U.PORTO

Healthy sustainable diet and parental education and anthropometric characteristics in children

Alimentação saudável e sustentável e a escolaridade dos pais e características antropométricas em crianças

Ana Catarina Ferreira da Silva

ORIENTADO POR: MESTRE FRANCISCA CASTRO MENDES
COORIENTADO POR: PROFESSOR DOUTOR PEDRO MOREIRA, DR.ª ÂNGELA FARIA

TRABALHO DE INVESTIGAÇÃO
1.º CICLO EM CIÊNCIAS DA NUTRIÇÃO | UNIDADE CURRICULAR ESTÁGIO
FACULDADE DE CIÊNCIAS DA NUTRIÇÃO E ALIMENTAÇÃO DA UNIVERSIDADE DO PORTO

TC

PORTO, 2021

Abstract

Introduction: Assessing diet sustainability and healthiness is increasingly a matter of concern, by its association with human impact on environmental sustainability and health. Nevertheless, the analysis of healthy sustainable diets in association with the population health, particularly in children, still lacks evidence. Parental education is one factor that can greatly impact children's obesity, and dietary intake. Therefore, we aimed to assess the association between parental education and BMI with sustainable and healthy diet patterns in school-aged children.

Methods: Anthropometric measurements and parental education data were analysed on 392 children (49.1% girls), aged 7 to 12 years. Total WISH score and sub-scores were calculated based on adherence to the recommendations of the EAT-Lancet reference diet, through a 24-hour dietary recall questionnaire administrated to children. Linear regression models were performed to study the association between parental education and BMI with total WISH scores and sub-scores.

Results: A higher parental education level was associated with healthier sustainable diets among school-aged children (ß=2.13, 95% CI=0.14; 4.13), also presenting positive significant association with less healthy score (ß=1.27, 95% CI=0.26; 2.27) and low environmental impact score (ß=1.72, 95% CI=0.26; 3.18), after adjustments. No significant associations were found between BMI and total WISH score or sub-scores.

Conclusion: These findings suggest that parental education is associated with the adherence to a planetary healthy diet, highlighting the importance of education in a healthy sustainable development.

Keywords: Healthy sustainable diet; Body Mass Index; Parental Education; WISH.

Resumo

Introdução: A avaliação da sustentabilidade e da saúde da dieta é uma preocupação crescente, pelo seu impacto humano na sustentabilidade ambiental e na saúde. No entanto, a análise destes parâmetros em associação com a saúde da população, particularmente em crianças, carece de evidência. A escolaridade dos pais pode influenciar a obesidade infantil e a ingestão alimentar. Assim, foi objetivo deste trabalho avaliar a associação entre a escolaridade dos pais e o IMC, com padrões de dieta sustentável e saudável, em crianças.

Métodos: Realizaram-se medições antropométricas e recolha do grau de escolaridade parental em 392 crianças (49,1% raparigas), entre os 7 e 12 anos. O *score* total da WISH e os *sub-scores* foram calculados com base na adesão às recomendações da dieta de referência da EAT-Lancet, através de um questionário às 24 horas anteriores, aplicado a crianças. Foram realizados modelos de regressão linear para estudar a associação entre a escolaridade dos pais e o IMC com o *score* total e os *sub-scores* da WISH.

Resultados: Um maior grau de escolaridade parental foi associado a dietas sustentáveis mais saudáveis (ß=2,13, 95% CI=0,14; 4,13), e apresentou uma associação significativa positiva com o *less healthy score* (ß=1,27, 95% CI=0,26; 2,27) e o *low environmental impact score* (ß=1,72, 95% CI=0,26; 3,18), após ajuste. Não foram encontradas associações significativas com o IMC.

Conclusão: Estes resultados sugerem que a escolaridade dos pais está associado à adesão a uma dieta saudável planetária, salientando a importância da educação no desenvolvimento sustentável e saudável.

Palavras-chave: Alimentação saudável e sustentável; Índice de massa corporal; Grau de escolaridade parental; *WISH*.

List of abbreviations, and acronyms

BMI – Body Mass Index

CDC – US Centers for Disease Control and Prevention

CI – Confidence interval

COSI - Childhood Obesity Surveillance Initiative

IAN-AF - Portuguese Food, Nutrition and Physical Activity Survey

ISAAC - International Study of Asthma and Allergies in Childhood

N – Frequencies

OO - Overweight + obese

SD – Standard deviation

TCA - Portuguese Food Composition Table

UNW – Underweight + normal weight

WISH - World Index for Sustainability and Health

WHO – World Health Organization

% - Frequencies

%BF – Body fat percentage

β – Unstandardized beta

Summary

Introduction

The Anthropocene is characterized by its major negative impacts on human environmental sustainability and health [1, 2], parameters to which food systems are intrinsically associated[3, 4].

Evaluating the sustainability and the healthiness of our diets is increasingly a matter of concern, resulting in the development of several different indices [5-7]. The World Index for Sustainability and Health (WISH) is an example of an index that scores the environmental sustainability and healthiness of the diet in a stepwise scoring system [8], based on adherence to the EAT-Lancet Commission's recommendations for dietary consumption levels [9]. This Commission published, for the first time, a framework of global recommendations for food systems, in order to achieve a planetary healthy diet for nearly ten billion people in 2050 [9]. Nevertheless, analysis of the developed indices in association with the population health, particularly in children, still lacks evidence.

