High Blood Pressure and Diet Quality in the Spanish Childhood Population

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Abstract

The objective is to analyze the association between the degree of compliance with Mediterranean Diet and blood pressure in 1078 Spanish schoolchildren (514 boys, 564 girls) aged 9 to 16 years. We measured weight (kg), height (cm), waist circumference (cm), skinfold thicknesses (bicipital, tricipital, subcapular and suprailiac) and blood pressure. The Waist-to-Height Ratio (WtHR), Body Mass Index (BMI), and the percent body fat (%BF) were calculated. Subjects were classified as “underweight”, “normal weight”, “overweight” or “obese” according to the International Obesity Task Force (IOTF). Diet quality was assessed by the KIDMED index and the hypertensive status according to National High Blood Pressure Education Program Working Group.

Results show that media values of systolic and diastolic blood pressure significantly increase at the same time that diminished the quality of the diet. Schoolchildren with high blood pressure (4.66% boys; 4.78% girls) are not distributed uniformly in the different KIDMED categories. In the “poor” diet category (KIDMED-score <3) there were 8.33% of hypertensive children, in the “average” category (KIDMED-score 3-7) there were a 3.38% and, by contrast, there were not hypertensive children in “good” category (KIDMED-score > 7). A multiple linear regression analysis found that KIDMED index had a negative correlation with systolic and diastolic pressure. Also BMI and WtHR were positively correlated with both blood pressure levels, and %BF was associated only with diastolic BP. In conclusion, although the KIDMED index is a fast and simple tool to assess diet quality, it clearly reveals an inverse association between adherence to Mediterranean diet and blood pressure in healthy Spanish schoolchildren.

Keywords: Blood pressure; Mediterranean diet; Schoolchildren; Body mass index; Body fat; Waist to height ratio

Abbreviations: MD: Mediterranean Diet; BP: Blood Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HBP: High Blood Pressure; %BF: Percent Body Fat; BMI: Body Mass Index; WtHR: Waist to Height Ratio

Introduction

Review studies have reported that, on average, hypertension affects 33.2% of people in developing countries and also to 40.8% in developed ones, although there is a significant worldwide variation [1,2]. However, this problem does not only affect the adult population. The metanalysis of Kavey et al. reported that between 1% and 5% of hypertensive children, in the “average” category (KIDMED-score 3-7) there were a 3.38% and, by contrast, there were not hypertensive children in “good” category (KIDMED-score > 7). A multiple linear regression analysis found that KIDMED index had a negative correlation with systolic and diastolic pressure. Also BMI and WtHR were positively correlated with both blood pressure levels, and %BF was associated only with diastolic BP. In conclusion, although the KIDMED index is a fast and simple tool to assess diet quality, it clearly reveals an inverse association between adherence to Mediterranean diet and blood pressure in healthy Spanish schoolchildren.

During childhood, HBP is associated with certain health problems, such as left ventricular hypertrophy, thickening of the carotid vessel wall, retinal vascular changes, and even subtle cognitive changes [9]. There is also evidence that BP levels in infancy predict BP later in life, so that prevention of childhood hypertension is the first step to reduce cardiovascular disease in adults. Preventive measures are aimed at reducing excess weight, through physical activity and improving diet, increasing consumption of vegetable foods rich in potassium, calcium and magnesium, and lowering the intake of meat and rich products in fat and sodium. This kind of diet known as DASH (Dietary Approaches to Stop Hypertension) has also been recommended by the Committee on Atherosclerosis, Hypertension, and Obesity in the Young (AHOT) dependent on the American Heart Association and its effectiveness has been proven at the clinical level [10-12].

The traditional diet in Mediterranean countries broadly in the past was characterized by an abundance of vegetal origin foods, such as bread, pasta, vegetables, salads, legumes, fruits and olive oil as the main source of fat, likewise a low intake of red meat and moderate consumption of fish, poultry, dairy and eggs. The nutritional transition and diet globalization are modifying this pattern in the southern European countries. Also, the rising prices of food items as...
a result of current economic crisis, is facilitating the abandonment of traditional habits [13]. Particularly in Spain, the level of adherence to the Mediterranean Diet (MD) is estimated at 50%, with a significant reduction in the last two decades [14-17].

