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Behavioral, socio-environmental, educational and demographic correlates of excess body weight in Italian adolescents and young adults

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Abstract *Background and Aims:* Excess body weight (EBW) is the most prevalent nutritional disorder among adolescents worldwide. Identifying determinants of EBW may help find new intervention strategies. Behavioral, socio-economic, educational and demographic correlates of EBW were examined in a population of Italian adolescents, separately for males and females.
Methods and results: As many as 1039 male and 2052 female students (aged 16–19 ys) attending the last three years of different types of high-school of the Emilia-Romagna region in Italy were offered participation, with 552 males and 841 females being finally evaluated. The prevalence of EBW was 21.0% in males and 14.1% in females. Step-wise multivariate logistic regression analyses were performed showing that EBW was negatively related to energy intake in males (odds ratio for 100 kcal/day (OR) = 0.94, 95% confidence interval (CI): 0.89 to 0.98; P = 0.008), and to father's educational attainment (OR = 0.70, 95% CI: 0.52 to 0.95; P = 0.020), but positively related to parental obesity (OR = 2.80, 95% CI: 1.65 to 4.76; $P < 0.001$). In females, EBW was positively related to parental obesity (OR = 1.94, 95% CI: 1.15 to 3.29; P = 0.013), but negatively to mother's educational attainment (OR = 0.66, 95% CI: 0.45 to 0.97; P = 0.034) and type of attended school (OR = 0.66, 95% CI: 0.49 to 0.89; P = 0.007). Mother's occupation was also an independent determinant of EBW status in females (OR = 0.39, 95% CI: 0.18 to 0.85; P = 0.018 for being unemployed *vs* blue-collar).
Conclusion: Parental obesity is associated with EBW in male and female adolescents. Importantly, we found sex differences in socio-economic and educational factors impacting on EBW, supporting possible distinct area of investigation.

Introduction

Excess body weight (EBW) is the most prevalent nutritional disorder among adolescents throughout the world and it has been associated with adverse implications for health, with a higher risk of morbidity and mortality as obese adolescents are likely to be obese in adulthood [1]. Although the gap between energy input and energy

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expenditure plays a major role in the development of EBW, energy balance is not the solely player [2]. In fact, obesity is a multifactorial disorder in which genetic and hormonal as well as environmental and psychological (such as chronic stress) causative factors are involved, with a great inter-individual variability. Moreover, an emerging body of epidemiological evidence suggests that the etiology of obesity may differ significantly between different populations, implying the need to target different causative factors for different ethnicities and/or countries [3].

Evidence regarding specific factors that promote weight gain in adolescents is more limited than in adult individuals, and most cross sectional or prospective studies have analyzed populations within a wide age range [4]. A negative association between EBW and the familial socioeconomic status has been published in adolescents belonging to developed countries [5]. In Italy the available data on this topic are very few and specific to define geographic area that only partially reflects the economic/political status of all country [6,7].

Puberty is a critical phase characterized by intensive growth and modifications of body composition [8], and also by dramatic behavioral changes, driven by the need for independence from parents [9]. Moreover, determinants of EBW may differ according to age and sex.

Few years ago, we performed an epidemiological study in a large population of late adolescent-young adult males and females aged 16–19 years from Emilia-Romagna (Italy), aimed at investigating the prevalence of altered sex steroid profiles and EBW together with a list of potential correlates. Data on the prevalence of hyperandrogenic states in female students and on their psychological correlates have been published in the recent years [10]. In the present study, for the first time, we evaluated the prevalence of EBW in males and females adolescents of a specific Italian region (Emilia-Romagna), that represent economically one of the most advanced region of Italy and, according to Italian National Institute of Statistics (ISTAT) data, the northern region with the higher prevalence of EBW [11]. In addition, a list of its possible correlates including nutritional, parental, behavioral, educational and socio-environmental features was also investigated.

Methods

Study design

The study data were obtained from a survey on the students attending the last three years of different types of high-schools of two provinces (Bologna and Forlì-Cesena) of the Emilia-Romagna region in Italy, from October 2007 to November 2008 [10]. The study protocol was designed with increasing levels of participation: (i) the first level consisted of a self-compiled questionnaire collecting socio-demographic background and physical activity; (ii) the second level added a medical examination with a structured interview and a physical examination; (iii) the third level of participation consisted of blood sampling for laboratory testing. Each evaluation was performed in the morning during school hours [10]. Subjects included in this study fulfilled the first and the second level of participation (Fig. 1). The participation to the study was voluntary and required parental approval.

