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Original article

The relationship between behavioral factors, weight status and a dietary pattern in primary school aged children: The GRECO study

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SUMMARY

Background & aims: Numerous factors have been associated with the increase in childhood overweight and obesity, including environmental, dietary and behavioral. The latter have been associated with unhealthy eating behaviors but studies of their relation to dietary patterns are limited. Dietary patterns serve as a better means to evaluate children's diet and risk of obesity and therefore the aim of the study was to examine the relationship of behavioral factors with a specific dietary pattern developed for children (child derived Food Index (cdFI)), and to assess how behavioral and diet are related to children's weight status when addressed together in a model.

Methods: Study included school-aged children (n = 4434) from the Greek Childhood Obesity study (GRECO), a cross-sectional survey. Participants self-reported behavioral habits and dietary intake, using a semi-quantitative food-frequency questionnaire (FFQ). A high dietary pattern-cdFI is related to a healthier dietary pattern. Anthropometric data were measured. Multiple linear and logistic regressions were performed, adjusting for age and gender.

Results: The dietary pattern was positively associated with sleep, family meals and study hours, and was inversely associated with total screen time, frequency of eating out and eating while on some screen. Overweight and obese children were more likely to have a lower cdFI score (2%), sleep less (8%) and report more study hours (6%).

Conclusion: In order to reduce and prevent child overweight and obesity, interventions probably need to address specific behavioral and dietary patterns together.

1. Introduction

Numerous factors have been associated with the increase in childhood overweight and obesity, including environmental, dietary and behavioral [1,2]. For this reason, these factors have been termed as “obesogenic” and it is unlikely that they exert their effects individually.

Obesogenic factors that have been associated to the increase of child overweight & obesity include sleep [3,4], sedentary lifestyle and various eating behaviors. The latter encompass frequency of eating during the day (meal frequency), frequency of having family meals, frequency of eating while watching TV, and frequency of eating or ordering from a restaurant [5,6]. Television-viewing has been used as a proxy measure to sedentary lifestyle and is the behavioral variable most examined, linked to poor health outcomes and unhealthy weight gain [6–8]. The effect of total screen time (TV and other media types) on weight status, which is also related to sedentary lifestyle and is an increasing trend among children [9], is limited. Total study hours, has recently been suggested [10,11] as an additional factor adding to total sedentary time in school aged children, but has not been adequately investigated to date.

Diet & unhealthy eating patterns have been associated with childhood weight status [11,12] and short sleep duration has been found to increase risk of childhood obesity by 58%–89% [3,4].

The association of these behavioral factors on children's dietary preferences has also been investigated. Sleep duration and TV-viewing and screen time [13–17] have been associated with

Abbreviations: GRECO, Greek Childhood Obesity study; cdFI, child derived Food Index.

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unhealthier food intakes, including high fat & sugary foods and low fruit & vegetable intake. An overall assessment of children's food choices based on individual intakes has been found highly heterogenic [18], which makes it difficult to provide an evidence-based association between Body Mass Index (BMI) status, diet and child-behaviors. The use of dietary patterns, has been shown to decrease heterogeneity since all dietary patterns are assessed based on the same standards. The use of a previously validated dietary pattern, such as the child derived Food Index (cdFI), designed to predict child overweight and obesity, can account for diet heterogeneity and help provide stronger associations. Studies examining the relationship between obesogenic behavioral factors on a dietary pattern as a whole are limited.

Therefore, the aim of the present study was firstly, to examine the association of specific childhood obesogenic behavioral factors, with a specific dietary pattern, the child derived Food Index (cdFI) and secondly, to assess how these behavioral factors and total cdFI score are related to children's weight status, in total and by gender, when addressed together in a model.

2. Materials & methods

2.1. Procedure

The study was carried out from October 2008 to May 2009, from the whole district of Greece, via stratified sampling scheme weighted by age, sex, and region, according to the population distribution (National Statistical Services, 2001 census). Precise details on the stratification scheme have been previously published [19]. The number of children required to increase the power of the study to 85% (5% type I error) was considered prior to the study with odds ratio (OR) evaluated to equal 1.10, based on data reporting the prevalence of childhood overweight and obesity in Greece. The study included a random sample of 117 schools from 10 selected regions, with a total of 5000 children aged 10–12 years old, studied. Parental consent forms were obtained from 4965 out of the 5850 children invited (84.9% participation rate), therefore achieving a good study power.