Childhood obesity is one of the most serious public health crises, at the present time. In 2021, the fourth round of the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) indicates that the prevalence of obesity was 9.0% among girls and 13.0% among boys aged 7-9 years [10]. In Portugal, the prevalence of childhood obesity was 10.7% in girls, and 12.0% in boys, at 7 years [10]. Although a decreasing trend has been observed within COSI rounds in Portugal, this prevalence remains inadequate and detrimental to children’s health [10]. Therefore, this problem should be continuously addressed with the acknowledgment of the association between body mass index and sustainable and healthy dietary patterns [11].

Parental education is one factor that can greatly impact children's health, obesity and dietary intake [12, 13]. However, knowledge on possible correlations between parental education and adherence to sustainable diet patterns is weak [14].

Objectives

To evaluate the association between children's BMI and sustainable healthy dietary patterns. To assess the hypothesis that parental education may be associated with healthy diets from sustainable food systems, in school-aged children.

Methodology

This cross-sectional study selected school-aged children from the 20 schools with the highest number of students, among the 53 primary schools located in the city of Porto, Portugal. The evaluations included an International Study of Asthma and Allergies in Childhood (ISAAC)-based questionnaire that was filled by the legal guardians and a clinical and physical assessment of children. This study was approved by the Ethics Committee of the University Hospital São João, and every procedure was performed accordingly to the Helsinki Declaration.

Participants

A total of 1602 children in the third or fourth grade, aged 7 to 12 years old, were invited to participate. Children without a signed informed consent (n=686) or who refused to perform clinical test (n=58) were excluded. From the 858 included participants, 392 had complete available dietary data and anthropometry measures, being considered for this analysis.

Parental education

Parental education level was reported as the number of completed school years and then classified into one of three categories: ≤9 years, between ≥10 and ≤12 years, and >12 years, according to the parent with the higher education level.

Anthropometry and body composition

Anthropometric measurements were performed by a trained research nurse. Weight (kg) and percentage of body fat (%BF) were measured using a digital scale (BC-Tanita™ BC-418 Segmental Body Analyser), and height (cm) was measured with a portable stadiometer. Body Mass Index (BMI) was calculated using the formula weight/height^2 (in kg/m^2) and classified into four different categories, namely underweight, normal weight, overweight or obese, giving the age- and sex-specific percentiles defined by US Centers for Disease Control and Prevention (CDC)[15] and World Health Organization (WHO)[16]. According to the CDC, each category, namely underweight, normal weight, overweight or obese, corresponds to one of the following percentiles: <15th, between the 15th and <85th, between the 85th and <95th, and ⩾95th, respectively[15]. For the WHO classification, these four categories are defined for BMI z-scores, <-2, between ⩾-2 and ≤1, >1, and >2, respectively[16]. The %BF was categorized into underfat, normal, overfat, and obese by cut-offs, in which the 2nd , 85th and 95th centiles represented the upper limit of each category, respectively[17]. In the current analyses, the four BMI categories were re-categorized into two categories: underweight + normal weight (UNW), and overweight + obese (OO).

Dietary assessment and healthy sustainable diet

Dietary information was acquired from a single trained interviewer-administered 24-hour recall questionnaire answered by children. The portion size was estimated using a photograph atlas. Data on their food and beverages consumption, brands, consuming time and place, as well as cooking methods was obtained according to standard procedures [18].

In this study, children's consumption (grams/day) of each food group from EAT-Lancet reference diet [9] was included, as well as energy intake. Food Processor® software (ESHA Research, USA), pattern recipes from Portuguese Food, Nutrition and Physical Activity Survey (IAN-AF) [19], and Portuguese Food Composition Table (TCA) [20] were used to obtained information on single food groups from mixed dishes and from other food groups not included in the WISH calculation. Nutritional data was estimated with the Food Processor® software (ESHA Research, USA).

To assess the environmental sustainability and the healthiness of the diets, the WISH method was used [8]. The WISH divides consumption into the following 13 food groups: whole grains, vegetables, fruits, dairy foods, red meat, fish, eggs, chicken and other poultry, legumes, nuts, unsaturated oils, saturated oils, and added sugars [8]. Each food group is scored individually from zero (0) to ten (10), according to its consumption adherence to the EAT-Lancet recommendations [9]. The total WISH score represents the sum of all food groups, ranging from 0 to a maximum of 130 that reflects the most environmentally friendly and the healthiest diet [8]. In order to decrease the diluting effect expected from the total WISH score, four sub-scores were created: healthy score, less healthy score, low environmental impact score, and high environmental impact score. The sub-scores assessment considers the diet quality concept and the environmental sustainability of the food groups. A higher sub-score punctuation is given when there is a higher adherence to the recommendations of the parameter considered (i.e., a higher less healthy score means a higher adherence to the recommendations for the considered limiting food groups) **(Supplementary Table 1)**.

The study analysis included all 13 food groups. Nonetheless, the whole grains group was modified to cover all grains (i.e., rice, wheat, breakfast cereals, bread, biscuits, and other sources), regardless of whether they were whole grains, considering the diet characteristics of the population in this study and some difficulties in discriminating whole grain foods from non-whole grains, when applying the 24-hour diet recall to children.

