MEDITERRANEAN DIET ADHERENCE IN 9-YEARS OLD CHILDREN: A CROSS-SECTIONAL STUDY IN THE PART OF THE SPLIT-DALMATIA COUNTY, CROATIA

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SUMMARY

Objectives: Childhood obesity is a growing global problem that can be prevented by improving diet quality. Mediterranean diet (MedDiet), historically present in Mediterranean countries, is considered one of the healthiest dietary patterns. This cross-sectional study aimed to determine the MedDiet adherence and anthropometric parameters in 9-year-old children from the central geographic locations of Split-Dalmatia County, Croatia.

Methods: The study analysed data obtained from 158 children aged nine years from central parts of Dalmatia: Split and Hvar. To assess the MedDiet adherence, the parents of the children filled out the Mediterranean Diet Index (KIDMED) questionnaire. Appointed school medicine specialists collected anthropometric data of the children and categorized them into body mass index (BMI) categories according to the Center for Disease Control and Prevention (CDC) criteria. Additionally, we assessed the influence of parents' education degree on children's MedDiet adherence and anthropometric measures.

Results: Results showed that more than a quarter of nine-year-olds included in this study were overweight or obese (BMI ≥ 85th percentile for age and sex). One of the main findings was that 72% of children had suboptimal (poor or average) MedDiet adherence. Moreover, children with suboptimal KIDMED results (KI < 8) had significantly higher body weight, waist circumference, hip circumference, and waist-to-height ratio. Also, results showed that mothers' education notably influences children's anthropometry.

Conclusion: Our study found that childhood obesity is a significant concern among 9-year-olds, with a high prevalence of overweight and obesity. Additionally, our results showed that MedDiet adherence is suboptimal among this age group. These results indicate that children of the Mediterranean are not spared of modern life challenges. This problem should be prioritized in the future to prevent the development of a metabolically compromised adult population.

Key words: Mediterranean diet, KIDMED, children's health, public health, obesity

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INTRODUCTION

The postulates of the Mediterranean diet (MedDiet) emanate from the natural wealth of the Mediterranean countries, where it was easily accessible for years (1). MedDiet is a dietary pattern first described by Ancel Keys during the 1960s. Generally, it includes a high intake of plant-derived food and products like fruits, vegetables, grain, legumes, and olive oil, a moderate intake of meat, fish and dairy products, and a low intake of sugar-rich food (2). Cochrane reviews have shown that adherence to the MedDiet may have a favourable effect on preventing chronic diseases with emphasis on negative cardiovascular events (3), nonalcohol-related fatty liver disease (4), chronic kidney disease (5), and rheumatoid arthritis (6), but further investigation is needed to fully verify these benefits. Furthermore, there are strong indications that diet quality significantly influences maintaining mental health and improving cognitive flexibility in children (7).

Contemporary trends, such as sedentary lifestyle, low physical activity, and availability of processed and nutritionally deficient food have led to the suppression of the traditional MedDiet from the countries of the Mediterranean basin which leads to an increase in the incidence of obesity and metabolic syndrome, especially in children and young (2, 8). A major problem concerning childhood obesity is the fact that obese children have a higher risk of becoming obese later in life, leading to an increased risk of morbidity (9). The prevalence of childhood obesity is reaching new heights year by year. According to the World Health Organization (WHO), in the past forty years, the prevalence of overweight and obesity among children and adolescents has increased from 4% to 18% (10). Unfortunately, Croatia is among the countries

that follow global trends. According to the European Childhood Obesity Surveillance Initiative 2018/2019 (CroCOSI), there were 35% of overweight or obese children aged 8 to 9 years in Croatia. Moreover, the biggest prevalence was detected in the Adriatic region (36.9%), which is alarming considering the historical presence of the MedDiet on the islands and cities of the Adriatic shore (11).

The main objective of this study was to assess how well elementary school children aged 9–9.5 years from Split, the largest Dalmatian city, and Hvar, the fourth most populous Croatian island, adhere to the guidelines of the Mediterranean diet. Hence, we analysed the association between MedDiet adherence and anthropometric parameters and parents' education degree.