Upon data inspection, a total of 452 children were excluded; 117 children had all data missing; 95 children had left unanswered over 20% of the FFQ ($\geq$10 questions); and 240 individuals had reported implausible energy intake (<600 kcal/day or >6000 kcal/day). A total of 4434 children (81 missing in random) were finally included in the analysis. The power of the study was not affected since the prevalence of overweight and obesity found in this population was higher than anticipated a-priori (OR = 1.4). Furthermore, selection bias was examined between respondents and non-respondents by assessing potential differences in children's age and gender in relation to their weight status and by gender. No significant differences were found ($p > 0.5$ in both cases).

The present study was conducted in accordance with ethical principles and guidelines laid down in the Declaration of Helsinki. The Agricultural University of Athens research committee approved procedures as well as the Hellenic Ministry of Education (Department of Primary Education) as the law provides in Greece for any studies conducted at school during formal working hours. All children, teachers and primary caregiver were informed of the aims and study procedures, and consent forms were obtained.

2.2. Assessment of predictors

The questionnaire included two sections. The first section referred to descriptive information, including age, gender, anthropometric measurements, and questions relating to behavior & activity, and the second to the frequency of dietary intake.

2.2.1. Dietary and behavioral factors (Questionnaire)

Dietary pattern was assessed from a 48 item, previously validated, picture aided Food Frequency Questionnaire (FFQ) [20]. The FFQ was self-administered and was used to construct and validate the dietary pattern-cdFI designed to predict child overweight & obesity [11]. This is further explained in section 2.3.2.

Behavioral data were obtained on total screen time, hours of sleep, eating behaviors and hours of studying. Total study-hours were assessed by averaging hours reported over weekdays and weekends.

The questionnaire was structured to provide information on overall screen time during weekdays and weekends, separately. Total screen time was defined as the amount of time spent watching TV, playing video games and computer in hours per day. Children reported how much time they spent on screen (TV/DVD/computer/games) on a typical school day (Monday to Friday) and on a typical weekend (Saturday and Sunday). Average reported hours per weekday and per weekend were summed and divided by two (2) to create an average viewing of hours per day. Implausible screen hours, defined as: >120 h per week in accordance to Falbe et al. (2013) were not reported and therefore no children were further excluded from the sample [9].

Sleep duration was self reported by the children and recorded as the time they went to sleep at night and the hour they usually wake up, during weekdays and weekends, separately. Total hours of sleep were then mathematically calculated for each child, taking an average for weekdays and weekends.

2.2.2. Eating behavior

The questionnaire included questions on various eating behaviors, including number of meals per day, frequency of having meals while on a screen (watching TV, DVD, playing video games/consoles, using computer), frequency of having family meals with family members, and frequency of eating/ordering out. Response categories for the former two behaviors, ranged from 1 to 6 times a day. The latter three behaviors had the following response options: Everyday, 5–6 times/week, 3–4 times/week, 1–2 times/week, and seldom/never.

2.3. Assessment of outcomes

2.3.1. Anthropometric measurements

Trained investigators and personnel from the Unit of Human Nutrition of the Agricultural University of Athens performed the anthropometric measurements. A series of meetings were planned for training in conducting surveys, anthropometric measurement and techniques. A two-week practical period was implemented prior to study instigation. During formal study measurements and in all study sites, at least 2 investigators were present in each class using same measuring equipment and procedures. All measurements were made during morning hours. Anthropometrics gathered included standing body weight (kg) to the nearest 100 g with the use of a digital scale (Tanita TBF 300), with the children without shoes and dressed lightly. Standing height was measured to the nearest 0.1 cm, again without (Leicester height measure), with the head positioned in the Frankfort plane. Children were asked to gently expire in order to measure waist circumference to the nearest 0.1 cm with the use of a non-elastic tape (Seca, Germany). The tape was placed in a horizontal plane around the trunk, midway between the lower rib margin and the iliac crest. Body mass index (BMI) was calculated by dividing weight (kg) by standing weight squared (m^2). Children's BMI cutoffs were defined based on International Obesity Taskforce (IOTF) age and gender specific BMI cut-off criteria [21].