Ethics

The study was conducted according to the ethics guidelines of the "World Medical Association" Declaration of Helsinki. The study protocol was approved by the Institutional Review Board of S. Orsola-Malpighi Hospital. Participants gave their written informed consent (in the case of minors, parents signed an appropriate consent form).

Questionnaires (first level of participation)

Socio-environmental items included: (i) family structure (coded as nuclear family or other: reconstituted family, single-parent-family or living together with grandparents or other relatives); (ii) parental occupational category (coded as blue-collar, sales/office, management/professional and being unemployed); (iii) house size (categorized into: <100 m^2, 100–150 m^2, >150 m^2) and ownership. Educational items included: (i) parental education (categorized according to the highest achieved educational level: elementary, lower secondary, higher secondary, or tertiary education, i.e. specialization/college/university); (ii) self-reported school performance (coded as insufficient, sufficient, good, very good).

Leisure-time and sport physical activities were collected by a standard Baecke questionnaire on 5-point scales and the sum of the three partial scores was used as an overall score of activity [12].

Medical examination and interview

A structured interview was carried out to collect data on drug consumption (including hormonal contraceptives and illegal drugs) and personal and familial history of diseases. Family history of obesity or type 2 diabetes (T2D) was registered only for first degree parents (father or mother or both). Parental body mass index (BMI) was calculated from reported weight and height (weight/height; kg/m^2) and values ≥ 30 kg/m^2 for father, mother or both were used to define obesity. Parental body weight and height were collected from each student at home and reported the day after.

Anthropometry

Height and weight were measured and BMI calculated. We used sex- and age-independent BMI standard deviation scores (BMI-SDS), calculated by the LMS method according to Cole [13], using Central–North Italy reference charts [14]. In brief, the LMS method summarizes the distribution of BMI at each age by its median (M) and coefficient of variation (S), plus a measure of skewness based on the Box–Cox power (L) required to transform the data to normality. The allocation to the respective BMI category

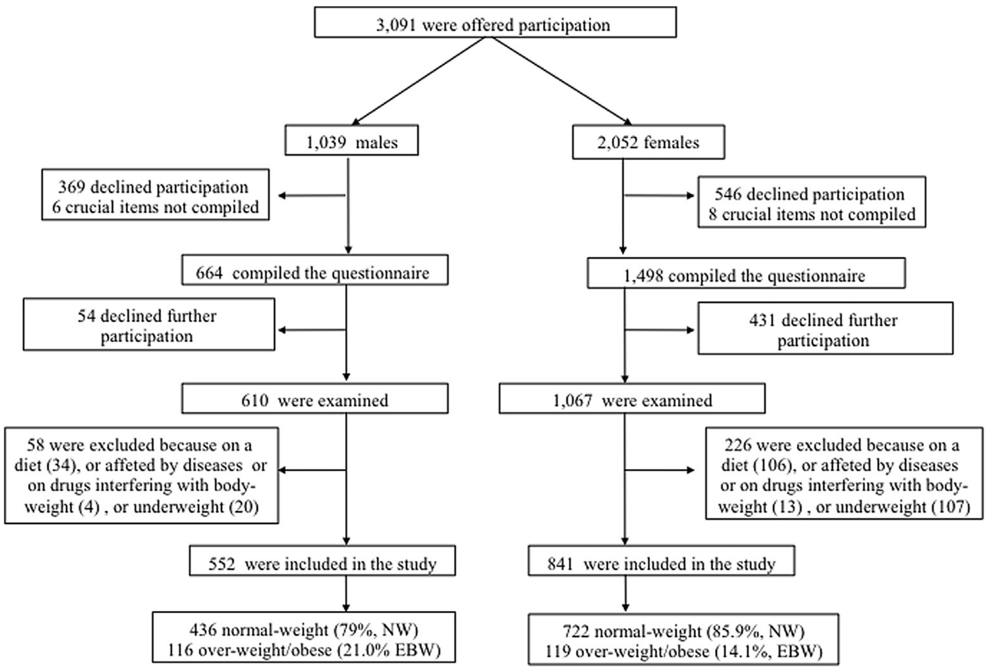

Figure 1 Flow of the study participant.