MATERIALS AND METHODS

Study Design

This cross-sectional epidemiological study included 164 children aged 9–9.5 years from Split and the island of Hvar. The research included consecutively selected children from the midtown of Split and all nine-year-olds from the island of Hvar who have met the main condition for inclusion (signed parental consent). The main author is a school physician responsible for approximately 160 children aged 9 years from the midtown of Split. To match the number of respondents in Split with those in Hvar, KTE selected nearly every second child who had undergone a planned systematic examination. Data was collected from February to March 2023. Six of 164 respondents have not completed the Mediterranean Diet Index (KIDMED) questionnaire or did not have a signed parental consent and were therefore excluded from further analysis. Height, weight, waist and hip circumference were measured as a part of the regular screening examination of nine-year-old children, which is routinely performed under the supervision of the appointed school medicine specialist. Also, children's parents filled out the KIDMED questionnaire and were asked about their education degree (elementary school, high school, undergraduate, graduate/PhD).

Anthropometric measurements were taken according to the National Health and Nutrition Examination Survey (NHANES) 2021 (12). Body height was expressed in meters (m), body weight in kilograms (kg), waist (WC) and hip circumference (HC) in centimetres (cm). Body mass index (BMI, kg/m^2) was calculated for every child by CDC's BMI Calculator for Children and Teens (metrics mode) (13). The same calculator was used to determine to which percentile for age and gender each child belongs. Based on that, children were categorized into three groups: underweight (less than the 5th percentile), healthy weight (5th percentile to less than the 85th percentile), and overweight/obese (85th percentile or greater) (14). Waist to hip ratio (WHR) and waist to height ratio (WHtR) were calculated as well.

As previously mentioned, to determine adherence to MedDiet, parents were given a KIDMED questionnaire to fill out. KIDMED is the most used questionnaire for assessing MedDiet adherence in children and the young (15). It was designed in 2004 by a group of Spanish authors. It consists of 16 questions which can all be answered simply with "yes" or "no". Depending on the answer, +1, 0, or −1 point is given. The KIDMED index (KI) is the total number of points ranging from 0–12. Based on KI, respondents were grouped into three categories: optimal MedDiet adherence (≥ 8), average MedDiet adherence (4–7), and poor MedDiet adherence (≤ 3) (16). To determine the anthropometric differences between those who entirely stick to the Mediterranean dietary patterns and those who do not, we chose to classify all participants into two groups: optimal MedDiet adherence (≥ 8) and suboptimal MedDiet adherence (<8). KIDMED questions are listed in Supplementary Table 1.

Ethical Aspects

Participation in the research was voluntary. After detailed information provided by the school medicine specialist, who is the main author of the research, the parents of the children signed a written consent form. Children who did not have signed parental consent were excluded from the study. The present study was approved by the Ethics Committee of the Teaching Institute for Public Health, Split-Dalmatian County (approval no. 2181-103-01-23-1), and was performed in accordance with the ethical standards described in the 1964 Declaration of Helsinki and its later amendments.

Statistical Analysis

Categorical data are represented by absolute frequencies (n) and percentages (%). Differences between categorical variables were determined using chi-square test. For numerical data, the normality of distribution was tested using the Kolmogorov-Smirnov test. In the case of normal distribution, the data were described by arithmetic mean and standard deviation (SD). Significance of differences between groups was established using t-test or one-way analysis of variance (ANOVA). In the case of significant deviations from Gaussian distribution, the data were described using the median and interquartile range (IQR). Significance of differences between groups was then established using the Mann-Whitney U test or Kruskal-Wallis H test with post-hoc Dunn's multiple comparisons test. For all tests, the significance level was set at $p < 0.05$. Data were analysed using IBM SPSS Statistics for Windows, Version 26 (IBM Corp., Armonk, New York, USA). Figures were created using GraphPad Prism7 (GraphPad Software, San Diego, California, SAD).