2.3.2. Dietary pattern-cdFI

Using the children's responses from their reported frequency of consumption (48-item, picture aided FFQ) the dietary pattern-cdFI, with a food index score (cdFI) was constructed. The index was purely food based to understand how dietary patterns may predict children's risk for overweight & obesity. The process for deriving the cdFI score has been previously described in detail [11]. In summary, a total of 14 foods, categorized as positive – non-obesogenic or negative – potentially-obesogenic foods, were included in the cdFI, based on a priori knowledge of food items and dietary patterns for children. Specifically, the dietary pattern-cdFI included eight (8) positive – non-obesogenic foods: fruit, vegetables, whole grains, fish, nuts, legumes/pulses, milk and yogurt; and six (6) negative – potentially-obesogenic foods including: cheese, red meat, sugared sweet beverages (ssb's), processed food, fast food, and sweets. The dietary pattern-cdFI was validated and its sensitivity of detecting overweight and obesity prediction was tested by randomly splitting the study sample (75%–25%). Theoretically a minimum of 16 to a maximum of 64 was the range of total FI score the children could achieve. The higher the dietary pattern-cdFI, the healthier the children's dietary pattern.

2.4. Statistical analysis

Descriptive statistics, including frequencies, means, range (minimum, maximum) and standard deviations were calculated for all continuous study variables. Chi-square tests were used for categorical variables in order to assess gender differences and Student t-test for mean differences between normally distributed variables.

All continuous variables were assumed to follow a Normal distribution according to the central limit theorem, due to the large sample size. Scatter plots and studentized residuals were used to detect outliers.

Outcome variables included dietary pattern-cdFI and children's weight status, defined by BMI dichotomized into a binary variable (healthy weight and overweight/obese children). The association between behavioral variables and total cdFI score was assessed via multiple linear regression. BMI was used as an indicator variable in this model, overweight & obese children from normal weight peers. The model included total sleep time, screen time, study-hours and other behavioral variables stated, in a step-wise approach, and was adjusted for age and stratified by gender. Variance inflation factor (VIF) was performed to test the independency of the variables and avoid collinearity. All factors included in the model had a VIF <10, therefore meeting the credentials.

Total cdFI score, as determined from the dietary pattern-cdFI, was further split into quintiles. Box plots were used to examine variable distribution by upper and lower FI split into the lower 2 quintiles (Q1&Q2) and the upper 3 quintiles (Q3–Q5) and graphed by gender. This was performed since dietary pattern-cdFI was originally created to predict children at risk for overweight and obesity, therefore the distribution of other risk factors with lower and higher scores was deemed necessary.

Univariate and multiple logistic regression analysis was used to examine the relationship between child's weight status and the multiple explanatory variables viewed in this paper. Crude and adjusted Odds ratios (OR) with 95% confidence intervals are presented. The significance of the model was tested using Likelihood Ratio test (LR test). All reported P-values were based on two-sided hypothesis tests, with significance level at 5%. The statistical models were computed using STATA 12.0 (STATA corp. Texas).

Table 1
Participant characteristics including anthropometric and behavioral variables.

Child characteristics	Total	SD	Boys	Girls	P-value[c]
Total children N (%)	4434		2164 (48.8)	2270 (51.2)	
Age (years)	10.90	0.70	10.96	10.88	**<0.001**[d]
Height (m)	1.50	0.10	1.49	1.5	**<0.001**[d]
Weight (kg)	45.70	10.91	45.7	45.69	0.971[d]
Waist circumference (cm)	68.61	9.60	69.80	67.40	**<0.001**[d]
BMI (kg/m^2)	20.24	3.71	20.37	20.13	**0.034**[d]
Weight status[a,b] (%)					
Under- & Normal weight	58.36		56.93	59.72	0.091[e]
Overweight	29.71		30.18	29.26	
Obese & morbid obese	11.93		12.89	11.02	
Dietary pattern-cdFI total score	34.81	5.01	34.93	34.70	0.069[d]
Total sleep time (h/day)	9.10	1.51	8.90	9.30	**<0.001**[d]
Total screen time (h/day)	2.41	1.56	2.52	2.31	**<0.001**[d]
Total study time (h/day)	2.61	1.30	2.47	2.76	<0.001[d]
Meals per day[b] (%)					
1	10.62		11.02	10.25	0.088[e]
2	20.97		21.99	20.00	
3	31.45		31.49	31.42	
4	23.06		22.23	23.84	
5	10.55		9.54	11.51	
6	3.34		3.72	2.98	
Ordering Eating out[b] (%)					
Never	8.65		8.36	8.96	0.02[e]
1–2 times/month	58.30		60.61	55.86	
1 time/wk	21.68		20.70	22.71	
2 times/wk	8.77		8.32	9.25	
3–6 times/wk	2.04		1.54	2.57	
Every day	0.55		0.47	0.64	

