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How do the home food environment, parenting practices, health beliefs, and screen time affect the weight status of European children? The Feel4Diabetes-Study

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ABSTRACT

Background: Childhood obesity remains one of the most significant challenges in public health globally.
Objective: The aim of this study was to assess the association between home food availability, parenting practices, health beliefs, screen time, and childhood overweight/obesity.
Methods: This was a cross-sectional analysis of 12 041 parent–child dyads from six European countries. Details on the home food environment, parenting practices, health beliefs, and digital devices were collected by questionnaires.
Results: Permissive parenting or rewarding children with screen time at a frequency of *rarely/never* and parents disagreeing with the statement "I believe that people have little power to prevent disease" were negatively associated with childhood overweight/obesity; whereas being "physically active with my child" *rarely/never* was positively associated. Regarding the home environment, the availability of fruit *rarely/never* was positively associated with childhood overweight/obesity, whereas the absence of digital devices in the child's room was negatively associated.
Conclusion: Findings from the present study suggested that future school- and community-based initiatives in Europe that aim to prevent childhood obesity should also target the home environment, parenting beliefs, and practices. Programs designed to educate, facilitate, and support parents to adopt a healthy and active lifestyle

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with their children would empower parents to be agents of good role models and are probably the most efficient ways forward to tackle the childhood obesity epidemic. Future longitudinal intervention studies are needed to confirm the long-term efficacy of positive parenting in reducing childhood overweight/obesity.

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Introduction

Childhood obesity remains one of the most significant global public health challenges. Secular trends from population-based studies reveal that the prevalence of childhood obesity has accelerated at an alarming rate, particularly in East and South Asia and plateaued in Northwest Europe and high-income English-speaking countries, although at high levels [1]. Recent estimates document that obesity prevalence in school children and adolescents has increased from 11 million in 1975 to 124 million in 2016 with 216 million classified as overweight [1]. Along those same lines, the latest data from the World Health Organization's (WHO) European Obesity Surveillance Initiative (COSI) study (2015–2017), which measured trends in overweight and obesity from 250 000 primary school children residing in 36 European countries reported that overall, the prevalence of overweight in 6- to 9-y-olds was 29% in boys and 27% in girls, whereas the prevalence of obesity was 13% and 9%, respectively [2]. Notably, the highest rate of childhood overweight and obesity predominated in the Mediterranean countries of Cyprus, Greece, Italy, and Spain, where >40% of boys and girls were classified as overweight, and 19% to 24% of boys and 14% to 19% of girls obese [2].

With the failure of governments to address the severity of the childhood obesity pandemic, it is anticipated that by 2030 >250 million children will develop overweight/obesity globally [3]. These predictions are significant because compared with normal weight peers, overweight or obesity in children causes health complications throughout the life cycle including physical, social, and psychological comorbidities [4]. Furthermore, overweight/obesity is associated with depression, anxiety, negative body image, low self-esteem, increased likelihood of social discrimination and bullying, poor academic performance, school absenteeism, and low quality of life [4,5]. Another growing concern is the emergence of adult-onset diseases such as metabolic disorders, cardiovascular disease, hypertension, hyperlipidemia, hepatic steatosis, gastroesophageal reflux, orthopedic problems, type 2 diabetes, as well as asthma, eating disorders, and sleep apnea, which are consequences of excess weight in children [4–11].

There is strong evidence that obesity originates early in childhood and tracks into adulthood [12]. Givcn that this condition is a major risk factor for poor health, premature death, and disability in later life [13,14], preventing and reversing excess weight during childhood will have direct benefits on overall well-being and good health throughout the life span. Obesity has been described as a multifactorial disease caused by the complex interplay of genetic, environmental, and lifestyle factors. Over the past 3 decades, lack of physical activity, increased sedentariness, the decline of nutritious home-cooked meals, large portion sizes leading to increased energy intake, along with the high-caloric density and *trans*-fat content of convenient meals and fast food can only partly explain the childhood obesity epidemic [4]. Indisputably, the home food environment is the most influential setting when it comes to molding children's dietary behaviors facilitated by food availability and accessibility, parental role modeling of both healthy and unhealthy dietary habits as well as parenting skills and beliefs surrounding a healthy lifestyle [15]. Therefore, parenting approaches not only will have a profound effect on children's dietary habits but on their physical development and weight trajectories as well.

Regarding previous interventions, behavioral change in individuals or groups including dietary modifications and increased physical activity has been the cornerstone of weight management in children [16]. However, the continuing increase in childhood obesity signifies the failure of this approach in sustaining behavioral change, thereby suggesting that the correct approach has not yet been targeted. Additionally, there is ample research on the relation between the home food environment, parenting skills, and children's eating patterns, but there is a paucity of studies focusing on childhood obesity in the European Union [17]. Furthermore, the use of digital technology has become part of everyday living, however, the influence of such devices on overweight status in children remains unknown, to our knowledge.

Therefore, this study aimed to investigate multiple aspects of the home environment encompassing food availability, parenting practices, parents' health beliefs, and digital technology in association with childhood overweight and obesity in European residents. The overarching hypothesis is that there is an association between the home environment, parenting practices, health beliefs, use of digital devices, and European children's weight status. Improved understanding of the factors driving children's weight status will guide future research, interventions, and policy development.

