An observational study on the effects of early and late risk factors on the development of childhood obesity in the South of Italy

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ABSTRACT

Background: Child obesity is today one of the greatest health emergencies, on such a large scale as to be considered a global epidemic by the WHO and, unfortunately, Italy holds the worst European record.
Methods: We conducted an observational study to investigate the effects of early and late risk factors on the development of primary childhood obesity. We collected anthropometric parameters, information about early risk markers and late risk factors on a sample of 280 children from March 2016 to December 2017.
Results: Statistically significant associations emerged between: child's BMI and education level of the mother ($p<0.001$) and the father ($p<0.05$); level of parents' education and qualitative variables (subjects' physical activity level ($p<0.05$), consumption of carbonated beverages ($p<0.05$), fruit juices ($p<0.05$) and snacks ($p<0.05$); BMI and the presence or absence of a family history of obesity, DM and cardiovascular diseases. Significant linear correlations were found between weight classification (overweight/obese) and the consumption of carbonated drinks ($p<0.05$), snack consumption ($p<0.05$), physical activity levels ($p<0.001$) and duration of sleep in the afternoon ($p<0.05$).
Conclusions: In our sample we found incorrect eating habits to be frequently linked to a low level of parental education; particularly for the mother, the main childcare provider.

Key words: childhood obesity; early risk factors; late risk factors; nutrition; physical activity; life style

INTRODUCTION

Childhood obesity is today one of the greatest health emergencies, on such a large scale as to be considered a global epidemic by the WHO. According to WHO growth standards, obesity in children is defined as a body mass index (BMI) above the 95th percentile [1-3]. In Italy BMI is evaluated against growth charts based on age and

gender formulated by Cacciari et al. [4].

The excessive weight increase in early childhood (0-2 years) is a risk factor for the development and persistence of overweight/obesity; indicators of risk include: a z score ≥ 1 of the "Weight for length" curve. Moreover, if BMI does not reduce after 12 months of age or reverses towards the first peak, this suggests early adiposity rebound, a phenomenon presenting a statistical risk of persistent obesity in later years of life [5]. Obesity is worrying because it can affect the immediate health of children and their educational level, as well as their future quality of life [6].

Unfortunately, Italy holds the worst European record for overweight children and adolescents, as shown in the latest report of the "Okkio alla Salute" project. In particular, there is a peak in the 8/9-year-old age group within which 20.9% are overweight and 9.8% are obese, with a substantial difference between Northern and Southern Italy. In southern regions, excess weight is found in 37.1% of the population; as regards children in the region of Sicily, 3.7% are severely obese, 10.2% are obese and 23.2% are overweight [7,8].

Childhood obesity is a multifactorial condition influenced not only by genetics, but also environmental factors. The latter include: prenatal exposure to gestational diabetes, maternal smoking and excessive maternal adiposity regardless of neonatal weight. By contrast, exclusive breastfeeding during the first six months of life is correlated with a lower incidence of childhood obesity, with a reduced risk of approximately 20-30% [9-11].

The obesity epidemic we are facing today is also dependent on lifestyle changes: nowadays children spend more time using electronic devices than on any other activity, except for sleeping. These devices are often used concurrently and all involve sedentary behavior. They are also present in children's rooms and this has led to an increase in screen time [12,13]. As a potential direct mechanism, it has been hypothesized that watching television during a meal can alter energy intake, delaying and reducing the sense of satiety from foods already consumed [14].

Another possible route to obesity could derive from exposure of the child to advertisements for food items high in fat and sugar, as these are designed to increase the demand for such products. As a consequence, screen time could exert its obesogenic effect not solely on energy consumption but also on calorie intake [15-19]. The American Academy of Pediatrics therefore recommends limiting screen time to 1-2 hours a day, with quality programming and advocates removing televisions from children's bedrooms [20].