Other assessments

Sport activity was assessed based on the question "Does your child participate in any sport activity outside of normal school-period at least once per week?" and categorized into "less than 2 times a week", "2-3 times a week", and "4 or more times a week". The children's intake of nutritional supplements was assessed with the question, "Has your child taken nutritional supplements (vitamins/minerals) in the past year?". The school attended by the children was also considered, for statistical analyses.

Statistical analyses

Skewness and Kurtosis measures were studied to verify the normal distribution of continuous variables. In the presence of normal distributed variable, the results were expressed as mean ± standard deviation (SD), otherwise it was given as median (25th; 75th percentile). Categorial variables were presented as frequencies (N) and their respective percentages (%).

Independent Samples t-Test, Mann-Whitney test and Chi-square test were performed to compare variables between sexes, for continuous and normal distributed, continuous and non-normal distributed, and categorical variables, respectively.

To assess the association between the total WISH score with parental education and BMI classifications (UN, and OO categories), linear regressions models were performed. Results were reported as unstandardized beta (ß) and its respective 95% confidence interval (CI). Two models were performed for each exposure: an unadjusted model- for the main effect, and an adjusted one- for confounders sex, age, energy intake, nutritional supplement intake in the last year, sport activity, school, and parental education, which were selected based on prior knowledge on the subject [21] and on their association with the exposure or outcome (p-value<0.20).

Linear regressions were also performed to study the associations with sub-scores. Results were reported as unstandardized beta (ß) and its respective 95% confidence interval (CI). Similarly, two models were performed: unadjusted and adjusted for potential confounders that were selected as previously described.

A 95% CI and an α-value of less than 5% (p-value<0.05) were considered. The statistical package software SPSS v26.0 (IBM, USA) was used to statistically analyse the data.

Results

Characteristics of the participants are presented in Table 1. The mean age was 8.8 ± 0.8 years old, and 49.1% were girls. The proportion of parental education <10 years, 10 to 12, and >12 was 34.0%, 34.0%, and 32.1%, respectively. The prevalence of OO was 27.7%, 33.6% and 32.1%, according to CDC, WHO, and %BF, respectively. Significant differences between girls and boys were found for energy intake, total WISH score, and less healthy score **(Table 1)**.

The consumption and score of food groups are presented in supplementary table 2. The highest scores in food groups were found in grains, fish, and eggs, where the median was 10.0 (10.0;10.0). These same groups had the following consumption: mean of 271.8 ± 120.4 grams/day, median of 0.0 (0.0;100.0) grams/day and median of 0.0 (0.0;0.0) grams/day, respectively. Significant differences between girls and boys were found for fruits score (6.4 ± 4.2 for girls, and 5.5 ± 4.5 for boys), red meat score (3.1 ± 4.5 for girls, and 2.2 ± 3.9 for boys), red meat consumption [74.9 (4.5; 132.4) for girls, and 92.8 (23.0;169.0) for boys], eggs consumption [0.0 (0.0; 0.0) for girls, and 0.0 (0.0; 0.0) for boys], and added sugars consumption [200.0 (0.0; 300.0) for girls, and 250.0 (0.0; 447.5) for boys].

Table 1. Characteristics of the participants

	Total *n=393*	*Girls* *n=193 (49.1%)*	*Boys* *n=200 (50.9%)*	*P-value*
Age (Years)[1]	8.8 ± 0.8	8.8 ± 0.8	8.8 ± 0.9	0.611
Parental education [n(%)] [a]				0.667
0-9 years	106 (34.0)	47 (32.4)	59 (35.3)	
10-12 years	106 (34.0)	53 (36.6)	53 (31.7)	
>12 years	100 (32.1)	45 (31.0)	55 (32.9)	

Table 1. Characteristics of the participants (continued)

	Total *n=393*	*Girls* *n=193 (49.1%)*	*Boys* *n=200 (50.9%)*	*P-value*
Sport activity [n(%)] [b]				0.054
Less than 2 times a week	185 (52.4)	97 (57.1)	88 (48.1)	
2-3 times a week	122 (34.6)	58 (34.1)	64 (35.0)	
4 or more times a week	46 (13.0)	15 (8.8)	31 (16.9)	
Nutritional supplements [n(%)] [c]				0.670
Yes	59 (16.7)	30 (17.6)	29 (15.8)	
No	295 (83.3)	140 (82.4)	155 (84.2)	
Diet				
Total WISH score[1]	59.1 ± 14,1	60.6 ± 14.2	57.6 ± 13.9	**0.031**
Healthy score [1]	46.0 ± 11.6	46.3 ± 11.4	45.6 ± 11.8	0.535
Less healthy score [1]	13.1 ± 7.8	14.3 ± 8.1	12.0 ± 7.4	**0.003**
Low environmental impact score [1]	26.7 ± 10.1	27.7 ± 10.3	25.8 ± 9.9	0.067
High environmental impact score [1]	32.4 ± 9.6	33.0 ± 9.9	31.8 ± 9.4	0.218
Total energy intake (kcal/day) [2]	2162 (1862;2471)	2063 (1733;2412)	2249 (1970;2580)	**<0.001**
BMI classification [n(%)]				
CDC				0.838
Underweight	11 (2.8)	6 (3.1)	5 (2.5)	
Normal Weight	273 (69.5)	130 (67.4)	143 (71.5)	
Overweight	64 (16.4)	33 (17.1)	31 (15.5)	
Obese	45 (11.5)	24 (12.4)	21 (10.5)	
WHO				0.313
Underweight	4 (1.0)	3 (1.6)	1 (0.5)	
Normal Weight	257 (65.4)	119 (61.7)	138 (69.0)	
Overweight	78 (19.8)	44 (22.8)	34 (17.0)	
Obese	54 (13.7)	27 (14.0)	27 (13.5)	
Body fat (%) [d]				0.548
Underfat	5 (1.3)	1 (0.5)	4 (2.0)	
Normal	257 (66.6)	129 (68.6)	128 (64.6)	
Overfat	67 (17.4)	32 (17.0)	35 (17.7)	
Obese	57 (14.8)	26 (13.8)	31 (15.7)	