Methods

Sampling and respondents

This was a cross-sectional analysis of baseline data of all families participating in the international population cohort, the Feel4Diabetes-Study (Families across Europe following a healthy Lifestyle 4 Diabetes prevention) conducted during 2016–2018. The parent study was a school- and community-based intervention promoting a healthy lifestyle and preventing type 2 diabetes that targeted vulnerable families across six European countries (Belgium, Finland, Greece, Hungary, Bulgaria, and Spain). The scope of this intervention was to develop a social and physical environment at home and school to support children and their families in adopting a healthy and active lifestyle. The Feel4Diabetes-Study was a cluster-randomized design study that consisted of two components: all families and high-diabetes risk families. The sample was selected from provinces of the six European countries, following a multistage, stratified sampling design. Elementary schools were randomly selected and recruited within each area. A comprehensive account of the study design, development, and sampling procedure is available in a previous publication and only details relevant to this substudy are described elsewhere [18]. In brief, the first stage of the Feel4Diabetes-Study involving all families was delivered by teachers in the school setting and included 12 041 families and at least one child from each family attending grades 1 to 3 of elementary school. However, to avoid duplication of parental information, one child per family was randomly selected. In all centers, data was collected using validated standardized questionnaires [19] self-reported by parents/or guardians. The questionnaires were administered by the teachers and research assistants at the school site.

Ethics

This study was abided by the guidelines laid down in the Declaration of Helsinki and all procedures involving humans were approved by the human ethics committees of all the tertiary institutions of the six European countries. Before the commencement of this study, an information letter describing the study objectives and requirements was distributed to all families, and written informed consent was obtained from all parents/or legal guardians interested in participating.

Measurements

Anthropometric indices

Basic anthropometric assessments were performed by trained personnel in all centers using the same protocol and equipment. A portable upright stadiometer (SECA 217) and digital scales (SECA 813) were used to measure children's height in the Frankfort position and weight to the nearest 0.1 cm and 0.1 kg, respectively, without shoes and in light clothing. Body mass index (BMI) was then calculated by weight (kg)/ height^2 (m^2) and classified into normal, overweight, and obese groups, applying the International Obesity Task Force (IOTF) sex–age-specific cut-off points, which are based on adult cutoff values for overweight (BMI 25 kg/m^2) and obesity (30 kg/m^2) at age 18 y [20]. For this study, BMI groups were converted from three to two categories (normal weight versus overweight/obesity) by combining data on overweight and obesity to form one group.

Physical activity

Weekly physical activity in children was measured qualitatively by the following question:

On how many days during the last week was your child physically active for a total of ≥1 h daily?

Possible responses were none, 1 d, 2 d, 3 d, 4 d, or 5 d. Data were recoded to two categories <3 d and ≥3 d/wk, where regular physical activity was 1 h of physical activity ≥3 d/wk.

Home environment

Details of the home food environment, parenting practices, and health beliefs, and the presence of digital devices in children's rooms were derived using validated questionnaires [19].

Home food availability of specific foods was evaluated by questioning respondents

On a weekly basis, how often are the following foods (fruits, vegetables, sweets, and salty snacks) available at your home?

The type of foods belonging to sweets and salty snacks were indicated in questionnaires. Examples of sweets were biscuits, ice cream, cakes, and pastries, whereas of salty snacks were chips and savory pastries. Five possible response options were available: *always, often, sometimes, rarely,* or *never*. For analytical purposes data for *sometimes* was excluded from the analysis, and the remaining four options were recoded into two categories *always/often* and *rarely/never*.

Parenting practices

Similarly, parenting practices were evaluated by nine questions.

On a weekly basis, how often do you do the following?

1. Consume fresh fruit with your child?
2. Be physically active with your child?
3. Watch TV together with your child?
4. Allow your child to eat sweets and /or salty snacks whenever he/she asks for them?
5. Allow your child to watch TV or DVD when he/she wants?
6. Allow your child to use the computer, mobile, or tablet when he or she wants?
7. Reward your child by allowing him/her to watch TV/DVD or use the computer, mobile, or tablet?
8. Reward your child with sweets, salty snacks (e.g., potato chips), or fast food?
9. Reward your child by being physically active together with him/her or by taking him/her to the playground or to the park?'

Responses were recoded from four choices *very often, often, rarely, never*to the binary outcome of *very often/often* versus *rarely/never*.

Health beliefs

Opinions of parents/guardians regarding health beliefs were assessed with three questions:

We would like to know what your opinion is on each of the following questions.

1. I believe that my health and well-being are determined by my destiny.
2. I believe that people have little power on preventing diseases.
3. I choose to eat the food that I like without thinking too much about it.'

Response choices ranged from 'strongly disagree, disagree, neither agree nor disagree, or agree to strongly agree, which were dichotomized to strongly agree/ agree versus strongly disagree/disagree, excluding data for neither agree nor disagree.

Digital devices in children's room

The presence of digital devices TV, DVD player, game consoles, computer, tablet, or a smartphone in children's room was evaluated by the question.