Significant differences are shown in bold.
BMI, Body Mass Index; cdFI, child derived Food Index.
[a] BMI categorized as per IOTF (International Obesity Task Force) standards.
[b] Categorical variables, depicted with frequencies and percentages in ( ).
[c] Significant at 0.05 level, compared by gender.
[d] Tested via Student t-test.
[e] Tested via chi-square test.

3. Results

The basic total and gender specific characteristics of the study population are shown in Table 1. Mean values along with their standard deviation (SD) are depicted for continuous variables, and frequencies with percentages presented for, categorical variables. Statistically significant gender differences in anthropometric measurements were found in the mean values for height, age, waist-circumference and BMI. BMI categories, as per IOTF standards, did not significantly differ ($p = 0.091$).

Gender differences were also found in sleep duration, total screen and study time, frequency of eating while watching TV per day, in family meals and frequency of eating out on a weekly basis.

3.1. Distribution

The box plot (Fig. 1) presents in detail the distribution of behavior variables in respect to the dietary pattern-cdFI.

3.1.1. Results in total population

Mean BMI was lower among children scoring at the upper quintile range compared to the lower 2 quintiles ($p = 0.03$), with mean BMI being 0.25 units lower in children scoring at the upper quintile range versus the lower 2 quintiles.

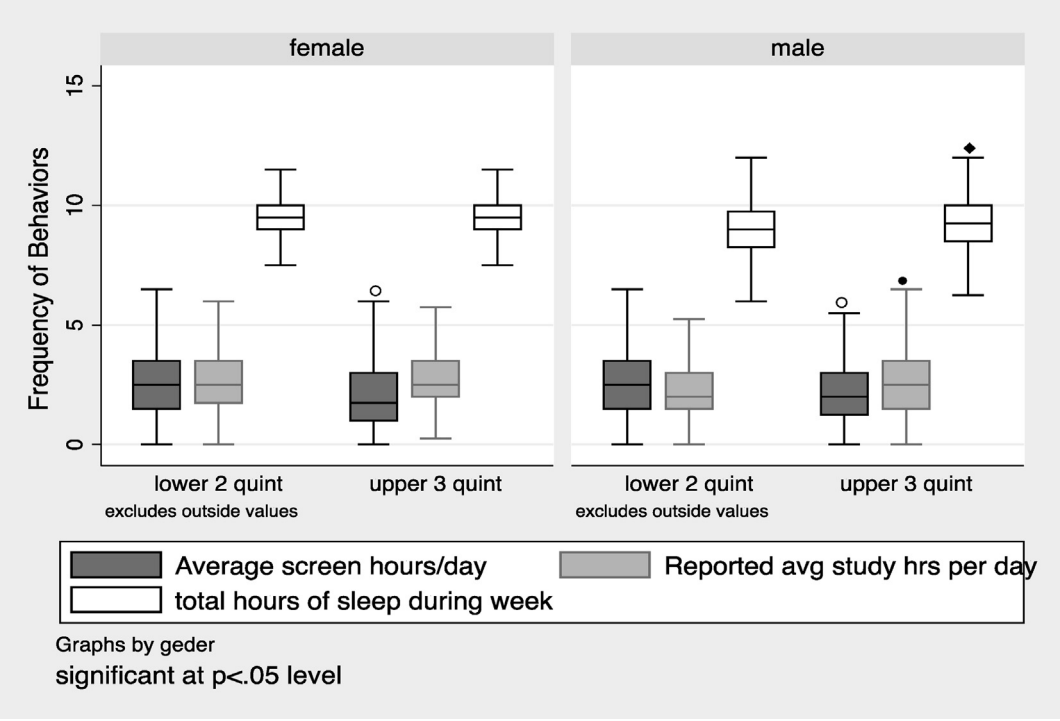

Fig. 1. Children's Sleep, Screen and Study hour distribution by child derived Food Index quintile level.