(underweight, normal weight, overweight or obese) was done. For the purpose of the study the underweight subjects were excluded from the analysis (Fig. 1), whereas overweight and obese subjects were included as a single category defined as EBW. Waist and hip circumferences were measured and the waist-to-hip ratio (WHR) was calculated accordingly to the Wealth Health Organization (WHO) report.

A bioimpedentiometric estimate of fatty mass was also performed with a single-frequency 50 kHz bioelectrical impedance analyzer (BIA 101 RJL, Akern Bioresearch, Florence, Italy) according to the standard tetrapolar technique. Body composition was calculated by applying the software provided by the manufacturer, which incorporated validated predictive equations for total body water, free fatty mass, and fatty mass (FM) was calculated by subtraction and expressed as percent.

Dietary assessment

Dietary habits were investigated by multiple 24-hour dietary recall and food frequency questionnaire (FFQ) [15]. The dietary recall was performed during a face-to-face interview with four trained dieticians; each participant was asked to recall his/her meals (foods and portion sizes) on 3 non-consecutive days (including a weekend day). The FFQ was additionally administered in order to estimate correspondence to average meals. The dietitians checked the questionnaire for completeness and plausibility. Energy intake analysis [total energy intake (kcalories/day) and percent energy from proteins, lipids and carbohydrates] was carried out using a software which is specific for the analysis of Italian food habits (WinFood, 2; Medimatica, Martinsicuro, TE, Italy) validated in 2008 by the Dietary and Clinical Nutrition Italian Association and already used in other Italian studies [16]. The values were calculated for each participant from the mean of the three 24-h recalls.

Domain description

In order to figure out which were the main determinants of EBW, the study variables were merged in four domains: a) "behavioral" domain, which includes energy intake, physical activity, use of hormonal contraceptives and illegal drugs; b) "parental" domain, comprising parental history of T2D and parental obesity; c) "socio-environmental" domain, including family structure, parental occupational category, house size and ownership; d) "educational" domain, comprising the type of school attended, school performance and parental education.

Statistics and data analysis

Mean $\pm$ standard deviation (SD) and absolute and relative frequencies were used as descriptive statistics. Since age plays an important role in anthropometry in adolescence [8], age was tested by means of a one-way ANOVA and was considered as covariate in all the analyses. One-way ANCOVA adjusted for the age of the population was applied to test all the descriptive characteristics between EBW and normal weight (NW) while the relationships between pairs of variables were evaluated by means of ANOVA, chi−squared test and linear by linear association according to the type of variables analyzed.

Bivariate logistic regressions adjusted for age were used to compare the entire set of variables of the four domains between EBW and NW. The independent variables of the four domains were identified by applying a multivariate logistic regression model. We chose a two-step model in order to limit the loss of cases due to the presence of missing data in the multivariate logistic regressions. In the first step, one forward step-wise regression for each of the four domains was made by including age together with all the variables of the domain that proved significant at the previous bivariate analyses. This step allowed us to identify the set of variables with an independent role within each domain. In the second step, one forward step-wise multivariate logistic regression was made by including all the variables of the four domains that proved significant at the first step. This step allowed us to identify the entire set of variables with an independent role. In addition, in order to account for the potential intercorrelations between variables of different domains, a multivariate logistic regression was made within each sex considering all the independent variables and their interactions.

The odds ratios (OR) computed by the logistic regressions were reported together with their 95% confidence intervals (95% CI). These ORs represent the increase of the risk of EBW related to the increase of one unit of the value of the variable in case of scalar variables of the four domains, while the ORs represent the risk of EBW of each category *versus* a reference category in the case of discrete variables of the four domains. Finally, a multivariate logistic regression was performed considering gender, age, as well as the variables resulted independent both in male and female together with their interactions with gender, in order to identify factors influencing body weight in a different manner between sexes.

Data were managed and analyzed by using the IBM-SPSS Statistics package (IBM Co., Armonk, NY, USA, Version 23) and two-tailed P values less than 0.05 were considered significant.

Supplemental analysis: adjustment of energy intake data for basal metabolic rate (BMR)

In order to take into account the role of implausible energy reporting the basal metabolic rate (BMR) was computed according to the Harris-Benedict equation revised by Mifflin and St Jeor [17] together with the physical activity level (PAL) according to Black [18] and the bivariate logistic regression adjusted for age comparing energy intake data between NW and EBW were replaced by trivariate analyses adjusted for age and BMR values too.