Are the following devices available in your child's room?

Respondents ticked either *Yes* or *No*.

Maternal education

The socioeconomic status (SES) of families was represented by the mother's educational level. Exploring the link between maternal education and children's overweight status might be beneficial in the management of pediatric obesity. Maternal education attainment was assessed by a question that measured the number of years of completed education. which was based on a 6-item Likert scale: ≤6, 7–9, 10–12, 13–14, 15–16, and >16 y. Response options were recoded to dichotomous outcome variables ≤12 y and >12 y of education. Therefore, in this paper "low SES" refers to mothers with ≤12 y of educational attainment.

Statistical analysis

SPSS version 27 (IBM, Armonk, NY, USA) was used for all statistical analyses. Continuous variables were assessed for normality by applying the Kolmogorov–Smirnov test and visually via the histogram plot. Normally distributed variables were expressed as means and SD and in the case of skewness, as frequencies (n) and percentages. Group differences were assessed using Pearson's χ^2 test or Kruskal–Wallis non-parametric test. The binary logistic regression model was applied to investigate associations between the home food environment, parenting practices, health beliefs, and digital devices (as the independent variables) and children's overweight/obesity (dependent). For each independent variable, a separate regression analysis was performed, and measures of associations were estimated by computing crude odds ratio (OR) with 95% confidence intervals (CI). Furthermore, multivariate analysis was conducted adjusting for children's age, sex, regular physical activity, maternal education, and country of residence. All reported *P* values were based on a two-sided test and $P < 0.05$ was considered statistically significant.

Results

Questionnaires were completed by 11 491 parents (10 267 mothers/stepmothers, 1224 fathers/stepfathers), response rate was 95.4 % (11 491/12 041).

The analysis included 12 041 children; about half were male (49.4% n = 5942) and children ranged from 5.36 to 12 y of age. Overall, 25.5% (n = 3068) of children had overweight/obesity (1408 boys: 45.9% versus 1660 girls: 54.1%; $P < 0.001$) and 85.5% (n = 9756) regularly exercised for1 h at least 3 d/wk (4916 boys: 50.4%, versus 4839 girls: 49.6%; $P < 0.001$).

Table 1 presents the population characteristics by country of residence. The table shows that there were country variations in the rate of overweight/obesity in children with the highest frequency noted in Greece at 36.5% (832 of 2282) and the lowest in Belgium at 14.2% (253 of 1780; $P < 0.001$). The prevalence of overweight/obesity in girls was highest in Greece at 38% (453 of 1191) and lowest in Belgium at 17.2% (153 of 891; $P < 0.001$).

Regarding tertiary education attainment, around 50% of mothers had >12 y of education in Greece and Hungary (55.7% and 48.9%, respectively) compared with the other European countries (Belgium: 78.1%; Finland: 90.6%; Bulgaria: 73.4%; and Spain: 95.1%; $P < 0.001$). Stratification of data according to the BMI group, revealed marked differences in the frequency of overweight/obesity in children in the low SES group, with the highest rate observed in Greece and Hungary at 46.1% and 48.5%, respectively.

Frequency of overweight/obesity in children in low SES families per country (data not shown) is shown here:

- Belgium 34.3% (80 of 233);
- Finland 11.7% (37 of 315);
- Greece 46.1% (367 of 796);
- Hungary 48.5% (224 of 642);
- Bulgaria 31.1% (219 of 705); and
- Spain 5.3% (16 of 309); $P < 0.001$.

Table 2 shows the comparisons of the home food environment, parenting practices, health beliefs, and digital devices in children's room per BMI category. Table 2 shows that there were significant

Table 1
Population characteristics by country of residence

	Country					
	Belgium (n = 1787)	Finland (n = 1504)	Greece (n = 2283)	Hungary (n = 1828)	Bulgaria (n = 2972)	Spain (n = 1667)
Characteristics						
Children, % (n)						
Sex						
Boy	49.92 (891/1785)	50.27 (756/1504)	47.83 (1092/2283)	47.76 (873/1828)	48.79 (1450/2972)	52.79 (880/1667)
Girl	50.08 (894/1785)	49.73 (748/1504)	52.17 (1191/2283)	52.24 (955/1828)	51.21 (1522/2972)	47.21 (787/1667)
Age, y, mean ± SD	7.96 ± 0.92	8.69 ± 0.94	7.79 ± 0.88	8.68 ± 1.02	8.31 ± 0.91	7.90 ± 0.95
BMI category, % (n)						
Normal weight	85.79 (1527/1780)	78.33 (1175/1500)	63.54 (1450/2282)	73.56 (1344/1827)	74.97 (2226/2969)	74.07 (1234/1666)
Overweight/obesity	14.21 (253/1780)	21.67 (325/1500)	36.46 (832/2282)	26.44 (483/1827)	25.03 (743/2969)	25.93 (432/1666)
Girls (Overweight/obesity)	17.17 (153/891)	22.62 (169/747)	38.04 (453/1191)	27.23 (260/955)	26.87 (409/1522)	27.45 (216/787)
Regular exercise (≥1 h/d)						
<3 d/wk	20.44 (359/1756)	4.82 (72/1494)	17.48 (388/2220)	7.48 (132/1764)	18.46 (531/2876)	13.70 (179/1307)
≥3 d/wk	79.56 (1397/1756)	95.18 (1422/1494)	82.52 (1832/2220)	92.52 (1632/1764)	81.54 (2345/2876)	86.30 (1128/1307)
Maternal						
Education, y, % (n)						
≤12	21.94 (373/1700)	9.42 (139/1475)	44.34 (971/2190)	51.13 (903/1766)	26.60 (755/2838)	4.89 (61/1247)
>12	78.06 (1327/1700)	90.58 (1336/1475)	55.66 (1219/2190)	48.87 (863/1766)	73.40 (2083/2838)	95.11 (1186/1247)

