year. Participants were invited via flyers handed out in the faculty. At the time the study was conducted, all participants had their residence in the urban part of the city of Zagreb and none of them had any kind of medical problems. A recruitment announcement was also circulated by email and e-newsletter to university staff with a request to pass the study information between students. All participants were instructed that the study was voluntary and participants could withdrawn at any time. Also, each participant and parent provided written informed consent for participation in the study All the procedures performed in this study were anonymous and in accordance with Declaration of Helsinki, also approved by the Institutional Review Board of the Faculty of Kinesiology, University of Zagreb, Croatia (ethics approval code: 16/2017).

2.2. Adherence to the MD

The Mediterranean Diet Quality Index (KIDMED) questionnaire was used to evaluate the adherence to the MD. It consists of 16 items, where there are 4 questions denoting poor adherence to the Mediterranean diet (consumption of fast food, baked goods, sweets and skipping breakfast) and 12 questions denoting good adherence (oil, fish, fruits, vegetables, cereals, nuts, pulses, pasta or rice, dairy products and yoghurt consumption). Questions denoting poor adherence are scored with −1, while those denoting good adherence are scored with +1. According to the KIDMED index, a score of 0–3 reflects a poor adherence, a score of 4–7 describes average, and a score of 8–12 a good adherence to the MD [37]. For the purpose of this study, we used a continuous scale to present adherence to the MD. This questionnaire has shown good reliability and validity properties with the food frequency questionnaire (FFQ) and has been previously used in similar sample of participants [12–15].

2.3. Body composition assessment

To assess body composition characteristics of the participants, we used bioelectric impedance analysis (BIA) (Model TBF-310, Tanita Corporation of America, Inc., Arlington Heights, IL; Tanita-BIA). BIA was performed in the morning after an overnight fast and the first urine void. All procedures were performed with the subjects lying supine on a nonconductive flat surface (mat) after their shoes, socks, and any kind of metal jewelry (earrings, bracelets, neck-laces, etc.) had been removed. The transmitting electrodes were placed on the posterior surface of the right hand at the distal end of the third metacarpal and on the anterior surface of the right foot at the distal end of the second metatarsal, at least 5 cm from the receiving electrodes, which were positioned between the radial and ulnar styloids and between the medial and lateral malleoli of the ankle [38]. It has been well-documented, that BIA is correlated with X-ray absorptiometry method and represents a simple and reliable tool for determining body composition [39]. As additional variables, we measured body height (BH) to the nearest 0.1 cm, by using a stadiometer (SECA). Body weight (W) was measured to the nearest 0.1 kg by using a calibrated electronic scale. BMI was calculated as W/H^2 (kg/m^2). Blood pressure (systolic-SBP and diastolic-DBP) and resting heart rate (HR) were measured three times in a sitting position using a standard mercury sphygmomanometer BP cuff according to the American Heart Association's standardized protocol [40].

2.4. Physical activity

As a measure of physical activity, we considered university students' physical activity (PA) in the last 7 days. Physical activity was assessed by using the validated short version of the International Physical Activity Questionnaire (IPAQ) and was expressed as metabolic equivalent-hours per week (MET-h/week) [41]. For the purpose of this study, we summed up hours participants spent in moderate and vigorous PA in the last 7 days. Previous studies showed satisfactory reliability and validity of the questionnaire [41].

2.5. Data analysis

Basic descriptive statistics of the study participants are presented as mean ± standard deviation. Gender differences were calculated by using Student *t*-test for normally distributed and Man-Whitney test for not normally distributed variables. Differences between tertiles of adherence to the MD were analyzed by using one-way analysis of variance (ANOVA) or Kruskall-Wallis rank test. Post hoc comparisons between groups were determined by using Tukey test or multiple rank comparison test. Relations between MD index score and body composition characteristics were analyzed by using Pearson and Spearman coefficient of correlations (r). Also, coefficient of determination (r^2) was used to explain the % of shared variance between the dependent and independent variables. Significance in all of the analysis was set up at $\alpha \leq 0.05$ and it was two sided (2-sided). All the analysis conducted in this study were performed in Statistical Packages for Social Sciences ver. 22 (SPSS ver. 22, Il: Chicago, USA).

Table 1
Basic descriptive statistics of the study participants.