The interest in promote again this type of feeding, is based on two fundamental factors. First, the extensive scientific evidence derived from epidemiological studies that demonstrate benefits of MD for cardiovascular health [18]. Secondly the good palatability and acceptance of this diet that can be used in non-pharmacological management of patients at risk of diseases related to the metabolic syndrome [19].

The effect on the reduction of BP is well documented in adults since the last three decades [20]. The PREDIMED Study (PRévención con DIetaMediterránea) showed, in Spanish population, that the MD has a greater effect on the reduction of cardiovascular morbidity and BP levels than a conventional low-fat diet [21]. In children and adolescents, this topic is still poorly explored and that is why the aim of the present paper is to analyze the association between the degree of compliance to MD and BP in Spanish school children (22).

Material and Methods

We conducted a cross-sectional study involving a sample of 1078 schoolchildren (514 boys, 564 girls) between 9 and 16 years, sons and grandsons of Spanish parents. The data was collected from 2004 to 2008 in 15 Primary and High Schools of Community of Madrid (Spain). The socioeconomic characteristics of the students were ranked in the intermediate level in terms of parental occupation and educational level (29.20% were college graduates, 31.44% were high school or vocational school graduates, and 39.36% had a primary education). The primary and secondary schools included were those that showed an interest in participating in the project, with the support of the Education Department of the Community of Madrid. We required the informed consent of the parents or guardians, in accordance with the Helsinki Declaration and Spanish Organic Law, for the Protection of Personal Data (15/1999, of December 13) [23]. The exclusion criterion was the presence of any chronic disease, including diagnosed HBP.

We measured the weight (kg), height (cm), waist circumference (cm) and skinfold thicknesses (bicipital, tricipital, subcapsular and suprailiac) (mm), employing homologated anthropometric instruments and following the protocols of the International Biological Programme and the International Society for the Advancement of Kinanthropometry [24,25]. The WHR was calculated by dividing the waist circumference by the height and the BMI by dividing the weight (kg) by the height squared (m). The sum of the four skinfold thicknesses was computed and the percent body fat (%BF) was determined using the Siri equation once the density had been estimated by applying the equation proposed by Broek or Durnin and Rahaman, depending on age. Subjects were classified as “underweight”, “normal weight”, “overweight” or “obese” according to the International Obesity Task Force (IOTF) standards published by Cole et al. [26-30].

BP was measured after a 10 minutes rest, using a mercury sphygmomanometer and Riester stethoscope. With the child in a sitting position, with back support, feet flat on the floor and right arm extended, Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were measured using, as reference, Korotkoff phases I and V, respectively. The measurements were performed 3 times, since normally, the pressure tends to stabilize when the child becomes accustomed to the method and reduces anxiety. The lowest of the 3 values was considered valid. As classification criteria, we used the tables from the RICARDIN study (RiesgoCARDiovascular en la INfancia [Cardiovascular Risk in Children]) [31]. In accordance with the recommendations of the National High Blood Pressure Education Program Working Group and the Cook et al. proposal to define metabolic syndrome in childhood, we considered normotensive those boys and girls with BP levels below the 90th percentile of the standard [32,33]. Children with SBP and/or DBP equal or higher than this cutoff point were grouped in the HBP category.

To assess the diet quality of the schoolchildren, it was used the KIDMED Index (Mediterranean Diet Quality Index in children and adolescents) that was developed for Spanish population by Serra Majem et al. [34]. The KIDMED Index is a food consumption frequency test, based on the MD which is considered the ideal healthy diet for this population.

This questionnaire consists of 16 affirmative items about which the child must answer by saying if the statement is true or false. Each item has a positive or negative associated punctuation. At the end of the test the overall score reflects the diet quality, so the children who is below 3 points have a very low quality diet (“poor” category), if the punctuation is between 4 and 7 the diet needs improvement (“average” category) and if child have 8 or more points is considered that have a healthy diet (“good” category).