Statistically significant differences between sexes are in bold; [1]Mean ± SD; [2]Median (25th percentile;75th percentile); [a]n= 312; [b]n= 353; [c]n= 354; [d]n= 386; Total WISH score: total world index for sustainability and health score; BMI: body mass index; CDC: US Centers for Disease Control and Prevention; WHO: World Health Organization.

There was a positive and significant association between parental education and total WISH score (unadjusted model, β= 2.76, 95% CI=0.83; 4.69). After adjustment for sex, age, energy intake, sport activity, and school, the association remained significant (adjusted model, β=2.13, 95% CI=0.14; 4.13) **(Table 2)**. No significant associations were found between total WISH score and BMI, for all the classifications studied **(Table 2)**.

Table 2. Association between parental education, BMI, and total WISH score

		Total WISH Score		
		β	95% CI	*P-value*
Parental education	Unadjusted	2.76	(0.83; 4.69)	**0.005**
	Adjusted †	2.13	(0.14; 4.13)	**0.036**
BMI				
CDC	Unadjusted	-1.69	(-4.81; 1.44)	0.290
	Adjusted ‡	-2.97	(-6.56; 0.63)	0.106
WHO	Unadjusted	-0.94	(-3.91; 2.03)	0.534
	Adjusted ‡	-2.40	(-5.86; 1.07)	0.174
Body fat (%)	Unadjusted	-0.17	(-3.20; 2.86)	0.913
	Adjusted ‡	-1.21	(-4.75; 2.33)	0.503

Significant associations in bold; Total WISH score: total world index for sustainability and health score; BMI: body mass index; CDC: US Centers for Disease Control and Prevention; WHO: World Health Organization; %BF: body fat percentage; † adjusted for sex, age, energy intake, sport activity, and school; ‡ adjusted for sex, age, energy intake, nutritional supplement intake in the last year, sport activity, and parental education.

Parental education had a positive and significant association with less healthy score (unadjusted model, β= 1.36, 95% CI=0.32; 2.40) and low environmental impact score (unadjusted model, ß= 1.62, 95% CI=0.2; 3.02). After adjustment, the associations remained significant (less healthy score: adjusted model for sex, age, and energy intake, ß=1.27, 95% CI=0.26; 2.27) (low environmental impact score: adjusted model for sex, age, energy intake, sport activity, and school, ß=1.72, 95% CI=0.26; 3.18) **(Table 3)**. No significant associations were found between sub-scores and BMI, for all the classifications studied **(Table 3)**.

Table 3. Association between parental education, BMI and sub-scores of WISH

		Healthy score		
		ß	95% CI	*P-value*
Parental education	Unadjusted	1.40	(-0.25; 3.04)	0.096
	Adjusted †	1.27	(-0.38; 2.93)	0.131
BMI				
CDC	Unadjusted	-2.23	(-4.79; 0.33)	0.088
	Adjusted ‡	-3.07	(-6.17; 0.02)	0.052
WHO	Unadjusted	-1.75	(-4.18; 0.69)	0.159
	Adjusted ‡	-2.45	(-5.42; 0.53)	0.107
Body fat (%)	Unadjusted	-1.27	(-3.75; 1.21)	0.313
	Adjusted ‡	-2.17	(-5.20; 0.87)	0.161
			Less healthy score	
Parental Education	Unadjusted	1.36	(0.32; 2.40)	**0.011**
	Adjusted †	1.27	(0.26; 2.27)	**0.014**
BMI				
CDC	Unadjusted	0.55	(-1.19; 2.28)	0.536
	Adjusted ‡	0.54	(-1.33; 2.41)	0.568
WHO	Unadjusted	0.81	(-0.84; 2.45)	0.336
	Adjusted ‡	0.54	(-1.25; 2.33)	0.552
Body fat (%)	Unadjusted	1.11	(-0.58; 2.79)	0.198
	Adjusted ‡	1.29	(-0.55; 3.13)	0.168

Table 3. Association between parental education, BMI and sub-scores of WISH (continued)