3.1.2. Results by gender

Total screen hours per day were lower in both genders, while the median for sleep duration was significantly higher in males but not females, among children scoring at the upper 3 quintiles. An increasing trend across the FI quintiles was found for total sleep and study hours. A decreasing trend was observed for total screen time and BMI (data not shown). Boys in the upper quintiles, but not girls, reported more study hours.

3.2. Multiple linear and logistic regression

A multiple regression was run to predict dietary pattern-cdFI score from BMI, total sleep, screen and study time, and frequency of: (i) eating while on some screen, (ii) meals per day, (iii) family meals and (iv) eating/ordering out. Model was adjusted by age. All variables, excluding meals per day (Table 2), significantly predicted dietary pattern-cdFI score ($F = 12.46$, $p < 0.001$) with the model explaining 6.4% of the variance.

3.2.1. Results in total population

Overweight and obese children had a lower dietary pattern-cdFI score, compared to their normal weight peers (−0.45 (0.16) 95% CI −0.77, −0.14), when the mean of the other variables was kept constant as seen in Table 2. Total screen time (−0.34 (0.05) 95% CI −0.45, −0.24), frequency of eating while on some screen (−0.25 (0.07) 95% CI −0.4, −0.11) and frequency of eating/ordering out (−0.83 (0.09) 95% CI −1.01, −0.65), were lower for children achieving a higher cdFI score. Sleep duration (0.13 (0.05); 95% CI 0.03, 0.24), total study hours (0.22 (0.06) 95% CI 0.09, 0.34), and frequency of having family meals per week (0.27 (0.06) 95% CI 0.15, 0.38) increased as cdFI score increased. Significant gender differences were found in weight status, total sleep time and with

Table 2
Behavioral variables associated with total child derived Food Index (cdFI) score, stratified by gender.

Dietary pattern-cdFI total score	Total		Males		Females	
	β-coef.	95% CI	β-coef.	95% CI	β-coef.	95% CI
Weight status[a]	−0.45**	−0.77, −0.14	−0.34	−0.8, 0.12	−0.58**	−1.02, −0.15
Total sleep time (h/d)	0.13*	0.03, 0.24	0.24**	0.09, 0.39	0.03	−0.13, 0.18
Total screen time[b] (h/d)	−0.34***	−0.45, −0.24	−0.2 ***	−0.43, −0.14	−0.42***	−0.5, −0.26
Total study hours[c] (h/d)	0.22***	0.09, 0.34	0.26**	0.09, 0.44	0.17*	0.01, 0.34
Eating while on some screen[d]	−0.25***	−0.40, −0.11	−0.105	−0.31, 0.1	−0.40***	−0.61, −0.19
Meals per day[d]	0.02	−0.11, 0.14	−0.04	−0.23, 0.15	0.05	−0.12, 0.22
Family meals[e]	0.27***	0.15, 0.38	0.30***	0.12, 0.47	0.25**	0.09, 0.4
Order/Eat out[e]	−0.83***	−1.01, −0.65	−0.79***	−1.04, −0.53	−0.86***	−1.12–0.6
Age	−0.36	−0.57, −0.15	−0.49	−0.79, −0.18	−0.16	−0.45, 0.13

OW, overweight children; OB, obese children; cdFI, child derived Food Index; BMI, Body Mass Index; h/d, hours per day; Values were significantly different between the reference level and other levels within a given characteristic: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

[a] OW&OB children relative to Healthy weight children (reference level); BMI used as an indicator variable.
[b] Measured as total screen time, in h/day, including TV-viewing, pc and video games.
[c] Measured as total studying, in h/day; used as a proxy for other sedentary times.
[d] Frequency per day: 1 to 6 times per day.
[e] Frequency per week: Never-rarely, 1–2 times/wk, 3–4 times/wk, 5–6 times/wk, every day.

frequency of eating while on some screen. More specifically, females (but not males) with higher weight status and with higher mean frequency while on some screen had a significant lower dietary pattern-cd-FI (β-coef: −0.58; 95% CI: −1.02, −0.15 and β-coef: 0.40; 95% CI: −0.61, −0.19). Also, the dietary pattern-cdFI score was significantly correlated with sleep duration in males only (β-coef: 0.24; 95% CI: 0.09, 0.39).