The mean and standard deviation were calculated for continuous variables and percentage for categorical parameters. Tested normality of distributions (Kolmogorof-Smirnov test) parametrical (t-test, ANOVA) or no parametrical test (Mann Whitney U) was used to assess differences between groups. For percentages, differences were assessed by Chi-Squared test. Multivariable correlations among analyzed variables were performed applying multiple linear regression models. Software SPSS version 19.0 (SPSS Inc. Chicago, IL, USA) was used for the statistical procedures.

Results

Excluding WHR, all measurements shown significant changes with age (p<0.001). Boys had higher height, weight, and waist circumference than girls, from age 12 (p<0.05), while girls had a higher values for sum of skinfolds and %BF from 11 years (p<0.001) (Table 1). There were no differences in BMI between girls and boys, and distribution by nutritional categories was similar in both sexes. As shown in figure 1, excess of weight (overweight plus obesity) was of 31.3% in males and 29.6% in females. According the expected pattern, SBP and DBP, also

![Figure 1: Distribution of nutritional categories by sex.](image-url)
For the quality of the diet (Table 3), the highest proportion of schoolchildren (63.07%) was in the "average" category (KIDMED score 4-7), although the percentage of individuals with "good" diet (KIDMED score ≥ 8) was higher in girls (6.56%) than in boys (2.52%). Analyzing separately the items of KIDMED index, differences were observed for consumption of fruit and vegetables in favor of the female series. By contrast, boys had higher consumption of cereals and yoghurts, but the mean KIDMED score was similar in both sexes (4.38 for girls and 4.86 for boys). The association between degree of adherence to MD and BP is evident in the results presented in Table 4. It is shown that median SBP for boys). The association between degree of adherence to MD and BP significantly increase at the same time that diminished the quality of the diet. In table 5 we observe that schoolchildren with HBP and DPB significantly increased at the same time that diminished the proportion observed in the "average" categories and, by contrast, the HBP proportion in the "poor" diet (4.66% boys; 4.78% girls) are not distributed uniformly in the different quality of the diet. In table 5 we observe that schoolchildren with HBP and DPB significantly increase at the same time that diminished the proportion observed in the "average" categories (3.38%). Another way to demonstrate this association is the performed multiple linear regression (Table 6). It was found that KIDMED index had a negative correlation with SBP and DBP. Also BMI and WtHR were determinants of both BP levels (positive correlations) and %BF was positive associated with DBP.

### Discussion

In this paper, the association of diet quality and BP in healthy Spanish schoolchildren was analyzed. The major findings were that children with low level of adherence to MD had a significantly higher SBP and DBP levels compared to their peers with high KIDMED score.

The level of adherence to the MD, in our sample resulted lower than other Spanish populations such as Granadian schoolchildren studied in 2008 by Mariscal-Arcas et al., and that in the Madrilenian boys and girls analyzed by Montero in 2006 [34-36]. In these samples, the percentage of subjects classified with "good" diet was 48.6% and 37.5% respectively, although the latter were among a nutrition education program at school. Our data are closer to those obtained for the Balearic Islands, where the average degree of adherence to MD among adolescents of 12 to 17 years was 57.9% [37].

The prevalence of excess weight (30.5%) was similar to that obtained among adolescents of 12 to 17 years was 57.9% [37].

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**Table 1:** Descriptive anthropometric characteristics of sample.