		Low environmental impact score		
		ß	95% CI	*P-value*
Parental Education	Unadjusted	1.62	(0.22; 3.02)	**0.023**
	Adjusted *	1.72	(0.26; 3.18)	**0.021**
BMI				
CDC	Unadjusted	-0.28	(-2.53; 1.97)	0.809
	Adjusted **	-1.29	(-3.94; 1.35)	0.337
WHO	Unadjusted	-0.45	(-2.58; 1.67)	0.681
	Adjusted **	-1.20	(-3.75; 1.35)	0.354
Body fat (%)	Unadjusted	0.38	(-1.81; 2.57)	0.731
	Adjusted **	0.41	(-2.22; 3.03)	0.760
		High environmental impact score		
Parental Education	Unadjusted	1.14	(-0.18; 2.45)	0.091
	Adjusted ₣	0.56	(-0.72; 1.83)	0.390
BMI				
CDC	Unadjusted	-1.41	(-3.54; 0.72)	0.194
	Adjusted ¶	-1.71	(-4.03; 0.61)	0.148
WHO	Unadjusted	-0.49	(-2.52; 1.53)	0.631
	Adjusted ¶	-1.22	(-3.45; 1.02)	0.286
Body fat (%)	Unadjusted	-0.55	(-2.61; 1.51)	0.599
	Adjusted ¶	-1.43	(-3.71; 0.84)	0.215

Significant associations in bold; BMI: body mass index; CDC: US Centers for Disease Control and Prevention; WHO: World Health Organization; %BF: body fat percentage; † adjusted for sex, age, and energy intake; ‡ adjusted for sex, age, energy intake, nutritional supplement intake in the last year, and parental education; * adjusted for sex, age, energy intake, sport activity, and school; ** adjusted for sex, age, energy intake, nutritional supplement intake in the last year, sport activity, school, and parental education; ₣ adjusted for sex, age, energy intake, and sport activity; ¶ adjusted for sex, age, energy intake, nutritional supplement intake in the last year, sport activity, and parental education.

Discussion

This study demonstrates that higher parental education level was associated with healthier sustainable diets among school-aged children. These associations remained robust after adjustments for potentially relevant confounders, including sex, age, energy intake, sport activity, and school. These results suggest that parental education might be an important determinant for children to attain more sustainable and healthier diets, in line with the fourth goal of the Sustainable Development Goals: quality education [22].

The results from this study demonstrated an association between the total WISH score as well as less healthy score, and low environmental impact score with parental education. Accordingly, other potentially sustainable and healthy dietary patterns, such as the New Nordic Diet, were studied and results showed that mothers of children with higher adherence to this dietary pattern were more likely to have more completed years of education [11]. Parental education has been considered one of the most used indicators of socioeconomic position [23], while lower socioeconomic position is associated with poorer dietary behaviours [24]. The existent link between higher parental education and higher nutritional knowledge and literacy (i.e., knowledge on the intake recommendations and healthier behaviours) [25, 26], resulting in a higher diet quality [27], could possibly be a mechanism to explain the findings of the present study on the association between parental education and children's sustainable healthy diets. Additionally, household finance could also explain this association, given its contribute as an extra risk factor for unhealthy dietary patterns, among parental education level[28]. Further research on the relationship between parental education and diet sustainability is still needed.

Contrarily to what was expected, this study did not find associations between body fat composition and BMI (even after considering BMI categories, according to different definitions) and healthy diets from sustainable food systems. Similarly, the New Nordic Diet showed that childhood adherence at six and 18 months and three and seven years was not associated with overweight at eight years old [11]. On the other hand, another study developing the EAT-Lancet diet score, also based on the EAT-Lancet reference diet [9], found a significant association of about 1.4 kg/m^2 lower BMI for higher EAT-Lancet diet scores (p-value<0.05) in the European Prospective Investigation into Cancer and Nutrition Oxford Study population [29]. These differences could be explained by the use of divergent methodologic procedures, including the use of different indexes, and the diet assessment and the index were applied in a different age ranged population [29].

The EAT-Lancet Commission highlights the need to consider local and regional realities, to achieve healthy diets from sustainable food systems. The framework of quantitate scientific targets set by the Commission is described as universal, with a high potential of local adaptation [9]. In Portugal, Mediterranean and Atlantic diets are known to be traditionally representative of the region's diet pattern [30, 31]. The Mediterranean diet was shown to be in synergy with the EAT-Lancet Commission goals [32] and also inversely associated with childhood obesity from two to nine years old, in Europe [33]. Atlantic diet, a more recent food pattern concept, and characteristic of northern Portugal and Galicia [34], has scored similarly to the Mediterranean Diet in carbon footprint and nutritional quality, being considered another example of a sustainable and healthy diet [35, 36]. Accordingly, this study sustains the need of safeguarding and promoting

Portuguese cultural food patterns [37], as the adherence has been tendentially decreasing [30, 32], shifting towards others non-beneficial diet patterns [31].