The use of electronic devices is also correlated with shorter sleep duration. This is another known risk factor for obesity but the exact mechanism through which sleep duration influences the onset of overweight/obesity is not yet clear. Plausible mechanisms proposed are the "behavioral" hypothesis (i.e. "less sleep - more time to eat") and the "endocrinological" mechanism mediated by the hormones insulin, cortisol, ghrelin and leptin [21-25].

Eating habits (type of food, quantity and place eaten) represent another fundamental factor. Young people in Europe today tend to consume more food in fast-food outlets and drink large quantities of sweetened drinks. They also eat outside the home more often and therefore spend less time eating healthy meals with their family. In addition, convenience and ready-made foods are more accessible than ever and portion sizes are larger [26, 27].

Reduced physical activity also plays an important role in the development of overweight and obesity. It is worrying that only 1 in 5 children in Europe take part in regular moderate-vigorous physical activity, and Italy shows the lowest levels for both boys and girls across all age groups [8, 28]. According to the WHO, people aged between 5 and 17 should do at least one hour of moderate physical activity per day [29].

Obesity therefore represents a condition which results in high social and economic impacts, not only affecting the current situation but also the future. This justifies the need to undertake urgent and incisive steps to counter the spread of the phenomenon [30]. It is necessary to invest in prevention, as recommended by the EU and the WHO through strategies and action plans. All regions in Italy are committed to the implementation of the National Prevention Plan (PNP) 2014-2018 that adopts a multi-sectoral approach in which the school plays a fundamental educational role in supporting and promoting correct behaviors starting from childhood and actively involving families [31].

The purpose of our study was to investigate possible associations between overweight and obesity and the presence of some early and late risk factors and also to evaluate any correlation between the degree of obesity and the abovementioned risk factors.

MATERIALS AND METHODS

A direct observational survey was carried out in the Pediatric Unit of the hospital "AOU G. Martino" from March 2016 to December 2017 by administering a face-to-face questionnaire to parents of children and adolescents aged between 6 and 15 who had been diagnosed with essential obesity or overweight. Anthropometric parameters, weight and height, were measured and BMI was calculated for the diagnosis of obesity, with a cut-off percentage for BMI higher than the 85th centile for overweight and 95th centile for obesity [3, 4]. Subjects with obesity due to secondary causes were excluded from the sample (i.e. due to endocrine, genetic or polymalformative diseases or iatrogenic effects). Haematochemical tests (total cholesterol, triglycerides, HDL and glycemia) were undertaken only on children

with severe obesity to investigate their metabolic profile. The following early risk markers were taken into account in our analysis: excessive weight gain during pregnancy; maternal smoking before or during pregnancy; gestational diabetes; low or high neonatal weight; lactation method and timing and years of parental education (under/over eight years) [32].

It was decided to evaluate the presence of any significant associations between the level of parents' education and the following qualitative variables: consumption of foods high in carbohydrates and/or fat (carbonated drinks, fruit juices, snacks) and subjects' physical activity level. Breastfeeding was assessed by converting it into a dichotomous variable ('never' or 'for at least one month').

The presence of late risk factors was assessed by analysis of habits and lifestyle. The food history was recorded including: number of meals, habitual breakfast consumption, weekly consumption of fruit and vegetables and of sweets, snacks and sweet drinks.

Habitual physical activity of subjects was estimated by evaluating sedentary factors (number of hours per day spent watching TV or at the computer/game console) together with the weekly frequency of planned physical activity (sports, recreational activities) at and after school. Hours of sleep, both nocturnal and diurnal, were assessed. Data was also collected regarding family history of obesity, cardiovascular disease, diabetes mellitus together with details regarding the education level of parents. Finally, the presence of medical conditions related to the development of obesity (type 2 diabetes mellitus, metabolic syndrome, polycystic ovary syndrome, etc.) were evaluated. Behavioral disorders or socialization problems with peers were also assessed.

The sample was determined considering a prevalence of overweight and obesity of 37.1% in Sicily, estimating a 99% Confidence Interval (CI) and absolute precision of 10%.