BMI, body mass index

differences between home food availability, parenting practices, health beliefs, and the presence of digital devices in children's rooms between the normal weight and overweight/obesity groups. It appears that the availability of fruit and vegetables *always/often* was higher in the normal weight group than in those with overweight/obesity. The same trend was observed for the availability of sweets and salty snacks at a frequency of *rarely/never,* being physically active with their child *very often/often*, along with permissive parenting practices such as "watching TV with your child" and "allowing and rewarding" by permitting the use of digital devices (computer, DVD, mobile, or tablet). With respect to health beliefs, a higher percentage of parents of the normal weight group responded that they *disagree/strongly disagree* with the statements: I believe that people have little power preventing diseases," "I choose to eat the food I like without thinking much about it" compared with the overweight/obesity group. Along the same lines, a higher percentage of parents of the normal weight group responded *no* to the presence of digital devices in the child's room compared with parents of the overweight/obesity group.

Table 3 shows the associations between the home food environment, parenting practices, health beliefs, digital devices, and child overweight/obesity.

In the crude regression analysis, home availability of fruit, vegetables, sweets, and salty snacks at a frequency of *rarely/never* compared with *always/often* were positively associated with overweight/obesity in children (fruit: OR, 1.70; 95% CI, 1.19–2.42; vegetables: OR, 1.52; 95% CI, 1.07–2.17; salty snacks: OR, 1.32; 95% CI, 1.18–1.47; sweets, OR; 95% CI, 1.18–1.59). Similarly, parenting practices such as "being physically active with my child" *rarely/never* was associated with increased odds of overweight/obesity compared with very *often/often* (OR, 1.46; 95% CI, 1.30–1.64). Contrastingly, "parents watching TV with their child" *rarely/never* and "allowing" or "rewarding" their "child by watching TV/DVD whenever he/she wants or computer/mobile/tablet use" at the same frequency were inversely associated with overweight/obesity than performing these practices at a frequency of *very often/often* (watching TV with child: OR, 0.88; 95% CI, 0.78–0.99); allow child to watch TV/DVD: OR, 0.89; 95% CI, 0.80–0.99); allow child to use computer/mobile/tablet: OR, 0.83; 95% CI, 0.75–0.93; reward by allowing to watch TV/DVD or use computer/mobile/ tablet: OR, 0.85; 95% CI, 0.75–0.97). Regarding health beliefs, parents responding that they *strongly disagree/disagree* to "I believe that people have little power in preventing diseases" and "I chose to eat the food that I like without thinking too much about it" were associated with decreased odds of overweight/obesity in their children (OR, 0.69; 95% CI, 0.61–0.78; OR, 0.79; 95% CI, 0.71–0.88, respectively) compared with those *strongly agreeing/agreeing*. In the same direction, parents responding *no* to the presence of digital devices in the child's room was also associated with decreased odds of childhood overweight/obesity compared with those who responded *yes* (TV: OR,0.69; 95% CI, 0.64–0.75; DVD: OR, 0.78; 95% CI, 0.70–0.88; play station: OR, 0.76; 95% CI, 0.66–0.87; computer: OR, 0.75; 95% CI, 0.68–0.83; tablet or smartphone: OR, 0.77; 95% CI, 0.70–0.83). After adjusting for children's age, sex, regular exercise, maternal education, and country of residence, statistical significance remained for all variables except for home availability of vegetables, "watch TV together with my child" and "I choose to eat the food that I like without thinking too much about it." Furthermore, for all variables regular exercise (1 h at least 3 d/wk) and mother's education level ≥12 y were associated with decreased odds of childhood overweight/obesity (data not shown).