Power analysis

The power analysis was based on the estimation of the 95% CI of the hypothesized prevalence of EBW in adolescent and young adults by using the formula $p \pm z\,(p\,(1\text{-}p)/n)^{1/2}$ where p is the hypothesized prevalence, n is the sample size and z is the desired confidence level (i.e., z = 1.96). Since literature data stratified by gender [19–21] showed that prevalence of EBW ranged 28.5–33.9% in males and 16.2–21.7% in females, by considering the sample size of our study (1039 males and 2052 females) the true proportion of EBW would be between ±3.8–3.9% and ±2.5–2.8% in males and females, respectively. These data represent an accurate estimation of the prevalence showing that the study was adequately powered.

Results

Participants and classification

Participation was offered to 1039 male and 2052 female high school students. As shown in Fig. 1, three hundred and sixty-nine males and 546 female students declined participation and 6 males and 8 females were excluded because of missing crucial items in the questionnaire. The reasons of decline were the lack of parental approval to participate into study. Fifty-four males and 431 females did not attend the medical examination (the second level of participation) after having compiled the questionnaire; thus the reasons of drop-out are not available. In conclusion, 610 male students and 1067 female students completed the study protocol. We excluded 4 males and 13 females for diseases or drug treatments interfering with body weight (2 affected by anorexia, 2 with growth retardation, 5 taking insulin for type 1 diabetes, 1 taking chronic corticosteroids for congenital adrenal hyperplasia, and 7 taking anti-epileptic drugs). We also excluded 34 males and 106 females who were on diets at the time of the survey. For the purpose of this study, we excluded all students who were underweight (males: n = 20/572, 3.5%; females: n = 107/948, 11.3%). Thus, a total of 552 males and 841 females were evaluated. None of the female participants was pregnant or breastfeeding. The prevalence of EBW was 21.0% (116/552; 100 overweight and 16 obese) and 14.1% (119/841; 101 overweight and 18 obese) in males and females, respectively. According to weight categories, age and anthropometric parameters of male and female participants are shown in Table 1. A small but significant age difference between NW and EBW male students was found: therefore, all the analyses were adjusted for age in both male and female groups. As expected, compared to their NW counterparts, the anthropometric and FM measurements were significantly higher in EBW groups.

Behavioral domain

Behavioral factors are summarized in Table 2a. Compared to NW students, total energy intake was significantly lower in both EBW males (OR = 0.94, 95% CI 0.90 to 0.98; P = 0.003) and females (OR = 0.94, 95% CI 0.89 to 1.00; P = 0.039), whereas no difference in percent energy from fats, proteins and carbohydrates was found. Physical activity, evaluated by total Baecke score, was similar between EBW and NW groups. Cannabis users were equally distributed between EBW and NW (none of the students declared consumption of other illegal drugs) and the use of hormonal contraceptives was similar between EBW and NW female students. Therefore, in both male and female

Table 1 Descriptive characteristics of male and female students categorized in normal weight (NW) and weight excess (EBW: overweight/obese) groups.

Variables	Males			Females		
	NW (n = 436)	EBW (n = 116)	*P-value*	NW (n = 722)	EBW (n = 119)	*P-value*
Age (yr)[a]	17.8 ± 0.9	18.0 ± 1.1	**0.020**	17.6 ± 1.0	17.6 ± 1.0	0.882
Weight (kg)[b]	68.4 ± 6.8	86.6 ± 10.1	**< 0.001**	57.2 ± 6.2	74.0 ± 10.2	**< 0.001**
BMI (kg/m^2)[b]	21.7 ± 1.6	27.3 ± 2.6	**< 0.001**	21.2 ± 1.7	27.7 ± 2.7	**< 0.001**
Waist circumference (cm)[b]	77.6 ± 5.8	90.6 ± 8.2	**< 0.001**	74.2 ± 6.2	88.0 ± 8.6	**< 0.001**
Hip circumference (cm)[b]	91.8 ± 8.0	103.1 ± 7.4	**< 0.001**	91.8 ± 6.4	104.0 ± 9.0	**< 0.001**
WHR[b]	0.85 ± 0.05	0.88 ± 0.06	**< 0.001**	0.81 ± 0.06	0.85 ± 0.07	**< 0.001**
Fatty mass (%)[b,c]	11.4 ± 9.0	20.8 ± 9.5	**< 0.001**	15.8 ± 7.5	27.9 ± 8.3	**< 0.001**

BMI: body mass index; WHR: waist-to-hip ratio.
[a] One-way ANOVA.
[b] One-way ANCOVA adjusted for age.
[c] Measured by bioimpedentiometry.

students, total energy intake only was significantly and inversely related to EBW within the behavioral domain.