| Age | N  | Height (cm) | Weight (kg) | BMI (kg/m²) | % 4 skinfolds (mm) | %BF | WC (cm) | WHR |
|-----|----|-------------|-------------|-------------|-------------------|-----|---------|-----|
|     | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 9   | 33  | 137.58 | 5.89 | 34.24 | 7.62 | 17.99 | 3.19 | 42.17 | 21.75 | 23.67 | 7.81 | 65.54 | 8.56 | 0.455 | 0.05 |
| 10  | 36  | 143.15 | 6.46 | 41.00 | 9.86 | 19.82 | 3.64 | 51.31 | 25.46 | 26.82 | 7.83 | 70.74 | 10.34 | 0.463 | 0.06 |
| 11  | 43  | 147.71 | 7.32 | 44.66 | 10.01 | 20.17 | 3.19 | 52.19 | 24.55 | 25.32 | 8.52 | 71.35 | 8.82 | 0.459 | 0.04 |
| 12  | 90  | 151.60 | 7.68 | 52.90 | 10.60 | 20.69 | 3.59 | 48.34 | 21.23 | 20.22 | 6.77 | 72.47 | 8.83 | 0.460 | 0.05 |
| 13  | 129 | 153.94 | 6.47 | 48.56 | 9.44 | 21.23 | 3.74 | 53.22 | 21.60 | 17.75 | 5.61 | 73.84 | 7.15 | 0.450 | 0.03 |
| 14  | 77  | 158.01 | 6.38 | 52.98 | 9.79 | 20.44 | 3.54 | 50.22 | 21.60 | 26.83 | 4.80 | 69.99 | 6.97 | 0.447 | 0.05 |
| 15  | 114 | 160.56 | 6.47 | 55.24 | 8.45 | 21.43 | 2.94 | 54.10 | 27.20 | 28.24 | 4.21 | 68.99 | 6.12 | 0.438 | 0.04 |
| 16  | 45  | 162.44 | 6.07 | 56.48 | 7.77 | 21.39 | 2.73 | 56.83 | 28.40 | 27.56 | 3.15 | 69.37 | 5.85 | 0.437 | 0.04 |

BMI: Body Mass Index; % 4 skinfolds (biceps+triceps+subscapular+suprailiac); %BF: percent Body Fat by Siri equation; WC: waist circumference; WHR: Waist to Height Ratio.
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in the ALADINO Study (Actividad Física, Obesidad y Desarrollo Infantil [Food Physical Activity Obesity and Child Development]) conducted in 2010 in which was reported a 31.3% (overweight plus obesity) on a sample of 7923 Spanish schoolchildren between 6 and 9.99 years [38]. Also, our data coincide with those obtained in the enKID study conducted in the past decade (30.4%) and are very close to those reported for other Mediterranean countries as Portugal (31.5%) and Italy (25.1% - 27.6%) [39-41]. On the other hand, are lower than the values obtained in Greece (overweight: 30.3% and obese: 13.0%) and higher than those corresponding to Morocco and Tunisia where overweight children are below 10.0% [22,42-44].

In Spain, the nutritional transition has been characterized by an increase of total energy consumption and a gradual abandonment of the MD. Since the 60s of last century, the proportion of protein and animal fat and sugary products with low nutrient density (sweets, candy, soft drinks, etc.) has augmented. At the same time the consumption of bread, cereals and legumes has decreased [45]. This phenomenon, together with the increasing of sedentarism and the decreasing of sleeping hours, has led to the rise of obesity both in adults and in children and adolescents [46].

In parallel to the increase in childhood obesity has detected an augmentation in BP at an early age. Several studies have discussed this aspect, revealing a significant association between excess adiposity and risk of hypertension in children. Years ago, classic studies like

Table 3: KIDMED-index scores.* p <0.05; ** p< 0.001, NS: no significant differences (X2-test)

Table 4: Mean sistolic (SBP) and diastolic (DBP) blood pressure by KIDMED categories.

Table 5: Children with high blood pressure (HBP) by KIDMED categories.

Table 6: Multiple linear regression analysis. Dependent variables: Sistolic blood pressure (SBP); Diastolic blood pressure (DBP). Sex code: 1 male. 2 female.
the Bogalusa Heart Study or the Muscatine Study found a positive correlation between body weight, BMI, and BP. More recent studies have focused on the importance of %BF and fat distribution as determinants of arterial pressure levels [44,47-51]. In this line, our research group found that the risk of HBP in children was increased with a body mass index indicative of obesity (7.87-fold in boys, 12.32-fold in girls), with a %BF >97th percentile (6.98-fold in boys, 18.51-fold in girls), or with a WHR ≥ 0.5 (10.56-fold in boys, 7.82-fold in girls) [52].