This study has some limitations. Firstly, the cross-sectional design does not allow the establishment of causal relationships between total WISH score or sub-scores with BMI, nor with parental education. Secondly, the whole grains group was modified to include all grains, which can affect score results. This modification was made giving the diet characteristics of the population in this study and some difficulties in discriminating whole grain foods from non-whole grains, when applying the 24-hour diet recall to children. Thirdly, a single 24-hour recall questionnaire was used, whereas multiple recalls are generally preferred for reporting individual intake [38]. However, it may be a good option to estimate children's food intake because of the greater ease in recording their food intake, without committing report errors [39]. Nutritionists administrated the questionnaire with a photograph atlas in resource, to diminish recall bias and indirect reporting [40]. Fourthly, parental education was the only variable used as proxy measure to socioeconomic status, which can be considered incomplete according to the present literature [41, 42]. Furthermore, research should be developed to study other associations. Lastly, the existence of residual confounding or other unmeasured confounders that may have an influence on results cannot be ruled out [43]. Nevertheless, several confounders were considered.

This study also has important strengths. To our best knowledge, this is the first work to applicate WISH in a different population than the original article, particularly in children, whereas the assessment of healthy and sustainable diets is still precocious. It is also the first study, to our knowledge, to study outcomes with WISH, helping possible future adjustments that this index might undergo [8]. Furthermore, since the adequacy of BMI assessment criteria in children is still under discussion [44, 45], two BMI classifications and the %BF were considered to avoid misclassifications. The CDC classification was used for its better agreement with all the other classifications for the study population (data not shown), the WHO classification was selected for its better ability to detect overweight and obesity in Portuguese school aged children [46], and the %BF was used for its reliability in distinguishing between lean and fat mass, an advantage compared to BMI [47].

Conclusion

In conclusion, the presented study suggests that parental education is associated with a planetary healthy diet, highlighting the importance of education in a healthy sustainable development. This study did not find associations for body fat composition and BMI with healthy sustainable dietary patterns.

Acknowledgements

The authors gratefully acknowledge the funding by Fundação para a Ciência e Tecnologia through the Project NORTE-01- 0145-FEDER-000010—Health, Comfort and Energy in the Built Environment (HEBE), cofinanced by Programa Operacional Regional do Norte (NORTE2020), through Fundo Europeu de Desenvolvimento Regional (FEDER), and the EXALAR 21 project financed by FEDER/FNR and by Fundação para a Ciência e Tecnologia (EXALAR 21 02/SAICT/2017—Project No. 30193).

References

1. Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza Dias BF, et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. The Lancet. 2015; 386(10007):1973-2028.
2. Marshman J, Blay-Palmer A, Landman K. Anthropocene Crisis: Climate Change, Pollinators, and Food Security. Environments. 2019; 6(2):22.
3. Tilman D, Clark M. Global diets link environmental sustainability and human health. Nature. 2014; 515(7528):518-22.
4. World Health Organization. Healthy and Sustainable Diets - Key workstreams in the WHO European Region - Factsheet (2021). 2021.
5. Hallström E, Davis J, Woodhouse A, Sonesson U. Using dietary quality scores to assess sustainability of food products and human diets: A systematic review. Ecological Indicators. 2018; 93:219-30.
6. Jones AD, Hoey L, Blesh J, Miller L, Green A, Shapiro LF. A Systematic Review of the Measurement of Sustainable Diets. Adv Nutr. 2016; 7(4):641-64.
7. Mertens E, Van't Veer P, Hiddink GJ, Steijns JM, Kuijsten A. Operationalising the health aspects of sustainable diets: a review. Public Health Nutr. 2017; 20(4):739-57.
8. Trijsburg L, Talsma EF, Crispim SP, Garrett J, Kennedy G, de Vries JHM, et al. Method for the Development of WISH, a Globally Applicable Index for Healthy Diets from Sustainable Food Systems. Nutrients. 2021; 13(1):93.
9. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019; 393(10170):447-92.
10. World Health Organization WHO European Childhood Obesity Surveillance Initiative (COSI): report on the fourth round of data collection, 2015–2017. Copenhagen: WHO Regional Office for Europe; 2021.
11. Agnihotri N, Øverby NC, Bere E, Wills AK, Brantsæter AL, Hillesund ER. Childhood adherence to a potentially healthy and sustainable Nordic diet and later overweight: The Norwegian Mother, Father and Child Cohort Study (MoBa). Maternal & Child Nutrition. 2021; 17(2):e13101.
12. Walker SP, Wachs TD, Grantham-McGregor S, Black MM, Nelson CA, Huffman SL, et al. Inequality in early childhood: risk and protective factors for early child development. The Lancet. 2011; 378(9799):1325-38.
13. Alderman H, Headey DD. How Important is Parental Education for Child Nutrition? World Dev. 2017; 94:448-64.
14. Fang SC. The Influence Of Parental Education On The Environmental Education Of Pre-Schoolers: A Case Study Of Self-Designed Picture Book. Journal of Baltic Science Education. 2018; 17(2):187-99.
15. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, et al. CDC growth charts: United States advance data from vital and health statistics, no. 314. Hyattsville, MD: National Center for Health Statistics. 2000
16. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007; 85(9):660-7.