Univariate and multiple logistic regression results are shown in Table 3, depicted of behavioral factors and cdFI score on children's weight status. As the table depicts, all crude explanatory variables were significantly associated with children's weight status. When entered in the model as shown in the table, the effect of total screen time was nulled (OR: 1.04; 95% CI: 0.99, 1.08). Age, unlike gender, was also significant in the model; the higher the age the less likely the overweight (22%) risk. The Likelihood Ratio test performed for the model as a whole was significant ($p < 0.001$), demonstrating that the independent variables entered in the model were related to children's weight status and increased the model's likelihood of predicting child overweight and obesity.

4. Discussion

The present study investigated the relationship between a child derived food pattern with behaviors linked to the obesity epidemic, including sleep duration, total screen time, and other eating behaviors. Study time, a factor that adds to sedentary time in school aged children and has not been extensively studied, was also examined. The result of each on children's weight status, in univariate and multivariate analysis was examined, accounting for residual confounding by these already known obesogenic variables.

The dietary pattern-cdFI is a food pattern that incorporates 'unhealthy' food items along with healthy foods, and was derived to predict children at risk for overweight and obesity [11]. Results from this study suggest a relationship between total cdFI score, sleep, screen, frequency of family meals, frequency of eating out, and frequency of eating while watching TV with the cdFI score being inversely associated with total screen time and positively associated with sleep duration and total study hours. Child derived FI dietary pattern decreased by 0.33 for every hour increase in screen time, whereas with every extra hour children slept or studied the total cdFI score increased by 0.15 and 0.21 respectively. Other researchers have also found sleep and food intake relations with Hart et al. (2013) reporting lower food intake among children that increased sleep duration [22], and Kjeldsen et al. (2014) reporting that short sleep duration may be associated with poor-obesity promoting diet in children upon adjusting for screen time and physical activity [16]. Other studies have also found an inverse association of specific dietary patterns and TV-viewing [23] or total screen time [24]. Researchers have also related screen time or "TV-viewing" with elements of a less healthy diet supported by this study which associates total screen time with a lower cdFI dietary pattern. In more detail, children with greater TV or screen time were found to consume less fruit and vegetables [17,25–27], more fast food [25,27,28], more energy dense food, drink more sodas, and have a higher energy intake [5,29,30]; foods that are all included in the cdFI-dietary pattern. This is further supported by Olafsdottir et al. (2014) that found that the likelihood of consuming sweetened beverages increased with TV total hours but also by commercial exposure [31].

This study also found that the greater the mean frequency of eating while on some screen and eating out the lower the cdFI score, whereas more frequent family meals resulted to a significantly higher dietary pattern-cdFI score. Total meals per day did not affect the score. Some associations differed between genders, with cdFI score being significantly lower among overweight and obese girls but not boys, and higher in boys that reported to sleep and study more, but not in girls. This may partly be explained by significant waist circumference differences observed between genders and by the higher mean sleep duration reported by girls, whereas the range on total sleep hours was larger among boys as seen in the distribution plots.

Overall the expected dietary pattern-cdFI score was 0.45 units lower among overweight and obese children compared to 0.057 when the model contained only age and sedentary factors [11], in relation to their normal weight peers. This suggests that including these factors in the analysis increased the index's potential predictive ability. This association was significant in the total sample and for females, whereas not in males. The model was not altered when physical activity was included (data not shown) hence was not accounted for, to decrease risk of over-adjusting, and in order to maintain the model simple.

In view of these associations, the odds of being overweight or obese among school aged children was examined, by dichotomizing the BMI variable. The likelihood of children being overweight or obese, was lower for children achieving a higher dietary pattern-cdFI, score slept more, studied less, had more frequently family meals and consumed more meals per day. More specifically, for each hour increase in total study hour, the likelihood of a child being overweight or obese increased by 6%, while with each hour of sleep duration the likelihood decreased by 8%. Meals per day, frequency of family meals were also significant to BMI status. The obesogenic effect of total screen time was nulled when entered in a multiple logistic regression model as has also been shown by others [5,17,28,32,33]. Pérez-Farinós et al. (2017), however, found that high screen time and short sleep duration were associated with increased BMI [17], but these were separately examined. These findings may suggest that the types and quantity of food, and the frequency that children eat while watching TV, and not total screen time, may be the factors leading to overweight and obesity.