Parental domain

Parental obesity was significantly higher in EBW compared to NW males (OR = 2.77, 95% CI 1.67 to 4.61; $P < 0.001$) and females (OR = 2.15, 95% CI 1.33 to 3.46; P = 0.002). On the contrary, no significant difference in parental history of T2D was found between NW and EBW students of both sexes (Table 2b).

Socio-environmental domain

Socio-environmental factors are summarized in Table 2c. EBW females were less likely to be part of a nuclear family than NW (OR = 0.58, 95% CI 0.35 to 0.95; P = 0.031), whereas no difference in family structure was found in male students. A significant correlation between father's occupational class and EBW was found only in males (P = 0.040); in fact, students whose father was classified as management/professional were at a lower risk of having EBW compared to those whose father was a blue-collar (OR = 0.50, 95% CI 0.28 to 0.88; P = 0.017). On the contrary, mother's occupational class correlated with the prevalence of EBW in females only (P = 0.002). In fact, female students whose mother was classified as sales/office (OR = 0.50, 95% CI 0.31 to 0.79; P = 0.003), management/professional (OR = 0.45, 95% CI 0.22 to 0.92; P = 0.029), or being unemployed (OR = 0.37, 95% CI 0.19 to 0.73; P = 0.004) were all at lower risk of having EBW compared to those whose mother was a blue-collar. House size was not significantly different between EBW and NW groups, whereas house ownership was less frequently declared by EBW *vs* NW females (OR0.50, 95% CI: 0.30 to 0.82; P = 0.006), while no significant difference was found in males.

Since father's occupational class was the only variable significantly related to EBW in the male group, and three socio-environmental factors were significantly related to EBW in females (part of a nuclear family, mother's occupational class and house ownership) a multivariate analysis of these three factors was made in females. House ownership did not reach statistical significance, whereas mother's occupational class (P = 0.003) and being part of a nuclear family (OR = 0.58: 95% CI: 0.34 to 0.99; P = 0.047) resulted independently related to EBW in females. Regarding mother's occupational class, sales/office (OR = 0.49, 95% CI: 0.31 to 0.78; P = 0.003), management/professional (OR = 0.48, 95% CI: 0.24 to 0.99; P = 0.047), and being unemployed (OR = 0.38, 95% CI: 0.19 to 0.77; P = 0.008) showed a lower risk of EBW compared to blue-collar.

Educational domain

As shown in Table 2d, no association was found between the type of school attended and EBW status in male students. At variance, EBW females were less likely to attend a lyceum than their NW counterparts (OR = 0.61, 95% CI: 0.48 to 0.76; $P < 0.001$). In both sexes, no significant differences in school performances were found between NW and EBW students. EBW male and female students were less likely than NW peers to have a father with high educational attainments (OR = 0.67, 95% CI: 0.51 to 0.88; P = 0.004; OR = 0.70, 95% CI: 0.54 to 0.91; P = 0.007; respectively), whereas an inverse correlation between mother's education and EBW reached significance in the female group (OR = 0.60, 95% CI: 0.46 to 0.78; $P < 0.001$).

Similarly to the results obtained in the socio-environmental domain, one educational factor was significant in males (father's education), whereas in females three educational factors were significantly different between NW and EBW (attended school, and father's and mother's education), although attended school only (OR = 0.66; 95% CI: 0.51 to 0.85; P = 0.001) and mother's education (OR = 0.73, 95% CI: 0.55 to 0.97; P = 0.029) proved to be independent factors associated with EBW in multivariate analysis in females.

Domain analysis

Table 3 shows the results of the multivariate analysis of all the variables within the four domains which were independently related to EBW, separately in males and females.

Table 2 Behavioral, familial, socio-environmental and educational characteristics in male and female students categorized in normal weight (NW) and weight excess (EBW: overweight/obese) groups.