We stratified the sample based on BMI standardized by gender and age using the growth curves in the software of the Italian Society of Pediatric Endocrinology and Diabetology (SIEDP) [33]. These are based on the growth charts of Cacciari et al. [4] that differentiate five weight classes: "severe obesity" (2.326 BMI SD or 99th centile), "moderate" (1.88 BMI SD or 97th centile), "mild" (1.645 BMI SD or 95th centile), "overweight" (1.036 BMI SD or 85th centile) and "at risk of being overweight" 0.67 BMI SD or 75th centile). The term BMI SD refers to the deviation of the BMI with respect to the average calculated by SIEDP software. The software calculated the BMI and we then assessed the SD. Therefore, the BMI SD is utilized in our statistical analyses. In this study, only the distinction between overweight children (85-95th centile) and obese children (> 95th centile) was considered for the purposes of statistical analysis. All statistical variables investigated were summarized as follows: number and frequency for qualitative data, mean, standard deviation, median and interquartile range (IQR) for quantitative data. The Kruskal Wallis test was used to detect any statistically significant differences between the classification of BMI SD and the four levels of education of the father and mother. Where significant differences arose, the Conover post-hoc test was used. The Wilcoxon rank sum test was used to compare BMI SD values with binary variables (family history, diabetes, smoking, etc.). The association between the classification of the BMI SD and all quantitative variables was carried out using Spearman's rank correlation coefficient. The Chi-Square test of independence was used to determine any statistically significant associations between the four classifications of children's weight (overweight, obese, moderate obesity and severe obesity) and all the categorical variables, adopting a relative partition model where the null hypothesis was rejected. Values of $p < 0.05$ were considered statistically significant. Linear correlations were calculated to evaluate any associations between incorrect eating habits (not consumption of fruit and vegetables, snacks, fizzy drinks and fruit juices) and BMI standardized for gender and age. All summary and inferential statistical analyzes were performed using R software.

RESULTS

All subjects interviewed agreed to answer the questionnaire and therefore the sample analyzed comprised 280 children. The sample was stratified by age, 6-10 years (52.89%) and 11-15 years (47.11%), and by gender (41.3% male and 58.7% female). The average BMI was 27.7 ±4.5 SD. The BMI SD was also calculated by age and the average was 2.03 ±0.53 (range 0.67-3.50) (Table 1).

23.2% of the sample were found to be overweight (BMI between 85th and 95th centile) and 76.8% to be obese (BMI > 95th centile).

Subjects in our sample were classified as follows: 27.5% with severe obesity, 31.9% moderate obesity, 17.4% mild obesity and 23.2% overweight. No child was found to belong to the group at risk of being overweight. We also investigated whether the sample had developed any medical complications (hyperinsulinemia, metabolic syndrome and early puberty, etc.) and/or experienced any difficulties in socializing.

Early risk factors

The results of the factors taken into consideration are summarized in Table 1.

Neonatal weight was found to be above 4,500 g in only 2.86% of the study sample (3139.46±550.43). The average weight increase during pregnancy was 13.63±6.43 Kg. The mean duration of breastfeeding was 6.67±9.53 months.

TABLE 1. Early risk factors investigated (percentage and number in our sample)

PARENTS' EDUCATIONAL LEVEL								
	Mother						Father	
Elementary	14 (5.00%)						10 (3.57%)	
Lower secondary	128 (45.71%)						124 (44.29%)	
Upper secondary	90 (32.14%)						28 (10.00%)	
University	46 (16.43%)						2 (0.71%)	
No reply	2 (0.71%)						116 (41.43%)	
FAMILY HISTORY								
Obesity	**DM**						**Cardiovascular diseases**	
209 (74.6%)	205 (73.2%)						233 (83.2%)	
EARLY RISK FACTORS								
Maternal smoking[a]			**Breastfeeding**				**Gestational diabetes**	
No	Yes	No	Yes (59.3%)[b]				No	Yes
			< 1 mo	1-6 mo	6 mo			
197 (70.4%)	81 (28.9%)	114 (40.7%)	47 (16.8%)	63 (22.5%	53 (18.9%)		262 (93.6%)	18 (6.4%)