Discussion

The present study aimed to uncover factors of the home environment that are linked to overweight/obesity in European children. Despite the stabilization of secular trends in childhood overweight and obesity in most European countries, the prevalence of this disorder remains high [21]. The findings of this school-based study portray the severity of pediatric overweight/obesity in Europe and the urgency for policymakers to address this problem. We identified that one in four European school children were affected by overweight/obesity according to the IOTF classification with a significantly higher prevalence in girls than in boys. Geographic variations were observed with a significantly higher prevalence of overweight and obesity in children residing in southern European countries surrounding the Mediterranean basin (specifically Greece and Spain) than in northern European areas. Along the same lines, the percentage of girls with overweight/obesity was two times higher in Greece than in Belgium. Our statistics are comparable to data from a recent meta-analysis of 28 European

Table 2
Differences in home food availability, parenting practices, health beliefs, and digital devices in children's room per BMI category for the total sample of European children

Variable	Frequency	BMI category		*P* value*
		Normal % (n)	Overweight/Obesity % (n)	
Home availability				
Fruits	*Always/Often*	98.93 (8054/8141)	98.20 (2672/2721)	**0.003**†
	Rarely/Never	1.07 (87/8141)	1.80 (49/2721)	
Vegetables	*Always/Often*	98.86 7969/8061	98.27 2617/2663	**0.020**†
	Rarely/Never	1.14 (92/8061)	1.73 (46/2663)	
Sweets	*Always/Often*	87.97 (5314/6041)	84.22 (1569/1863)	<**0.001**†
	Rarely/Never	12.03 (727/6041)	15.78 (294/1863)	
Salty snacks	*Always/Often*	50.88 (2856/5613)	44.01 (794/1804)	<**0.001**†
	Rarely/Never	49.12 (2757/5613)	55.99 (1010/1804)	
Parenting practices				
Consume fresh fruit with your child	*Very Often/Often*	85.06 (5214/6130)	83.36 (1698/2037)	0.065
	Rarely/Never	14.94 (916/6130)	16.64 (339/2037)	
Be physically active with your child	*Very Often/Often*	70.75 (3653/5163)	62.35 (1058/1697)	<**0.001**†
	Rarely/Never	29.25 (1510/5163)	37.65 (639/1697)	
Watch TV together with your child	*Very Often/Often*	67.42 (3211/4763)	70.12 (1178/1680)	**0.041**†
	Rarely/Never	32.58 (1552/4763)	29.88 (502/1680)	
Allow child to eat sweets/salty snacks whenever he/she asks for	*Very Often/Often*	34.63 (1775/5125)	35.31 (602/1705)	0.613
	Rarely/Never	65.37 (3350/5125)	64.69 (1103/1705)	
Allow your child to watch TV or DVD whenever he/she wants	*Very Often/Often*	48.08 (2451/5098)	51.01 (909/1782)	**0.033**†
	Rarely/Never	51.92 (2647/5098)	48.99 (873/1782)	
Allow your child to use the computer, mobile or tablet whenever he/she wants	*Very Often/Often*	39.04 (2146/5497)	43.41 (827/1905)	**0.001**†
	Rarely/Never	60.96 (3351/5497)	56.59 (1078/1905)	
Reward your child by allowing him/her to watch TV/DVD or use the computer, mobile or tablet	*Very Often/Often*	15.09 (949/6287)	17.27 (381/2206)	**0.016**†
	Rarely/Never	84.91 (5338/6287)	82.73 (1825/2206)	
Reward your child with sweets, salty snacks, or fast food	*Very Often/Often*	7.76 (521/6714)	7.52 (175/2328)	0.705
	Rarely/Never	92.24 (6193/6714)	92.48 (2153/2328)	
Reward your child by being physically active together or by taking him/her to the playground or park	*Very Often/Often*	62.73 (3161/5039)	63.04 (1134/1799)	0.819
	Rarely/Never	37.27 (1878/5039)	36.96 (665/1799)	
Health beliefs				
I believe that my health/well-being is determined by destiny	*Strongly Agree/Agree*	14.38 (931/6475)	15.80 (338/2139)	0.107
	Strongly Disagree/ Disagree	85.62 (5544/6475)	84.20 (1801/2139)	
I believe that people have little power preventing diseases	*Strongly Agree/Agree*	16.18 (1163/7186)	21.85 (505/2311)	<**0.001**†
	Strongly Disagree/Disagree	83.82 (6023/7186)	78.15 (1806/2311)	
I choose to eat the food that I like without thinking too much about it	*Strongly Agree/Agree*	23.41 (1590/6793)	27.90 (613/2197)	<**0.001**†
	Strongly Disagree/Disagree	76.59 (5203/6793)	72.10 (1584/2197)	

(*continued*)

Table 2 (*Continued*)

Variable	Frequency	BMI category		*P* value*
		Normal % (n)	Overweight/Obesity % (n)	
Devices in child's room				
TV	*Yes*	39.14 (3314/8466)	48.15 (1380/2866)	<**0.001**†
	No	60.86 (5152/8466)	51.85 (1486/2866)	
DVD player	*Yes*	14.04 (1118/7962)	17.22 (458/2660)	<**0.001**†
	No	85.96 (6844/7962)	82.78 (2202/2660)	
Game consoles	*Yes*	10.44 (827/7925)	13.31 (353/2653)	<**0.001**†
	No	89.56 (7098/7925)	86.69 (2300/2653)	
Computer	*Yes*	20.41 (1655/8110)	25.39 (691/2722)	<**0.001**†
	No	79.59 (6455/8110)	74.61 (2031/2722)	
Tablet or smartphone	*Yes*	38.50 (3179/8257)	44.98 (1251/2781)	<**0.001**†
	No	61.50 (5078/8257)	55.02 (1530/2781)	