Variables	Males				Females			
	NW (n = 436)	EBW (n = 116)	OR (95% CI)	*P-value*	NW (n = 722)	EBW (n = 119)	OR (95% CI)	*P-value*
a) BEHAVIORAL DOMAIN								
Energy intake:	n = 426	n = 116			n = 686	n = 113		
Total (kcal/day)[a]	2429 ± 511	2255 ± 490	0.94 (0.90–0.98)	**0.003**	1927 ± 391	1845 ± 405	0.94 (0.89–1.00)	**0.039**
- proteins (%)[b]	15.1 ± 2.0	15.2 ± 2.2	0.98 (0.88–1.09)	0.661	14.9 ± 2.5	14.9 ± 2.4	0.99 (0.91–1.07)	0.818
- lipids (%)[b]	35.0 ± 4.9	35.5 ± 5.6	1.02 (0.98–1.06)	0.349	35.9 ± 5.7	35.8 ± 6.0	1.00 (0.96–1.03)	0.784
- carbohydrates (%)[b]	49.9 ± 5.1	49.5 ± 5.9	0.99 (0.95–1.03)	0.514	49.2 ± 5.9	49.4 ± 6.4	1.01 (0.97–1.04)	0.741
Physical activity:	n = 430	n = 114			n = 683	n = 109		
Baecke's total score[c]	7.5 ± 1.1	7.6 ± 1.0	1.03 (0.85–1.25)	0.783	7.1 ± 1.1	6.9 ± 1.1	0.85 (0.71–1.02)	0.080
Drug use:								
Cannabis addiction	65/432 (15.0%)	18/115 (15.7%)	0.96 (0.54–1.71)	0.901	58/711 (8.2%)	14/115 (12.2%)	1.56 (0.84–2.91)	0.158
Hormonal contraceptives	–	–		–	162/722 (22.4%)	22/119 (18.5%)	0.77 (0.46–1.27)	0.306
b) PARENTAL DOMAIN								
Parental obesity	58/369 (15.7%)	33/97 (34.0%)	2.77 (1.67–4.61)	**< 0.001**	103/584 (17.6%)	31/98 (31.6%)	2.15 (1.33–3.46)	**0.002**
Parental DM2	20/420 (4.8%)	9/108 (8.3%)	1.74 (0.76–3.97)	0.188	40/690 (5.8%)	9/114 (7.9%)	1.39 (0.66–2.96)	0.388
c) SOCIO-ENVIRONMENTAL DOMAIN								
Nuclear family	384/434 (88.5%)	102/115 (88.7%)	1.13 (0.59–2.18)	0.715	623/715 (87.1%)	94/118 (79.7%)	0.58 (0.35–0.95)	**0.031**
Father's occupational class:[d]	n = 422	n = 111		**0.040**	n = 703	n = 114		0.273
- Blue-collar	150 (35.5%)	46 (41.4%)	Reference	–	368 (52.3%)	69 (60.5%)	Reference	–
- Sales/office	135 (32.0%)	44 (39.6%)	1.14 (0.70–1.84)	0.600	199 (28.3%)	31 (27.2%)	0.83 (0.52–1.31)	0.420
- Management/professional	134 (31.8%)	20 (18.0%)	0.50 (0.28.0.88)	**0.017**	127 (18.1%)	13 (11.4%)	0.54 (0.29–1.02)	0.057
- Unemployed	3 (0.7%)	1 (0.9%)	1.14 (0.12–11.3)	0.909	9 (1.3%)	1 (0.9%)	0.60 (0.07–4.78)	0.625
Mother's occupational class:[d]	n = 431	n = 114		0.871	n = 708	n = 114		**0.002**
- Blue-collar	118 (27.4%)	30 (26.3%)	Reference	–	244 (34.5%)	61 (53.5%)	Reference	–
- Sales/office	166 (38.5%)	43 (37.7%)	1.04 (0.62–1.76)	0.883	258 (36.4%)	32 (28.1%)	0.50 (0.31–0.79)	**0.003**
- Management/professional	87 (20.2%)	21 (18.4%)	1.00 (0.53–1.87)	0.997	88 (12.4%)	10 (8.8%)	0.45 (0.22–0.92)	**0.029**
- Unemployed	60 (13.9%)	20 (17.5%)	1.29 (0.67–2.46)	0.445	118 (16.7%)	11 (9.6%)	0.37 (0.19–0.73)	**0.004**
House size:[e]	n = 420	n = 107	1.03 (0.76–1.41)	0.834	n = 653	n = 100	0.81 (0.61–1.08)	0.153
- Less than 100 m^2	73 (17.4%)	12 (11.2%)			104 (15.9%)	26 (26.0%)		
- 100–150 m^2	183 (43.6%)	60 (56.1%)			273 (41.8%)	33 (33.0%)		
- More than 150 m^2	164 (39.0%)	35 (32.7%)			276 (42.3%)	41 (41.0%)		
House ownership	386/430 (89.8%)	103/112 (92.0%)	1.40 (0.66–2.98)	0.387	625/711 (87.9%)	91/116 (78.4%)	0.50 (0.30–0.82)	**0.006**
d) EDUCATIONAL DOMAIN								
Attended school:[e]	n = 435	n = 116	0.86 (0.64–1.16)	0.333	n = 722	n = 119	0.61 (0.48–0.76)	**< 0.001**
- Professional institute	55 (12.6%)	18 (15.5%)			155 (21.5%)	46/(38.7%)		
- Technical institute	122 (28.0%)	41 (35.3%)			172 (23.8%)	29 (24.4%)		
- Lyceum	258 (59.3%)	57 (49.1%)			395 (54.7%)	44 (37.0%)		
School performance:[e]	n = 434	n = 112	0.84 (0.64–1.11)	0.226	n = 715	n = 117	0.78 (0.58–1.04)	0.086
- Insufficient	36 (8.3%)	9 (8.0%)			27 (3.8)	3 (2.6%)		
- Sufficient	184 (42.4%)	55 (49.1%)			248 (34.7)	52 (44.4%)		
- Good	177 (40.8%)	44 (39.3%)			378 (52.9%)	57 (48.7%)		
- Very good	37 (8.5%)	4 (3.6%)			62 (8.7%)	5 (4.3%)		
Father's education:[e]	n = 412	n = 110	0.67 (0.51–0.88)	**0.004**	n = 683	n = 111	0.70 (0.54–0.91)	**0.007**
- Elementary	13 (3.2%)	4 (3.6%)			41 (6.0%)	9 (8.1%)		
- Lower secondary	102 (24.8%)	44 (40.0%)			234 (34.3%)	52 (46.9%)		