[a] *Two (0.7%) subjects refrained from responding to this item*
[b] *1.1% of those who breast-fed could not remember the duration*

TABLE 2. Percentage and BMI SD average ± SD vs parents' level of education (p<0.01 for mother and p<0.05 for father)

Level of education*	Father		Mother	
	Percentage (n)	BMI SD average± SD	Percentage (n)	BMI SD average ± SD
Primary	10 (3.65%)	2.46±0.59	14 (5.11%)	2.38±0.65
Lower secondary	116 (42.33%)	2.13±0.52	126 (45.98%)	2.17±0.49
Upper secondary	120 (43.8 %)	1.94±0.52	88 (32.12%)	1.85±0.48
University	28(10.22%)	1.84±0.48	46 (16.79%)	1.88±0.55

** As six subjects refrained from responding to this item, percentages were calculated on 274 children.*

- Statistically significant associations between early risk factors and the child's BMI SD were detected. Level of parental education was found to affect the degree of obesity (dividing the sample into two groups: overweight and obese) and statistically significant differences were observed in relation to the education level of both the mother (χ^2=11.3779; p<0.001) and the father (χ^2: 5.3621; p<0.05). This data was further investigated to determine whether the age;
- Standardized BMI for our sample of overweight and obese children decreased significantly with increasing parental education level and statistically significant differences were obtained (p <0.05 for paternal education level and p <0.01 for maternal) (Table 2).

Significant associations emerged between the years of paternal education (8 years or less) and the following variables: consumption of carbonated beverages more or less than once a week (χ^2 = 9.8517, p <0.01); fruit juices more or less than once a week (χ^2 = 7.3945, p <0.01) and physical activity more or less than two hours a week (χ^2 = 11.1382, p < 0.001). A statistically significant association also emerged between the number of years of paternal schooling and the consumption of snacks more or less than twice a week (χ^2 = 6.1283; p <0.05).

On analyzing correlations of variables with maternal education level (more or less than 8 years), the same statistical associations were observed as found for the father; in particular, with the consumption of carbonated drinks (χ^2 = 8.5905; p <0.05), fruit juices (χ^2 = 12.2966; p <0.001), physical activity (χ^2 = 3.896; p <0.05) and snacks (χ^2 = 5.4832; p <0.01).

The presence of a statistical association between

TABLE 3. Eating habits and parental education (years of education)

		Father		Mother	
		< 8 yrs(n)	>8 yrs(n)	< 8 yrs(n)	>8 yrs(n)
Carbonated beverages	Less than once a week	48 (17.65%)	96 (35.29%)	6 (41.18%)	88 (64.71%)
	More than once a week	8 (28.68%)	50 (18.38%)	82 (60.29%)	46 (33.82%)
Fruit juice	Less than once a week	24 (8.76%)	60 (21.9%)	24 (17.52%)	60 (43.80%)
	More than once a week	102 (37.23%)	88 (32.12%)	116 (84.67%)	74 (54.01%)
Physical activity	Less than two hours a week	50 (18.38%)	20 (7.35%)	50 (36.76%)	26 (19.12%)
	More than two hours a week	80 (29.41%)	126 (46.32%)	94 (69.12%)	106 (77.94%)
Snacks	Less than twice a week	18 (13.14%)	108 (78.83%)	22 (16.06%)	44 (32.12%)
	More than twice a week	48 (35.04%)	100 (72.99%)	118 (86.13%)	90 (65.69%)

years of parental education and skipping breakfast was assessed, and a significant correlation was found with maternal education level (χ^2 = 8.1855; p< 0.04233).

A family history of obesity, DM and cardiovascular diseases emerged in a considerable proportion of the sample (> 70%). The average number of family members ± SD for each of the abovementioned conditions were as follows: 1.57±1.51, 1.11 ±0.95, 1.31± 0.92 (Table 1).