RESULTS

This study included 164 children. Six of them were excluded because their parents refused to complete the KIDMED questionnaire. Therefore, we analysed data obtained from 158 children.

More than a quarter of the analysed children were categorized as overweight or obese. One of the main findings was that more than two thirds of the children did not have dietary habits in accordance with MedDiet postulates. Comparing the data of children from the city and from the island, no statistically significant differences were found across the different BMI categories or MedDiet adherence. Among anthropometric parameters, a significant difference was found for hip circumference, which was higher in children from Hvar ($p = 0.002$), and WHR, which was higher in children from Split ($p < 0.001$) (Table 1).

Table 1. *Anthropometric differences between 9-year-olds from the city of Split and the island of Hvar (N = 158)*

	n (%)	Split (n = 83) n (%)	Hvar (n = 75) n (%)	p-value
Sex				
Boys	73 (46.2)	39 (47.0)	34 (45.3)	0.835[c]
Girls	85 (53.8)	44 (53.0)	41 (54.7)	
BMI (percentile)				
Underweight (< 5)	3 (1.9)	1 (1.2)	2 (2.7)	0.660[c]
Normal weight (≥ 5 to < 85)	114 (72.2)	62 (74.7)	52 (69.3)	
Overweight (≥ 85)	41 (25.9)	20 (24.1)	21 (28.0)	
Anthropometric parameters				
Height (m)[a], mean (SD)	1.40 (0.06)	1.40 (0.06)	1.39 (0.06)	0.136[t]
Weight (kg)[b]	33.25 (9.0)	33.5 (9.0)	33 (9.0)	0.806[#]
WC (cm)[b]	59.75 (10.0)	60 (9.5)	59 (9.5)	0.673[#]
HC (cm)[b]	72 (10.0)	70 (12.0)	74 (9.0)	**0.002**[#]
WHR[b]	0.82 (0.06)	0.84 (0.06)	0.80 (0.05)	**< 0.001**[#]
WHtR[b]	0.42 (0.06)	0.42 (0.06)	0.43 (0.05)	0.254[#]
MedDiet adherence (KI)				
Optimal (KI ≥ 8)	44 (27.8)	26 (31.3)	18 (24.0)	0.305[c]
Suboptimal (KI < 8)	114 (72.2)	57 (68.7)	57 (76.0)	

[c] – χ^2 test; [#] – Mann-Whitney U test; [t] – T-test; [a] – arithmetic mean with standard deviation due to normally distributed data; [b] – median value with IQR due to the abnormal data distribution
Numbers in bold indicate statistically significant values.

Considering parental education degree and geographic region, there were significantly more parents with a higher level of education (graduated/PhD) in the city than on the island (p = 0.015 and p = 0.025 for the mother and father, respectively) (Table 2).

Furthermore, we wanted to assess anthropometric and dietary differences concerning parents' education level. No statistically significant differences were found across the different BMI categories or MedDiet adherence considering the education of the mother or the father. However, the results showed significant differences among the other children's anthropometric measures considering the mothers' education degree. There were differences in WC (p = 0.002), HC (p = 0.001), and WHtR (p = 0.001) that were all higher among children of mothers who had a lower level of education (high school vs. graduated/PhD) (Supplementary Table 2, Fig. 1). The category "elementary school" is not shown in Table S2 and in Fig. 1 because only one child had a mother in that group. That child was a girl with a healthy weight and optimal MedDiet adherence. There were no significant differences among the anthropometric parameters concerning the fathers' education level (Supplementary Table 3).

Finally, our results showed that children's anthropometric measures significantly varied considering MedDiet adherence; 9-year-olds who did not entirely adhere to the MedDiet (KI < 8) had significantly higher values of body weight (p = 0.043), waist

Table 2. *Parent's education degree*

	Total n (%)	Split n (%)	Hvar n (%)	p-value
Father	156	81 (51.9)	75 (48.1)	**0.025**[c]
Elementary school	4 (2.6)	0 (0.0)	4 (5.3)	
High school	97 (62.2)	47 (58.0)	50 (66.7)	
Undergraduate	24 (15.4)	12 (14.8)	12 (16.0)	
Graduate/PhD	31 (19.9)	22 (27.2)	9 (12.0)	
Mother	158	83 (52.5)	75 (47.5)	**0.015**[c]
Elementary school	1 (0.6)	0 (0.0)	1 (1.3)	
High school	82 (51.9)	39 (47.0)	43 (57.3)	
Undergraduate	39 (24.7)	17 (20.5)	22 (29.3)	
Graduate/PhD	36 (22.8)	27 (32.5)	9 (12.0)	

[c] – χ^2 test
Numbers in bold indicate statistically significant values.