17. McCarthy HD, Cole TJ, Fry T, Jebb SA, Prentice AM. Body fat reference curves for children. Int J Obes (Lond). 2006; 30(4):598-602.
18. Walker JL, Ardouin S, Burrows T. The validity of dietary assessment methods to accurately measure energy intake in children and adolescents who are overweight or obese: a systematic review. European Journal of Clinical Nutrition. 2018; 72(2):185-97.
19. Carla Lopes DT, Andreia Oliveira, Milton Severo, Violeta Alarcão, Sofia, Guiomar JM, Pedro Teixeira, Elisabete Ramos, Sara Rodrigues, Sofia Vilela, Luísa, Oliveira PN, Simão Soares, Lene Frost Andersen; Consórcio IAN-AF. Inquérito Alimentar Nacional e de Atividade Física, IAN-AF 2015-2016: Relatório metodológico. 2017. Disponível m: www.ian-af.up.pt. .
20. Instituto Nacional de Saúde Dr. Ricardo Jorge. Tabela da Composição de Alimentos. 4.1 ed.; 2019.
21. Seconda L, Egnell M, Julia C, Touvier M, Hercberg S, Pointereau P, et al. Association between sustainable dietary patterns and body weight, overweight, and obesity risk in the NutriNet-Santé prospective cohort. The American Journal of Clinical Nutrition. 2019; 112(1):138-49.
22. United Nations. Sustainable development goals. [citado em: 13 jul 2021]. 4 Quality Education. Disponível em: https://www.un.org/sustainabledevelopment/education/.
23. Zarnowiecki DM, Dollman J, Parletta N. Associations between predictors of children's dietary intake and socioeconomic position: a systematic review of the literature. Obes Rev. 2014; 15(5):375-91.
24. Mekonnen T, Havdal HH, Lien N, O'Halloran SA, Arah OA, Papadopoulou E, et al. Mediators of socioeconomic inequalities in dietary behaviours among youth: A systematic review. Obesity Reviews. 2020; 21(7):e13016.
25. Lehto E, Ray C, te Velde S, Petrova S, Duleva V, Krawinkel M, et al. Mediation of parental educational level on fruit and vegetable intake among schoolchildren in ten European countries. Public Health Nutrition. 2015; 18(1):89-99.
26. Vereecken C, Maes L. Young children's dietary habits and associations with the mothers' nutritional knowledge and attitudes. Appetite. 2010; 54(1):44-51.
27. Beydoun MA, Wang Y. Do nutrition knowledge and beliefs modify the association of socio-economic factors and diet quality among US adults? Prev Med. 2008; 46(2):145-53.
28. Rashid V, Weijs PJM, Engberink MF, Verhoeff AP, Nicolaou M. Beyond maternal education: Socio-economic inequalities in children's diet in the ABCD cohort. PLoS One. 2020; 15(10):e0240423.
29. Knuppel A, Papier K, Key TJ, Travis RC. EAT-Lancet score and major health outcomes: the EPIC-Oxford study. Lancet. 2019; 394(10194):213-14.
30. Esteve-Llorens X, Dias AC, Moreira MT, Feijoo G, González-García S. Evaluating the Portuguese diet in the pursuit of a lower carbon and healthier consumption pattern. Climatic Change. 2020; 162(4):2397-409.
31. Almeida M, Oliveira A. Padrão Alimentar Mediterrânico e Atlântico – uma abordagem às suas características-chave e efeitos na saúde. Acta Portuguesa de Nutrição. 2017; 11:22-28.
32. Real H, Dias RR, Graça P. Mediterranean Diet conceptual model and future trends of its use in Portugal. Health Promot Int. 2021; 36(2):548-60.
33. Tognon G, Hebestreit A, Lanfer A, Moreno LA, Pala V, Siani A, et al. Mediterranean diet, overweight and body composition in children from eight

European countries: cross-sectional and prospective results from the IDEFICS study. Nutr Metab Cardiovasc Dis. 2014; 24(2):205-13.
34. Velho VM, Pinheiro R, Rodrigues AS. The Atlantic Diet – Origin and features. International Journal of Food Studies. 2016; 5:106-19.
35. Esteve-Llorens X, Darriba C, Moreira MT, Feijoo G, González-García S. Towards an environmentally sustainable and healthy Atlantic dietary pattern: Life cycle carbon footprint and nutritional quality. Science of The Total Environment. 2019; 646:704-15.
36. International Center for Advanced Mediterranean Agronomic Studies/Food and Agriculture Organization of the United Nations. Mediterranean food consumption patterns: diet, environment, society,
economy and health.
. Expo Milan, Rome; 2015.
37. Despacho, nº 1939/2019. (2019) Determina a criação do Conselho Dinamizador para a Salvaguarda e Promoção da Dieta Mediterrânica (CDDM). Diário da República : II Série([citado em: 10 jul. 2021]. Disponível em: https://dre.pt/application/conteudo/120272961.
38. Shim J-S, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiol Health. 2014; 36:e2014009-e09.
39. Ortega RM, Pérez-Rodrigo C, López-Sobaler AM. Dietary assessment methods: dietary records. Nutr Hosp. 2015; 31 Suppl 3:38-45.
40. Biró G, Hulshof KF, Ovesen L, Amorim Cruz JA. Selection of methodology to assess food intake. Eur J Clin Nutr. 2002; 56 Suppl 2:S25-32.
41. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006; 60(1):7-12.
42. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 2). J Epidemiol Community Health. 2006; 60(2):95-101.
43. Data MITC, Danziger J, Zimolzak AJ. Residual Confounding Lurking in Big Data: A Source of Error. In: Secondary Analysis of Electronic Health Records. Cham (CH): Springer
Copyright 2016, The Author(s). 2016. p. 71-8.
44. Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. Obes Rev. 2004; 5 Suppl 1:4-104.
45. Daniels SR. The consequences of childhood overweight and obesity. Future Child. 2006; 16(1):47-67.
46. Fresán U, Martínez-González MA, Segovia-Siapco G, Sabaté J, Bes-Rastrollo M. A three-dimensional dietary index (nutritional quality, environment and price) and reduced mortality: The "Seguimiento Universidad de Navarra" cohort. Prev Med. 2020; 137:106124.
47. Aggarwal B, Jain V. Obesity in Children: Definition, Etiology and Approach. Indian J Pediatr. 2018; 85(6):463-71.