BMI, body mass index
Statistically significant $P = 5\%$ in **bold**
*P value derived by χ^2 test.
†Significant within-group differences as assessed by the paired z-test with the Bonferroni adjustment.

countries reporting a higher rate of overweight/obesity in girls than boys in most EU countries, along with an upward trend in childhood overweight in Mediterranean countries [21]. Sex differences in childhood overweight may be driven by differences in patterns of body weight gain and hormones [22]. Nevertheless, the shared obesogenic environment would explain the high rate of overweight/obesity in both sexes. In reference to disparities between northern and southern regions, higher body stature and resting energy expenditure for children dwelling in northern latitudes along with a genetic predisposition toward weight gain in southern-European children would partially explain this paradox [23]. Furthermore, accumulating evidence from other Mediterranean studies suggests that lack of physical exercise, insufficient sleep, excessive screen time, and a gradual shift away from the healthy Mediterranean diet to a more Westernized diet are obesity risk factors prevalent in these populations [24–27]. Antonogeorgios et al. documented that Greek children with low adherence to the Mediterranean diet were more likely to be overweight or obese [28]. Additionally, physical activity levels in children residing in Mediterranean countries are lower than those in Atlantic or central Europe [29].

It is worth mentioning that in our sample, only 50% of Greek mothers had completed tertiary education compared with 78% in Belgium; 46% of Greek children with overweight/obesity belonged to families of low socioeconomic position. Previous studies have reported that southern European children with high compliance to the Mediterranean diet were more likely to have at least one parent who attained a higher education [28,30]. Furthermore, there is robust evidence that obesity in European children is strongly linked to parents' SES as measured by educational level [31]. Contemporary reports from the European COSI study indicate that compared with children of mothers with tertiary education, those of mothers with primary or secondary school attainment had a higher prevalence of severe obesity [32] and were less likely to consume fruits daily [33]. Low SES and low family income are barriers to the purchase of fresh fruit and vegetables that are more expensive than energy-dense, fast foods and sweetened beverages [34,35]. Additionally, deprived neighborhoods tend to have a higher density of fast-food outlets than wealthier areas and less availability of healthy food stores, thereby affecting accessibility to fruits and vegetables [35]. Another limiting factor, the absence of safe streets, parks, or play areas, would confine children indoors and create an environment conducive to sedentary behavior such as increased TV viewing or use of digital media and decreased physical activity [23]. Jong et al. reported that daily vegetable intake below recommendations was related to 17% higher odds of being overweight for children of low SES and 73% higher odds among children of medium SES [36]. Contrastingly, consumption of two portions of fruit daily was associated with 34% lower odds of being overweight in children with high SES [36]. Therefore, in highly educated mothers, health literacy or knowledge of healthy eating, disease prevention, and close compliance to national dietary guidelines could decrease obesity risk in children from these families via positive role modeling and home availability/accessibility of healthy food choices such as fruits and vegetables [36,37].

Another interesting observation in this study was that there were significant differences in home food availability, parenting practices, parental health beliefs, and digital devices in children's rooms according to the BMI group. It appears that the availability of fruit and vegetables was higher in the normal weight group than in peers with overweight/obesity, although sweets and salty snacks were less frequent, respectively. Comparatively, in the normal weight group, parents consumed fruits with the child and engaged in physical activity with children more often than parents of those in the overweight/obesity group and were less likely to practice permissive parenting practices such as allowing and rewarding by watching TV and permitting the use of digital devices. With respect to health beliefs, a higher percentage of parents of the normal weight group agreed that they possess the power to prevent disease and contemplate the quality of foods consumed as compared to the overweight/obesity group. In the same direction, there was a tendency for parents of the normal weight group to

Table 3
Associations between home food availability, parenting practices, health beliefs, and digital devices in children's room vs overweight/obesity in children