The correlations between BMI, expressed as SD by age and gender, and the presence or absence of a family history of obesity, DM and cardiovascular diseases were evaluated. However, no significant associations were found, with the exception of cardiovascular diseases (BMI SD: 2.25±0.45 vs. 1.98±0.53; X2 = 5.1812; p <0.05) and as a quantitative variable with the number of family members suffering from obesity (r = 0.192; p < 0.05).

For breastfeeding, the mean BMI SD was found to be lower in breastfed subjects (1.98 vs 2.03) (Table 4).

TABLE 4. BMI SD average ± SD and breastfeeding

	Average	SD
< 1 mo	2.01	0.47
1-6 mo	2.03	0.53
> 6 mo	2.12	0.49

The presence of an association between breastfeeding and weight increase (expressed as BMI SD) was investigated. Lactation was evaluated both as a dichotomous variable (present or absent) and by dividing the children into three groups: breastfeeding less than one month or absent, breastfeeding between one month and 6 months and breastfeeding for more than six months. The Kruskal-Wallis test and the post hoc Conover with more codifications were then applied but no significant associations emerged (p = 0.555 in both cases).

Maternal smoking during pregnancy and high BMI was another variable investigated. Although a higher mean BMI SD in the smokers group was observed compared to nonsmokers (1.99 vs 2.03), this was not statistically significant.

However, a statistically significant association was observed between BMI SD and gestational diabetes in pregnancy (r = 0.186, p <0.05).

Late risk factors

In the second part of the questionnaire the presence of the following incorrect lifestyle habits was evaluated: consumption of carbonated drinks and/or fruit juices per week, little physical activity (hours/week), sedentariness, inadequate nighttime sleep (hours/night), hours of afternoon sleep, consumption of snacks (per week) and low consumption of fruit and vegetables (weekly).

Only 12.14% of the sample said they did not consume carbonated soft drinks, and 39% drank them at least once a week, with an average of 3.74±4.26 drinks per week. 10% of the sample consumed fruit juices with an average of 4±4.39 cartons per week. 98% of the children interviewed consumed sweet and/or savory snacks at least once a week, with an average of 6.92±10.36; 52.86% of the sample consumed more than the average. 83.14% of the sample did not consume the recommended amount of fruit and vegetables per week (<3-4 portions/day) and 9% did not consume any at all; the average amount consumed by the sample was 7.64±6.67 per week. Over half (52.14%) the sample

skipped breakfast. A statistically significant association emerged between weight classification (overweight/obese) and the consumption of carbonated drinks, less than twice, more than twice and over six times per week (χ^2 = 7.77483, p <0.05); snack consumption, less than once, between 2 and 6 times and over 6 times per week (χ^2 = 6.210, p <0.05). A positive correlation was also found between the number of carbonated drinks and BMI SD (r = 0.228, p <0.01).

14% of the sample did not engage in any physical activity and in 78.57% of cases the number of hours spent on recreational activities was less than 7 hours per week, with an average of 3.36±2.04.

On investigating the hours spent in sedentary activities (screen time, etc.), it was observed that only 20.71% of the sample limited their time to that recommended by the guidelines, with a daily average of 2.71±1.44 hours.

Statistically significant associations were observed on comparing the BMI SD with physical activity levels (less than two hours, 2-3 hours, 4 hours per week) (χ^2 = 14.9491; p <0.001).

17.86% of the children interviewed reported sleeping less than eight hours a night, with an average duration in the sample of 9.12±7.03 hours of rest, 89.29% did not rest in the afternoon. No statistically significant differences were found between the BMI SD of obese and overweight subjects in relation to number of sleep hours. However, BMI SD was observed to increase significantly as the number of hours of sleep in the afternoon increased (r=0.210; p<0.05).

Following the protocol adopted by pediatricians haematochemical tests were conducted only on children with severe obesity. Tests were required for only 9% of the sample and values obtained from these were not normally distributed (Table 5).