Supplementary material

Supplementary material

Supplementary Table 1. Sub-scores calculation

Score	Calculation
Healthy score	The sum of the eight protective food groups scores - whole grains, vegetables, fruits, dairy, fish, legumes, nuts, unsaturated oils - and two neutral food groups scores, namely eggs, and chicken and other poultry.
Less healthy score	The sum of the three limiting food groups scores: red meat, saturated oils, and added sugars.
Low environmental impact score	The sum of the six low environmental impact food groups scores: grains, vegetables, fruits, legumes, unsaturated oils, and added sugars.
High environmental impact score	The sum of the four medium scores – dairy, eggs, chicken and other poultry, and nuts - and three high environmental impact food groups scores, namely red meat, fish, saturated oils.

Supplementary Table 2. Consumption and score of WISH food groups

Variables	Total n=393	Girls n=193 (49.1%)	Boys n=200 (50.9%)	*P-value*
Grains				
Consumption[1]	271.8 ± 120.4	262.4 ± 119.5	280.9 ± 120.8	0.128
Score[2]	10.0 (10.0; 10.0)	10.0 (10.0; 10.0)	10.0 (10.0; 10.0)	0.540
Vegetables				
Consumption[1]	403.1 ± 304.2	402.6 ± 300.7	403.5 ± 308.2	0.976
Score[1]	6.7 ± 4.6	6.8 ± 4.5	6.6 ± 4.7	0.625
Fruits				
Consumption[2]	174.0 (84.0;323.0)	187.0 (100.0; 323.5)	174.0 (58.0; 315.5)	0.161
Score[1]	5.9 ± 4.4	6.4 ± 4.2	5.5 ± 4.5	**0.036**
Dairy				
Consumption[1]	508.9 ± 271.7	497.5 ± 275.2	519.8 ± 268.5	0.416
Score[1]	4.6 ± 4.8	4.6 ± 4.8	4.5 ± 4.8	0.825
Red Meat				
Consumption[2]	82.5 (20.0; 147.4)	74.9 (4.5; 132.4)	92.8 (23.0; 69.0)	**0.028**
Score[1]	2.6 ± 4.2	3.1 ± 4.5	2.2 ± 3.9	**0.046**
Fish				
Consumption[2]	0.0 (0.0;100.0)	0.0 (0.0;100.0)	0.0 (0.0;100.0)	0.650
Score[2]	10.0 (10.0;10.0)	10.0 (10.0;10.0)	10.0 (10.0;10.0)	0.573
Eggs				
Consumption[2]	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.0 (0.0;0.0)	**0.036**
Score[2]	10.0 (10.0;10.0)	10.0 (10.0;10.0)	10.0 (10.0;10.0)	0.139
Chicken and other Poultry				
Consumption[2]	0.0 (0.0;99.0)	0.0 (0.0;99.0)	0.0 (0.0;99.0)	0.541
Score[1]	6.0 ± 4.8	5.9 ± 4.8	6.2 ± 4.8	0.435
Legumes				
Consumption[2]	0.0 (0.0;4.1)	0.0 (0.0:10.0)	0.0 (0.0;0.0)	0.573
Score[2]	0.0 (0.0;0.5)	0.0 (0.0;1.3)	0.0 (0.0;0.0)	0.568

Supplementary Table 2. Consumption and score of WISH food groups (continued)

Variables	Total n=393	Girls n=193 (49.1%)	Boys n=200 (50.9%)	*P-value*
Nuts				
Consumption[2]	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.189
Score[2]	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.981
Unsaturated Oils				
Consumption[2]	8.1 (2.7;11.2)	8.1 (2.7;11.4)	8.1 (2.7;11.2)	0.847
Score[2]	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.0 (0.0;0.0)	0.081
Saturated Oils				
Consumption[2]	5.9 (3.0;12.0)	5.4 (2.2;11.5)	6.6 (4.0;12.4)	0.187
Score[1]	7.4 ± 4.4	7.7 ± 4.2	7.1 ± 4.6	0.131
Added Suggars				
Consumption[2]	210.0 (0.0;400.0)	200.0 (0.0;300.0)	250.0 (0.0;447.5)	**<0.001**
Score[1]	3.1 ± 4.6	3.5 ± 4.8	2.7 ± 4.5	0.079

Statistically significant differences between sexes are in bold; [1]Mean ± SD; [2]Median (25th percentile;75th percentile). Score: individual punctuation, from zero (0) to ten (10), according to consumption adherence to the EAT-Lancet recommendations[(9)]