- Higher secondary	190 (46.0%)	46 (41.9%)			309 (45.2%)	40/(36.0%)		
- Tertiary	107 (26.0%)	16 (14.5%)			99 (14.5%)	10 (9.0%)		
Mother's education:[e]	n = 416	n = 110	0.77 (0.58−1.03)	**0.077**	n = 686	n = 116	0.60 (0.46−0.78)	**<0.001**
- Elementary	9 (2.2%)	3 (2.7%)			31 (4.5%)	12 (10.3%)		
- Lower secondary	105 (25.2%)	38 (34.5%)			199 (29.0%)	47 (40.5%)		
- Higher secondary	210 (50.5%)	52 (47.3%)			359 (52.4%)	48 (41.4%)		
- Tertiary	92/(22.1%)	17 (15.5%)			97 (14.1%)	9 (7.8%)		

Media ± SD values, as well as, absolute and relative frequencies are shown in the table.
In all the analysis a logistic regression adjusted for age was applied.
[a] The OR shows the risk related to an increase of total energy intake equal to 100 kcal/day.
[b] The ORs show the risk related to an increase in % energy from proteins, lipids, and carbohydrates equal to 1%.
[c] The OR shows the risk related to an increase of Baecke's total score equal to one unit.
[d] Blue collar as reference category.
[e] The ORs show the risk related to the increase of one category.

Age was also considered in the analysis but did not enter the stepwise procedure. In male students, EBW was negatively related to energy intake (OR = 0.94, 95% CI: 0.89 to 0.98; P = 0.008 for higher *vs*. lower energy intake) and father's educational attainment (OR = 0.70, 95% CI: 0.52 to 0.95; P = 0.020 for higher vs. lower attainment), but positively correlated with parental obesity (OR = 2.80, 95% CI: 1.65 to 4.76; P < 0.001). In female students, EBW was positively associated to having one or both obese parents (OR = 1.94, 95% CI: 1.15 to 3.29; P = 0.013), but negatively related with mother's educational attainment (OR = 0.66, 95% CI: 0.45 to 0.97; P = 0.034 for higher vs. lower attainment) and type of attended school (OR = 0.66, 95% CI 0.49 to 0.89; P = 0.007). Moreover, mother's occupation too was an independent determinant of EBW in females (OR = 0.39, 95% CI 0.18 to 0.85; P = 0.018 for being unemployed *vs*. blue-collar).