	Overweight/Obesity		
		Model 1*	Model 2†
Home food availability	Frequency	OR (95% CI); *P value*	OR (95% CI); adjusted *P* value
Fruit			
	Always/Often	Ref‡	
	Rarely/Never	1.70 (1.19–2.42); **0.003**	1.56 (1.07–2.28); **0.020**
Vegetables			
	Always/Often	Ref	
	Rarely/Never	1.52 (1.07– 2.17); **0.021**	1.21 (0.82–1.79); 0.324
Sweets			
	Always/Often	Ref	
	Rarely/Never	1.37(1.18–1.59); <**0.001**	1.34 (1.14–1.57); <**0.001**
Salty snacks			
	Always/Often	Ref	
	Rarely/Never	1.32 (1.18–1.47); <**0.001**	1.21 (1.07–1.38); **0.003**
Parenting practices			
Consume fruit with your child			
	Very OftenOoften		
	Rarely/Never	1.14 (0.99–1.30); 0.066	1.13 (0.98–1.30); 0.100
Be physically active with your child			
	Very often/Often	Ref	
	Rarely/Never	1.46 (1.30–1.64); <**0.001**	1.27 (1.12–1.44); <**0.001**
Watch TV together with your child			
	Very often/Often	Ref	
	Rarely/Never	0.88 (0.78–0.99); **0.041**	0.89 (0.78–1.01); 0.062
Allow your child to eat sweets/salty snacks whenever he/she wants			
	Very often/Often	Ref	
	Rarely/Never	0.97 (0.87–1.09); 0.613	1.12 (0.98–1.28); 0.085
Allow your child to watch TV or DVD whenever he/she wants			
	Very often/Often	Ref	
	Rarely/Never	0.89 (0.80–0.99); **0.033**	0.81 (0.72–0.92); **0.001**
Allow your child to use computer/ mobile/tablet whenever he/she wants			
	Very often/Often	Ref	
	Rarely/Never	0.83 (0.75–0.93); <**0.001**	0.77 (0.68–0.88); <**0.001**
Reward your child by allowing to watch TV/DVD, computer/ mobile/ or tablet use			
	Very often/Often	Ref	
	Rarely/Never	0.85 (0.75–0.97); **0.016**	0.86 (0.74–0.98); **0.029**
Reward your child with sweets, salty snacks/or fast food			
	Very often/Often	Ref	
	Rarely/Never	1.03 (0.87–1.24); 0.705	1.13 (0.93–1.37); 0.233
Reward your child by being physically active together			
	Very often/Often	Ref	
	Rarely/Never	0.99 (0.88–1.10); 0.819	1.07 (0.95–1.21); 0.276
Health Beliefs			
I believe that my health is determined by destiny			
	Strongly agree/Agree	ref	
	Strongly disagree/Disagree	0.89 (0.78–1.02); 0.107	0.97 (0.83–1.12); 0.668
I believe that people have little power on preventing diseases			
	Strongly agree/Agree	Ref	
	Strongly disagree/Disagree	0.69 (0.61–0.78); <**0.001**	0.87 (0.76–0.99); **0.041**
I choose to eat without thinking too much about it			
	Strongly agree/Agree	Ref	
	Strongly disagree/Disagree	0.79 (0.71–0.88); <**0.001**	0.96 (0.85–1.08); 0.508
Devices in child's room			
TV			
	Yes	Ref	
	No	0.69 (0.64–0.75); <**0.001**	0.73 (0.66–0.82); <**0.001**

(*continued*)

Table 3 (*Continued*)

	Overweight/Obesity	Model 1*	Model 2†
DVD			
	Yes	Ref	
	No	0.78 (0.70–0.88); <**0.001**	0.88 (0.77–0.99); **0.042**
Game consoles			
	Yes	Ref	
	No	0.76 (0.66–0.87); <**0.001**	0.79 (0.68–0.91); **0.001**
Computer			
	Yes	Ref	
	No	0.75 (0.68–0.83); <**0.001**	0.84 (0.74–0.94); **0.003**
Tablet or Smartphone			
	Yes	Ref	
	No	0.77 (0.70–0.83); <**0.001**	0.82 (0.74–0.91); <**0.001**

BMI, body mass index; CI, confidence interval; OR, odds ratio.
Statistically significant *P* values at 5%
Total sample n = 12 041
*Unadjusted logistic regression model.
†Adjusted for children's age, sex, regular exercise, maternal education, and country of residence.
‡Reference group (first category: 0 = *always/often, very often/often, strongly agree/agree*), Dependent BMI category (0 = normal weight vs 1 = overweight/obesity).

respond *no* to the presence of digital devices in the children's room than those of children belonging to the overweight/obesity group.

Notably, these observations were replicated in the multivariate analysis. In both the crude and adjusted regression models, positive associations were observed between low availability of fruit, sweets, and salty snacks as well as parents being physically active with their child *rarely/never* and overweight/obesity in children as compared to *often/always*. In contrast, parenting practices such as allowing or rewarding their child by screen time whenever the child desires *rarely/never* compared with *very often/always* were inversely associated with childhood overweight/obesity. Similarly, the absence of digital devices in children's rooms and parents disagreeing that "they have little power on disease prevention" were also negatively associated with overweight/obesity.

There is accumulating evidence on the effects of the immediate family environment and children's dietary patterns including weight status. Several studies have demonstrated that increased home availability of fruits and vegetables [38–41], along with increased exposure to healthy food served during family meals [42] resulted in increased consumption of these foods by children mediated by family rules regarding healthy eating and role modeling of parents' healthy dietary behavior [38,39]. Home availability of fruit and vegetables was associated with reduced intake of snacks, sweets, and sugar-sweetened beverages [40] and decreased odds of child overweight [36]. Unexpectedly, we found that home availability of sweets and salty snacks at a frequency of *rarely/never* were associated with overweight/obesity. This paradox could be attributed to the underreporting of unhealthy food sources, which is common practice among parents of children with overweight/obesity [43]. On the other hand, parents' restriction, or limitation of specific foods as a preventive measure for children's weight gain, has been correlated to increased intake of that food [44] and higher BMI [38,45,46].