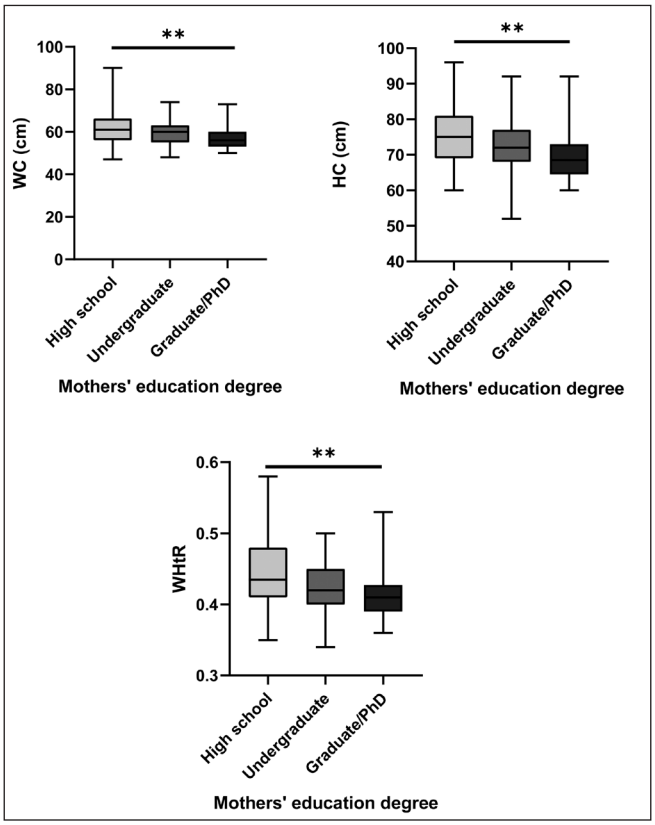

Fig. 1. *Differences in children's anthropometric measures in relation to mothers' education level.*

**p < 0.005

circumference (p = 0.002), hip circumference (p = 0.01), and WHtR (p = 0.004). However, there were no statistically significant differences among the different BMI categories considering KI (Table 3).

DISCUSSION

Out of 158 participants in our study, 25.9% would be classified as overweight (Table 1). That is no surprise, since childhood obesity has been a growing problem in the world. These results show us that Croatia is not an exception to that concerning trend. According to data from the World Health Organization, the prevalence of overweight and obesity in the paediatric population has been growing constantly in the last forty years, rising from 4% in the 1970s to 18% nowadays (10). Our numbers are even higher, suggesting that this trend is not ceasing. However, our results are more optimistic than those from the European Childhood Obesity Surveillance Initiative 2018/2019 (CroCOSI). The study suggested that 35% of the children aged 8.0 to 8.9 years on the national level were overweight or obese. The results were even less favourable in the Adriatic region, where 36.9% of the children had a higher BMI (11). The differences between these results and ours could be explained by the fact that we covered very specific geographic locations in Dalmatia (Split and Hvar), while the CroCOSI study was performed on a national level. It is to be expected that the people in these two places, which are in the middle of the Mediterranean area, are embracing the MedDiet principles more thoroughly than the rest of Croatians, which could lead to a lower BMI and more favourable anthropometric parameters.