Study variables	Total sample (N = 198) AM ± SD	Men (N = 86) AM ± SD	Women (N = 112) AM ± SD	P-value
H (m)	1.73 ± 0.09	1.80 ± 0.07	1.68 ± 0.06	< 0.001
W (kg)*	69.94 ± 14.90	80.84 ± 14.81	61.58 ± 7.99	< 0.001
BMI (kg/m^2)*	23.12 ± 3.66	24.82 ± 4.05	21.81 ± 2.70	< 0.001
FM (%)	27.49 ± 7.90	22.24 ± 6.97	31.52 ± 5.98	< 0.001
FFM (%)*	32.66 ± 6.12	38.42 ± 4.29	28.23 ± 2.61	< 0.001
VF (cm)*	4.56 ± 2.70	6.21 ± 3.26	3.29 ± 1.04	< 0.001
SBP (mm/Hg)*	120.16 ± 17.00	130.56 ± 16.99	112.18 ± 12.00	< 0.001
DBP (mm/Hg)*	74.88 ± 8.79	76.85 ± 8.90	73.37 ± 8.43	0.006
HR (bpm)*	79.64 ± 14.60	76.37 ± 16.12	82.16 ± 12.84	0.005
PA (d/week)*	3.93 ± 2.72	5.37 ± 2.70	2.83 ± 2.18	< 0.001
Adherence to the MD (index score)*	4.88 ± 2.71	5.28 ± 2.47	4.57 ± 2.85	0.068

* denotes using Man-Whitney test.
$p < 0.05$.

3. Results

Basic descriptive statistics of the study participants are presented in Table 1. As expected, men were taller, heavier with higher % of FFM and lower % of FM. Also, men had significantly higher SBP, DBP and participated more hours in moderate and vigorous PA weekly than women. However, women had lower values of HR, VF and BMI, respectively. No significant differences occurred between gender in adherence to the MD ($p = 0.068$). The rate of normal BMI in men and women was 61.6% and 87.5%. However, 65.1% of men and 38.4% of women had increased values of % FM (cut-off point for men: ≥20% and women: ≥33%) [42].

Differences between body composition characteristics and PA in low, average and high adherence to the MD are presented in Table 2. Participants in the lowest category had the highest values of BMI, % FM and VF and participated in less PA. On the other hand, participants in the highest category had the highest values of % FFM, participated more in weekly PA and had the lowest values of HR, yet this was not statistically significant.

Relationships between adherence to the MD and body composition characteristics stratified by gender are presented in Table 3. Higher adherence to the MD was related with lower values of BMI ($r^2 = 0.08$), % FM ($r^2 = 16$), VF ($r^2 = 0.06$), HR ($r^2 = 0.02$) and with higher values of % FFM ($r^2 = 0.08$) and PA ($r^2 = 0.10$) in the total sample. In men, higher adherence to the MD was related to lower values of W ($r^2 = 0.17$), BMI ($r^2 = 0.21$), % FM ($r^2 = 0.17$), VF ($r^2 = 0.23$), SBP ($r^2 = 0.13$), DBP ($r^2 = 0.10$), HR ($r^2 = 0.07$) and with higher values of % FFM ($r^2 = 0.09$) and PA ($r^2 = 0.13$). In women, higher adherence to the MD was related to lower values of W ($r^2 = 0.03$), BMI ($r^2 = 0.09$), % FM ($r^2 = 0.17$), VF ($r^2 = 0.16$) and with higher values of % FFM ($r^2 = 0.16$) and PA ($r^2 = 0.07$).

4. Discussion

The main purposes of this study were (i) to assess differences in body composition by gender and level of adherence to the MD and (ii) to assess relations between the body composition and level of adherence to the MD by gender.