The outcome of total study time, was significant in the model and was inversely associated with an increased likelihood of children being overweight or obese. Study hours were negatively associated with children's BMI status [10], but positively with total

Table 3
Crude and Adjusted Odds Ratios of overweight and obese children compared to their healthy weight peers as per total dietary pattern-cdFI score achieved and other behavioral factors.

BMI (kg/m^2)	OR[a]	95% CI	OR[b]	95% CI
Dietary pattern-cdFI total score	0.98	0.97, 0.99	0.98	0.97, 0.99
Total sleep time (h/d)	0.91	0.88, 0.95	0.92	0.88, 0.96
Total screen time[c] (h/d)	1.05	1.01, 1.1	1.04	0.99, 1.08
Total study hours[d] (h/d)	1.05	1.01, 1.1	1.06	1.01, 1.12
Meals per day[e]				
1–3 meals/day	Reference		Reference	
4–6 meals/day	0.84	0.74, 0.95	0.86	0.75, 0.97
Family meals per week[f]				
1–3 f. meals/wk	Reference		Reference	
4–6 f. meals/wk	0.83	0.73, 0.94	0.84	0.74, 0.95
LR test for model	$p < 0.001$			

OR, Odds Ratio; CI, Confidence Interval; BMI, Body Mass Index; cdFI, child derived Food Index; LR test: Likelihood Ratio test.

[a] Crude odds ratios per variable; Reference baseline category: healthy weight children.

[b] Adjusted Odds ratios for all variables in the model as shown in the table including age and gender.

[c] Measured as total screen time, in h/day, including TV-viewing, pc and video games.

[d] Measured as total studying, in h/day; used as a proxy for other sedentary times.

[e] Meals per day in two categories.

[f] Family meals per week in two categories.

cdFI score, as the current study showed. The mechanism behind this association is not clear since to date study time has not been well studied, although it seems that study time greatly increases total inactivity time. More studies evaluating similar child age populations may increase the understanding behind this 'new' potential obesogenic factor.

It must be underlined that in contrast to our study that examined total screen time, most studies have assessed TV-viewing in relation to the child overweight epidemic [28,32,33]. This along with the incorporation of total study time as an extra inactivity variable that children accommodate in their daily lives may explain the different results obtained in relation to other researchers. By assessing total screen time other media types are accounted for, including gaming, tablets and computer use, therefore strengthening the results of the study. Another strength is the use of a previously validated dietary pattern for children, that includes healthy and potentially obesogenic foods. The relationship of behavioral risk factors was therefore viewed on the diet as a whole, accounting for diet heterogeneity as well.

Although no causal associations can be drawn due to the cross-sectional nature of the study, the study's large sample size enables inferences to be drawn. Behavioral data were self-reported, but potential misreporting was random considering the large sample size. Selection bias was minimized by obtaining randomly sampled, from the whole region of Greece. Measurement error was reduced through personnel training.

Health professionals can use this information to add to their research strategies and implementations, since food intake, screen time, sleep and study time are all modifiable risk factors. Changing habits in childhood can prevent and reduce overweight and obesity epidemic. Although life changes may have occurred the past years in Greece the results of this study should not be disregarded.

5. Future research

The results of this study may form the basis for implementing public health policies but most importantly for designing intervention studies addressing children's dietary habits (either school oriented or specific overweight group targeted), most of which to date have no or very small effect. It must be recognized that in order to prevent or decrease childhood obesity interventions may need to target behavioral factors, specific dietary patterns and eating habits, in a reasonable time span.

Statement of authorship

The GRECO study started and was conducted from the Agricultural University of Athens. Responsibilities of A.Z., D.B.P., G.R. and P.F. included study design and field work supervision. Statistical analysis was performed and overall write up was performed by E.M., and D.B.P., E.M., and A.Z. interpreted the data. Data management and database preparation was performed by all authors, All authors participated in writing the final version of the submitted paper. The authors have no competing interests.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Compliance with ethical standards

Ethical Standards The Agricultural University of Athens research committee approved procedures as well as the Hellenic Ministry of Education (Department of Primary Education) as the law provides in Greece for any studies conducted at school during formal working hours. Data protection regulations were observed in the survey. Signed informed consent was obtained from main caregiver prior to enrolling the children in the study.

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