TABLE 5 . Median and IQR of haematochemical tests

Haematochemical tests	Median	IQR
Total cholesterol	147.5	26
Triglycerides	74	44
HDL	41	16
Glycemia	82	7

5% of the sample had already developed complications, namely hyperinsulinemia, metabolic syndrome and early puberty. 9% of parents said that their child had difficulties in socializing with peers due to the problem of overweight/obesity.

DISCUSSION

In our sample, which investigated only children diagnosed with overweight/obesity, we highlighted the presence among children of incorrect eating habits such as skipping breakfast (52% of the sample). The literature describes how the frequency of daily meals and skipping breakfast are both factors linked to the risk of overweight/obesity and to a higher body mass index at any age. Although the mechanisms underlying the phenomenon are not yet known, the role of parents in food choices has been implicated. In our sample these habits appeared to be related to low education level of the parents, in particular the mother, the main parental figure involved in child-rearing [35-42].

Another problem regarding eating habits detected in our sample was an inadequate, sometimes even zero, consumption of fruit and vegetables [8]. An extremely high percentage of our sample consumed carbonated and/or sweetened drinks and sweet/savory snacks (>80-90%), suggesting inadequate management of food choices by parents before the start of diet therapy provided by the dietician, as confirmed by the literature [8]. This factor affects the child's pathological condition and the linear correlations found suggest it could be ascribed to the low education level of the parents. These results are alarming given that the recommended intake according to the guidelines is 5 portions of fruit and vegetables per day [42].

Physical inactivity and sedentary behavior were both also high: 14% of the sample did not do any physical activity and 12% did so for only one hour per week and 79.29% did not limit their screen time to two hours a day, as confirmed by the Okkio health project.

Overweight and obesity in children and young people was found to be associated with a low education level of parents in our sample. This finding is confirmed by the existing literature, which shows how the level of schooling may be a factor associated with a greater development of excess weight [3, 32, 44].

We found that the level of parental education (low or high) influenced the intake of obesogenic foods in children according to the IDEFICS study (Identification and prevention of Dietary and lifestyle-induced health EFfects In Children and infants) [45]. The association between maternal smoking during pregnancy and childhood obesity was another factor studied as this link has been confirmed by several international studies. Maternal smoking during pregnancy is correlated with low neonatal weight, while during the first year of life, the offspring of mothers who smoked during pregnancy rapidly recovered their growth and this is correlated with higher BMI.

In our study, breastfeeding was not correlated with greater weight gain as no differences were found between obese and overweight subjects. Nevertheless, breastfeeding is a protective factor for the development of overweight/obesity since higher levels of adipose accumulation are found in subjects fed with formula. The protective effect may act against the development of obesity, but not the degree of obesity and other factors, both genetic and behavioral, undoubtedly play a decisive

role in its development. Breastfeeding is therefore essential and, according to the WHO, children should be breastfed naturally for the first 6 months, then on supplementing the diet with other nutrients for up to (or beyond) the first 2 years of life. Breast milk is in fact considered the ideal food for children as it provides adequate energy and nutritive intake while reducing, due to the presence of antibodies, the risk of neonatal infection, gastrointestinal conditions and pneumonia in childhood [46].

In our sample, 9% had already developed some conditions that are known to be related to excessive fat accumulation [47-53].

The final problem highlighted was the presence of socialization disorders in our sample, confirming what is evident elsewhere in the literature: overweight children run a higher risk of suffering low self-esteem and poor emotional well-being, and have poorer social skills and/or social difficulties, approaching levels of clinical depression and anxiety [54-57].

CONCLUSION

The results of our study suggest a potential link between the parents' education level and unhealthy lifestyle behaviors, particularly incorrect eating habits and physical inactivity. Clearly, it is the mother, the main childcare provider, who determines the eating habits of her offspring. In our study this is supported by the highly significant statistical associations found between maternal education level and some risk factors for obesity. Fortunately, these are modifiable behaviors which may be targeted in childhood obesity prevention programs.

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Abbreviations

United Nations Children's Fund (UNICEF)
World Health Organization (WHO)
Body mass index (BMI)
European Union (EU)
National Prevention Plan (PNP)

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