In the present study, we found significant differences in body composition characteristics between low, average and high adherence to the MD in university students. Specifically, we found that participants reported having low adherence to the MD had higher values of BMI, % FM and VF and lower participation in weekly PA. Evidence from previous studies indicates, that following MD pattern is related with lower values of BMI and risk of obesity in adult population [24,25], children and adolescents [26–29]. As stated before, MD is characterized by a high consumption of fruits and vegetables, which have been determined as important factors abdominal obesity and lower risk of metabolic syndrome in children [43]. Moreover, we found that participants with higher adherence to the MD had higher amount of % FFM. Most recently, findings from one study showed positive relationships between diet quality as measured by the MD and % FFM in women aged 18–79-year-old [44]. Kelaiditi et al. [44] reported, that cereals, fruits and vegetables, which are part of the MD, were significantly and positively related with % FFM. As for % FFM, higher adherence to the MD was also significantly and positively related with bone matrix production and mineralization, enhancing skeletal muscle function and density, due to a higher consumption of vitamins, minerals and

Table 2
Body composition traits and hours of physical activity by level of adherence to the MD in total sample (N = 198).

Study variables	Low (1st tertile) AM ± SD	Average (2nd tertile) AM ± SD	High (3rd tertile) AM ± SD	P-value
H (m)	1.71 ± 0.09	1.74 ± 0.08	1.75 ± 0.09	0.060
W (kg)*	70.94 ± 16.25	71.34 ± 15.00	65.01 ± 11.46	0.063
BMI (kg/m^2)*	24.00 ± 3.78[b,c]	23.39 ± 3.72	21.12 ± 2.49	< 0.001
FM (%)	31.41 ± 6.73[a,b,c]	27.07 ± 7.54	22.61 ± 7.51	< 0.001
FFM (%)*	30.07 ± 5.12[a,b]	33.24 ± 6.05	35.09 ± 6.40	< 0.001
VF (cm)*	5.07 ± 2.92[b,c]	4.82 ± 2.74	3.17 ± 1.68	< 0.001
SBP (mm/Hg)*	119.98 ± 19.62	121.05 ± 14.98	118.25 ± 17.72	0.679
DBP (mm/Hg)*	74.55 ± 10.23	75.74 ± 7.97	73.27 ± 8.30	0.307
HR (bpm)*	81.38 ± 13.87	79.70 ± 15.80	76.90 ± 12.33	0.324
PA (d/week)*	2.88 ± 2.29[a,b,c]	4.02 ± 2.37	5.30 ± 3.45	< 0.001

* denotes using Kruskall-Wallis test.
$p < 0.05$.
[a] Differences between the participants in the 1st vs. 2nd tertile.
[b] Differences between the participants in the 1st vs. 3rd tertile.
[c] Differences between the participants in the 2nd vs. 3rd tertile.

Table 3
Correlation coefficients between body composition traits and adherence to the MD.

Study variables	Total sample (N = 198) r coefficient (95% CI)	Men (N = 86) r coefficient (95% CI)	Women (N = 112) r coefficient (95% CI)
H (m)	0.17 (0.03–0.30)*	-0.01 (-0.20 to 0.19)	0.22 (0.02–0.40)*
W (kg)[a]	-0.13 (-0.25 to −0.01)	−0.41 (-0.55 to −0.26)***	−0.18 (-0.33 to −0.02)*
BMI (kg/m^2)[a]	−0.28 (-0.39 to −0.17)***	−0.46 (-0.59 to −0.32)***	−0.30 (-0.43 to −0.16)***
FM (%)	−0.40 (-0.50 to −0.27)***	−0.41 (-0.57 to −0.23)***	−0.41 (-0.54 to −0.27)***
FFM (%)[a]	0.29 (0.16 to 0.41)***	0.30 (0.09–0.50)**	0.40 (0.27–0.53)***
VF (cm)[a]	−0.25 (-0.36 to −0.15)***	−0.48 (-0.61 to −0.35)***	−0.40 (-0.53 to −0.26)***
SBP (mm/Hg)[a]	-0.05 (-0.20 to 0.10)	−0.36 (-0.59 to −0.12)***	0.04 (-0.17 to 0.23)
DBP (mm/Hg)[a]	-0.06 (-0.21 to 0.08)	−0.32 (-0.49 to −0.15)**	0.07 (-0.13 to 0.26)
HR (bpm)[a]	−0.16 (-0.29 to −0.03)*	−0.26 (-0.43 to −0.10)*	-0.05 (-0.24 to 0.16)
PA (d/week)[a]	0.32 (0.19 to 0.45)***	0.36 (0.15–0.51)***	0.26 (0.06–0.47)**

[a] denotes using Spearman's rank correlation.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$

macronutrients [23]. We also found, that participants in the lowest category spent less time participating in PA weekly. Previous findings have shown, that physically inactive children and youth have lower mean intake of yoghurt, fruits and vegetables, and higher intake of, so called "Westernized diet products", such as sweets, chocolate and products rich with saturated fatty acids [45].