It has been recognized that apart from children's dietary behavior, increased sedentariness due to many hours spent on TV/DVD viewing and digital device usage [47], has also contributed to the childhood obesity epidemic. Latest data from the WHO COSI initiative reported that 40% of European children spend ≥2 h/d TV viewing or using digital devices [48]. In fact, Mihrshahi et al. reported that having a TV in the bedroom and having no home rules on screen time were associated with 1.54 and 1.29 increased odds of overweight and obesity in children and adolescents respectively [47]. This is a matter of concern because TV or digital marketing of unhealthy food products can effectively influence children via persuasive techniques [49]. Television food marketing of energy-dense, nutrient-poor foods, snacks, and beverages high in fat, sugar, and salt, have been recognized as a significant risk factor for childhood obesity because advertised foods contradict dietary recommendations [50]. With home access to online services, there has been a parallel increase in passive advertising [50]. Subtle marketing techniques using social networking sites, mobile phone messages or applications, and embedded messages in web-based games give advertising companies access to children without parental oversight, which can undermine parents' efforts in the fostering of healthy food habits by their children [50].

The findings of the present study support the hypothesis that there are multiple aspects of the home environment linked to overweight/obesity in European children. Improved understanding of the drivers of children's overweightness will be valuable in developing multifaceted programs tackling childhood obesity. In terms of real-life implications, modifiable correlates of the home food environment, such as the availability of healthy foods on a regular basis, and education of parents/guardians on the counterproductivity of negative parenting practices of permissiveness (allowing), using food and screen time as a reward and unmonitored consumption of unhealthy foods by children, as well as emphasizing the importance of positive role modeling of parents concerning healthy dietary behavior and physical activity, could successfully reverse the trend in childhood overweight/obesity. Given that obesity is driven by sedentariness, lack of physical activity, and exposure to food advertising during excessive television viewing [47], then it would be prudent that national health committees along with school/community programs integrate these two factors in future initiatives. It is possible that parents are unaware of the detrimental effect of increased screen time on children's health. As advocated by the British Royal College of Pediatrics and Child Health, as well as the American Academy of Pediatrics on family media use for children >5 y, parents should monitor, and negotiate limits and restrictions on screen time duration and content viewed [51,52]. To date, because of a lack of concrete evidence, there is no universally accepted threshold for the number of hours of screen time exposure in this age group [52].

Limitations/Strengths

The empirical results reported herein should be viewed with consideration given to the strengths and limitations of the present study. Building on the work of the Feel4Diabetes-Study will enable the implementation of comprehensive national obesity practices targeting the family environment. A major strength of the Feel4-Diabetes-Study is that it provides one of the largest and most up-to-date data sets on the lifestyle and health status of European school children. Across all centers of the six participating countries, highly standardized objective anthropometric measurements were obtained from children by trained personnel following a common protocol as well as validated questionnaires to collect data [19]. Subsamples of study participants were examined to calculate the inter- and intraobserver reliability of anthropometry [53].

With the prevalence of overweight/obesity continuing to rise, it appears that public health recommendations of decreased energy intake, adherence to a healthy diet, and increased exercise for the maintenance of normal body weight, are non-transferable on the population level and sustainable beyond the intervention period [16,54]. Therefore, our study approach is unique since we have examined multicomponents of the family home environment in relation to unhealthy weight status in European children. Furthermore, unlike previous studies that investigated the effect of TV viewing on overweight/obesity in children, we accounted for the effect of digital media availability concerning children's weight status, which adds new data to the gap in the literature.

One drawback was that the cross-sectional design of this study did not allow the determination of the cause–effect relationship. However, it was useful for the establishment of hypotheses to be explored in future studies. Moreover, generalizability beyond the European population is limited. Bidirectionality in parent–child interactions is likely as parenting influences children's food choices and weight, whereas children's weight status also influences parenting practices. Potential limitation also stems from our exclusion of parents' BMI. Discrepancies between fathers' and mothers' parenting practices in relation to children's BMI were not assessed, which would be worth exploring in future studies. Another shortcoming, data was collected from parents using self-reported questionnaires, which may introduce reporting bias due to social desirability, especially for children's sweets and salty snacks intake [43]. Additionally, physical activity level was measured qualitatively by a single question, rather than quantitatively. Nonetheless, nutrition research questionnaires are still the most widely used tools as they are relatively cheap and efficient tools for collecting data on a large scale in a relatively short time [43]. Regarding the parenting questionnaire, daily frequency of intake of unhealthy foods such as sweets, salty snacks/and fast food were not measured, which would have added valuable information on parenting practices considered detrimental to children's health and weight status.

We acknowledge that BMI is not the ideal measure of adiposity, as it does not differentiate between fat and fat-free mass [55]. Nevertheless, it is a non-invasive and robust measure of adiposity for children and adolescents advocated by the WHO [56], that is most widely used in population-based studies to assess causal trends and allows for comparisons with similar studies on a population level [57].

Conclusion

Multiple aspects of the home environment appear to act synergistically on the overweight/obesity status of European children. The present findings suggested that future school- and community-based European initiatives aiming to prevent childhood obesity should also target the home environment, parenting beliefs, and practices. Programs designed to educate, facilitate, and support parents to adopt a healthy and active lifestyle with their children would empower parents as agents of good role models and are probably the most efficient way forward to tackle the childhood obesity epidemic. Future longitudinal intervention studies are required to confirm the long-term efficacy of positive parenting in reducing childhood overweight/obesity.

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