However, another concerning discovery in this study was a very low adherence to the Mediterranean diet in the places located in the heart of the Mediterranean region. Only 27.8% of the children adhered to the MedDiet optimally (KI ≥ 8), while 72.2% of the children showed suboptimal adherence to the MedDiet (KI < 8). These results are in consonance with those from a cross-sectional study performed on a sample of 10,001 inhabitants of the islands of Vis and Korcula, and the city of Split which showed a concerningly low adherence to the MedDiet (23%) among the people of

Table 3. *Differences in children's anthropometric measures in relation to the MedDiet adherence*

	Suboptimal (KI < 8) (n = 114) n (%)	Optimal (KI ≥ 8) (n = 44) n (%)	p-value
Sex			
Boys	58 (50.9)	15 (34.1)	0.058[c]
Girls	56 (49.1)	29 (65.9)	
BMI (percentile)			
Underweight (< 5)	3 (2.6)	0 (0.0)	0.094[c]
Normal weight (≥ 5 to < 85)	77 (67.5)	37 (84.1)	
Overweight and obese (≥ 85)	34 (29.8)	7 (15.9)	
Anthropometric parameters			
Height (m)[a], mean (SD)	1.40 (0.06)	1.39 (0.06)	0.132[t]
Weight (kg)[b]	33.5 (9.13)	32.0 (5.88)	**0.043**[#]
WC (cm)[b]	60.0 (10.0)	57.0 (5.75)	**0.002**[#]
HC (cm)[b]	73.0 (12.0)	70.0 (8.5)	**0.01**[#]
WHR[b]	0.82 (0.06)	0.81 (0.06)	0.126[#]
WHtR[b]	0.43 (0.07)	0.41 (0.04)	**0.004**[#]

[c] – χ^2 test; [#] – Mann-Whitney U test; [t] – T-test; [a] – arithmetic mean with standard deviation due to normally distributed data; [b] – median value with IQR due to the abnormal data distribution

Numbers in bold indicate statistically significant values.

18 years or older (17). This could suggest that the low adherence to the MedDiet in the paediatric population (shown in our study) could be a result of their parents' eating habits. This is supported by another study performed on the Mediterranean population in Croatia, which showed that the children of parents with a low MedDiet adherence are more prone to having poor MedDiet adherence as well (18). Many studies performed in the Mediterranean countries show low adherence to the MedDiet and consequently low KI scores. One systematic review, which included 18 cross-sectional studies performed in various Mediterranean countries on 24,067 children and adolescents, showed that only 10% of the participants followed the MedDiet optimally, according to the KI scores (19). However, one study from 2019, conducted on Dalmatian preschool children, showed more optimistic results, with only 6% of the children having a low KIDMED score (20).

Comparing the anthropometric parameters of the children from Split and Hvar, we noticed a statistically significant difference in HC and WHR. HC was lower in Split (70 cm compared to 74 cm on Hvar), while WHR was lower on Hvar (0.80 compared to 0.84 in Split). Higher WHR in Split could be a result of lower HC, because a significant difference in WC was not found. These results could suggest that the children in Split have a slight tendency to the central type of obesity, while children in Hvar are more prone to the peripheral type of obesity. Taking this into account, the children in Split could be more metabolically endangered than those on the island. The importance of WHR lies in its connection to the incident cardiovascular disease (CVD) events. Many studies have shown the correlation between WHR and CVD risk. Among them, one meta-regression analysis collected the data from 15 articles, which totalled 258,114 participants. For a 0.01 U increase in WHR, the relative risk of CVD increased by 5% (95% CI: 4–7) (21). Another study performed retrospective chart reviews for 754 patients aged 6 to 17 years. It showed a negative correlation between WHR and high-density lipoproteins (HDL) and a positive correlation between WHR and low-density lipoproteins (LDL) and triglycerides, leading to a higher metabolic risk in children with higher WHR (22).