Our main analysis showed that higher adherence to the MD was related with body composition characteristics. Specifically, higher adherence to the MD was inversely associated with values of BMI, % FM and VF in both men and women. The aforementioned studies have shown the same associations in general population [24,25] and population of children and adolescents [26–29]. It has been reported, that higher score for KIDMED index leads to better nutritional adequacy [46]. However, we also found that higher adherence led to lower values of SBP, DBP and HR in men, but not in women. Components of the MD, such as fruits, vegetables and olive oil, are mainly responsible for the protection against hypertension and cardiovascular diseases. Moreover, the high consumption of products rich with minerals and plant foods rich with antioxidants contribute to the health of vascular system and reduction of high arterial blood pressure [47]. Also, a few studies have shown that, although cereal consumption is part of the MD, it is positively related with both systolic and diastolic blood pressure, since carbohydrate intake has been related to several cardiovascular diseases [48,49]. In the present study, we found that 39.5% of men reported consuming cereals or grains for breakfast, opposed to 55.4% of women. Also, we found that higher percentage of women (38.4%) reported consuming sweets and candies several times every day, which may lead to high blood pressure. Moreover, men spent more hours in PA weekly than women. It has been reported, that PA decreases vascular resistance, arterial stiffness, oxidative stress and BMI and increases endothelial function, insulin sensitivity, renal function, angiogenesis and arteriogenesis [50]. Since we found somewhat higher adherence to the MD (not significant) and more hours spent in PA weekly in men, it is possible that those two mechanisms serve as a protective factors against high SBP and DBP, especially in men. We also found that higher adherence to the MD was related with lower values of HR in men, but not in women. Previous findings have shown, that higher adherence to the MD is related with lower average HR [51]. MD is rich in omega-3 fatty acids, which can reduce HR. The potential mechanism lies in fact, that omega-3 fatty acids do not need to be incorporated into the membrane phospholipid or even related to membrane components in order to be effective. In that way, omega-3 fatty acids in their free form can suppress the automaticity of cardiac contraction and thereby exert their heart rate-lowering effects and have an inhibitory effect on the electrical automaticity/excitability of the cardiac myocytes [52].

Our study has several limitations. First, due to a cross-sectional design, we cannot exclude the possibility of reverse causality. Second, to assess body composition, we used BIA. Although BIA is a reliable method with minimal intra- and inter-observer variability [53] and results are reproducible with < 1% error on repeated measures [54], we did not include for potential environmental factors, such as skin temperature [55]. Third, to assess adherence to the MD and PA, we used previously validated questionnaires [15,41]. However, the usage of subjective measures often leads to overestimation [56]. Fourth, we conducted a study on a small sample (N = 198) of university students. Future studies should take into account students from other faculties with different professions and lifestyle habits.

5. Conclusions

We found that higher adherence to the MD was related with lower values of BMI, % FM, VF and HR, yet with higher values of % FFM and PA in the total sample. In men, higher adherence to the MD was related with lower values of W, BMI, % FM, VF, SBP, DBP and HR, yet with higher values of % FFM and PA. In women, higher adherence to the MD was related with lower values of W, BMI, % FM and VF, yet with higher values of % FFM and PA.

The present study confirms that higher adherence to the MD has beneficial effects to body composition characteristics in university students. Also, such diet is related with higher levels of PA in both genders. Thus, special strategies and policies should be implemented within the university school system, in order to improve diet quality and enhance the levels of PA in university students.

Competing interests

All authors declare they have no competing interests.

Authors' contribution

LŠ, DJ and GS have planned the study, MČ and IM participated in data collection, LŠ and DJ did all statistical analysis. All authors were involved with data interpretation and revision of the paper. All authors read and approved the final version of the manuscript.

Ethics approval

This study was approved by the Institutional Review Board of the Faculty of Kinesiology, University of Zagreb, Croatia (ethics approval code: 16/2017).

Data availability

The authors confirm that all data underlying the findings are freely

available.

Patient consent

Obtained.

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