The works relating diet and BP or other indicators of cardiometabolic risk in children are still scarce. Rodriguez-Aralejo et al. in a study with 1112 kids aged 6-7 years, found a strong relationship between dietary patterns and different cardiovascular mortality in four Spanish cities with varying degrees of adherence to traditional MD [53]. In cities with high mortality by ischemic heart diseases (Cadiz, Murcia), the children consumed more precooked foods and soft drinks (products with high content in salt and refined sugars), but also more cheese and yogurt. In cities with lower mortality, children ate more fruit and milk. In children from the four cities, no differences were found for the prevalence of overweight (considered as BMI >17.6) and obesity (BMI >20.1) with values that ranged from 28.9% to 34.5% and 8.5% to 15.7% respectively. It therefore appears that nutritional factors in early stages of life may contribute to cardiovascular disease in adults although diet had no apparent effect on the excess of weight.

On the same line, Lydakis et al. in a sample of 277 Greek children aged 12 years, observed that the KIDMED score is negatively associated to "augmentation index" in the brachial artery, regardless of BMI [22]. This study was the first to analyze the relationship between MD and arterial stiffness in children, although a previous study had proven that daily consumption of fruits and vegetables (included as items in the KIDMED index) during childhood, was a protective factor for hypertension and arterial stiffness in adults [54]. Similarly, in a sample of children from the Framingham prospective study, the researchers found that boys and girls who consumed four or more servings, either of fruit or vegetables, per day had smaller yearly gains in SBP throughout their growth period [55].

In the Cyprus Kids Study (CYKIDS) made by Lazarou et al. on a sample of 622 Cypriot schoolchildren, were explored the relationship between diet quality (assessed by the "Electronic Kids Dietary Index" or E-KINDEX) and BP [56]. Researchers confirmed that E-KINDEX score was inversely correlated with SBP and DBP levels once adjusted for gender, age, obesity, parental status and parental educational level; particularly children who scored below the mean were 2.3 times more likely to have HBP. The E-KINDEX questionnaire includes 13 components that assess consumption frequency of foods or 11 major groups of foods, as well as two cooking techniques (frying and grilling). This index is relatively similar to KIDMED index, and the frequent consumption of fruit, vegetables, legumes, fish and milk contributes to obtain higher scores. Clearly, these products, key elements of the MD, are rich in potassium, calcium, vitamins, antioxidants and Omega-3 fatty acids, which have a protective role against HBP [57,58].

The results discussed and those obtained in this article for child population are consistent with those observed in Spanish adults and replicate the findings described in the ATTICA study with Greek adult population in which is noted that higher adherence to the MD is a protective factor against the development of hypertension [59,60]. This protection seems to act even when there are alleles of genetic predisposition to this disease as demonstrated by Godoy et al. for the G allele (rs3101336) in the NEGR1 gene [61].

It should be added that some research shows high prevalences of childhood hypertension, even though the food habits were correct and they were included in the MD. This is the case observed in Roman schoolchildren with 7.8% of hypertension that researchers justified by excess of salt added to the food [62]. In this regard, GRECO (Greek Childhood Obesity) Study also revealed that there was a high salt intake in children classified as "average" or "good" diet by KIDMED index [63]. It must keep in mind that the contents of salt in bread or cheese, both foods positively evaluated in this questionnaire, may be elevated.

Limitations

To provide greater consistency to present work, it would be interesting to consider other aspects that may eventually affect BP values in children such as birth weight, breastfeeding patterns or sleep habits. Furthermore, although take three successive measurements of BP would be appropriate to perform a longitudinal study of the participants. This would ensure that the hypertensive state is a real and permanent status in children affected and not the result of the specific situation in which the measurement was taken.

Regarding the assessment of the diet quality, any type of questionnaire involves some subjectivity and depends on the memory capacity of the individual who is being interviewed. However a food frequency questionnaire as the KIDMED index involves fewer inaccuracies than those obtained by the 24 h recall surveys, the other technique most usually employed in this kind of studies. In addition the separate study of the items can make this index be much more informative and also, it would better explain the results of the epidemiological studies which link diet quality with any child component of the metabolic syndrome like hypertension, hypercholesterolemia, hypertriglyceridemia, and diabetes.

Conclusion

There is an inverse association between diet quality and BP in healthy Spanish schoolchildren: children with low level of adherence to MD had had a significantly higher in SBP and DBP levels compared to their peers with high KIDMED score.

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