Furthermore, we collected the data about the parents' education level (elementary school, high school, undergraduate and PhD). Split is an urban area, the second largest city in Croatia, while Hvar is a sparsely populated island, a rural area. That is the reason we expected the parents in Split to be of a higher academic level. Education level of the parents in Split was indeed higher, so we assumed there should be more overweight children on Hvar. Highly educated people are expected to have a better understanding of the principles of a healthy nutrition, to have a higher household income and thus to be able to provide a healthier and more diverse nourishment to their children, leading to a more optimal BMI. Although we acquired that result (28% overweight and obese children on Hvar compared to 24.1% in Split), the difference was not statistically significant. However, a European cross-cohort study which included 45,413 children among 11 cohorts across Europe stated that low maternal education yielded a significant risk of adiposity in paediatric population (RR = 1.58, 95% CI: 1.34–1.85) (23). On the other hand, we did get a statistically significant difference in other anthropometric parameters – HC, WC and WHtR in relation to the mother's education level (Fig. 1). Mothers with lower level of education have children with higher anthropometric parameters (WC, HC and WHtR). These results are in accordance with the study performed on 1,483 Norwegian 11-year-olds. This study showed significant differences in weight, BMI, HC, WC, WHR, and WHtR, when comparing the children of highly educated parents to those of parents with lowest educational levels (24). Another study from Norway found that the relative risks of obesity and high WHtR (≥ 0.5) in children of mothers with primary levels of education compared to those of mothers with tertiary levels of education were 1.3 (95% CI: 1–1.6) and 1.8 (95% CI: 1.3–2.6), respectively (25). Lastly, we found no significant difference between the KIDMED scores in accordance with mothers' education level. Another interesting point is that the father's education level had no statistically significant correlations to any of the parameters. In Croatian families, mother is usually the household member who is preparing the meals and is more concerned for their child's nourishment. Two studies performed in France and Italy agree with this finding as well – they found that the mother's education bears a much more substantial correlation with their children's BMI than the education level of their fathers (26, 27).

Finally, it should be accentuated that our results indicate better MedDiet adherence results in favourable children's anthropometric measures. Comparing the children with optimal MedDiet adherence ($KI \geq 8$) to the children with lower, suboptimal adherence ($KI < 8$), we found that the latter category had significantly higher values of body weight, HC, WC and WHtR. According to a study performed in Greece, following nutritional education, the MedDiet adherence increased, as the BMI, blood pressure (BP), WC, and WHtR decreased significantly in the group of adolescents aged 12–17 years (28). Another Greek study found higher values of BMI, BP and WC among children with lower KIDMED scores (29). Similar results were noted in another Mediterranean country – Spain. A study on a sample of 2,513 young Spaniards calculated that a 5-point increase in KIDMED score led to a mean decline in WC by 1.54 cm (30).

The importance of this research lies in the fact that it was performed on a considerable sample of children in this specific area (Split and Hvar) in one specific age group (9-year-olds). Unlike other countries with the MedDiet tradition (e.g., Italy and Portugal), not so many MedDiet studies have been performed for this age group in our part of the Mediterranean world. Dalmatia is in the heart of the Mediterranean, so the fading of the MedDiet in this region can be an indicator of similar trends in other Mediterranean regions and countries.

There are some limitations to this study as well. The KIDMED questionnaire was filled out by the parents. It is to be expected that they did not completely accurate report their children's dietary habits. Additionally, the study was performed in a relatively compact area in a narrow age group, restricting its usefulness to reflect the dietary habits of the whole Dalmatian area. Furthermore, the omission of variables such as physical activity level, which can significantly influence anthropometric measures, limits study's scope. To enhance the validity of these findings, future studies should consider expanding to multiple cities and islands of the Dalmatian region, incorporating a broader range of factors.

CONCLUSION

Although Split and Hvar are a part of the Mediterranean world, which should be faithfully following the principles of the Med-

Diet, our results have shown that this is not the case. Unfortunately, the world trends of childhood obesity have not avoided this area. Notably, the persistence of non-adherence to the MedDiet could be one of the main factors leading to a disturbingly high prevalence of paediatric obesity, which remains ongoing public health concern. MedDiet is known to be one of the healthiest forms of nutrition and children should be encouraged to pursue that dietary pattern, especially in the regions where it has been traditionally present for centuries.

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Conflicts of Interest

None declared

Electronic Supplementary Materials

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