As far as potential intercorrelations between variables are concerned, it was found that in females all the variables were significantly correlated to each other (all P value < 0.001, except for parental obesity vs mother's occupational class where P value was equal to 0.031), whereas in males only parental obesity was associated with father's education (P = 0.011). At the analysis comparing NW and EBV by taking into account also the interactions between all independent variables, in females parental obesity only entered the procedure together with the interactions of mother's education with both attended school (OR = 0.86, 95%CI: 0.79–0.94; P = 0.001) and mother's occupational class (overall p = 0.04; due to unemployed vs blue collar: OR = 0.67, 95%CI: 0.48–0.94; P = 0.018), while in male the interactions of father's education with both energy intake (OR: 0.98, 95%CI: 0.97–0.99; P = 0.001) and parental obesity (OR: 1.41, 95% CI: 1.17–1.70; P < 0.001) entered the procedure.

Factors influencing body weight in a different manner between males and females

Table 4 shows the results of multivariate analysis of the independent variables and the interaction with gender. Total energy intake (P = 0.002) and parental obesity (P < 0.001) were significantly related to EBW in the overall population only without significant relationship with gender, while mother's education (P = 0.005) and attended school (P = 0.009) showed significant interactions with gender. In particular, both mother's educational (OR = 0.83) and attended school (OR = 0.84) showed a negative relationship with EBW significantly more evident in female than in male.

Supplemental analysis: adjustment of energy intake according to basal metabolic rate (BMR)

BMR mean ± SD values were 1747 ± 130 kcal/day (range: 1393–2316 kcal/day) and 1372 ± 116 kcal/day (range: 1111–2159 kcal/day) in males and females, respectively while PAL values were 1.38 ± 0.31 (range: 0.61–2.68) and 1.41 ± 0.32 (range: 0.61–4.08), in males and females,

Table 3 Multivariate analysis of the independent variables related to EBW.

Males (n = 442)			Females (n = 615)		
Variables	OR (95% CI)	*P-value*	Variables	OR (95% CI)	*P-value*
Behavioral domain: Total energy intake	0.94 (0.89–0.98)	0.008	**Behavioral domain:** Total energy intake	–	–
Parental domain: Parental obesity	2.80 (1.65–4.76)	<0.001	**Parental domain:** Parental obesity	1.94 (1.15–3.29)	0.013
Socio-environmental domain: Father's occupational class	-	-	**Socio-environmental domain:** Part of a nuclear family	–	–
			Mother's occupational class:	–	0.017
			- Blue-collar	Reference	–
			- Sales/office	0.57 (0.32–1.04)	0.069
			- Management/professional	1.38 (0.58–3.30)	0.466
			- Unemployed	0.39 (0.18–0.85)	0.018
Educational domain: Father's education	0.70 (0.52–0.95)	0.020	**Educational domain:** Mother's education	0.66 (0.45–0.97)	0.034
			Attended school	0.66 (0.49–0.89)	0.007

Table 4 Multivariate analysis of the independent variables and their interaction with gender related to EBW.

All cases (n = 1040)		
Variables	OR (95% CI)	*P-value*
EFFECTS IN THE OVERALL POPULATION		
Behavioral domain: Total energy intake	0.95 (0.91–0.98)	0.002
Parental domain: Parental obesity	2.17 (1.49–3.15)	<0.001
INTERACTIONS WITH GENDER		
Educational domain: Mother's education	0.83 (0.73–0.95)[a]	0.005
Attended school	0.84 (0.74–0.96)[a]	0.009

[a] These ORs compare the effects of mother's education and attended school on EBW in females versus the same effects observed in males.

respectively. According to these values 400 (73.8%) out of 542 males and 571 (71.5%) out of 799 females may be considered underreporters considering the cut-off value of 1.55 of PAL proposed by Goldberg [22]. These figures are similar to those reported by Black et al. [18].

The analyses comparing energy intake data between NW and EBW shown in Table 2a were redrawn by adjusting for BMR values too. The ORs and P values related to energy intake data are shown in Table S1 while, as expected, BMR resulted highly significant ($P < 0.001$) in all these analyses. These analyses confirmed the results reported in Table2a; In fact, after adjusting for BMR, the OR of total energy intake in males was highly significant and further decreased (0.90 vs. 0.94) while in females it was similar (0.95 vs. 0.94) but not reaching the significant value (See Supplement data Table S1).

Discussion

This study evaluated for the first time the prevalence of EBW in a large population of adolescents and young adults of the Emilia Romagna region in Northern Italy and examined the association between weight status and behavioral, parental and socio-environmental and educational factors. Based on the well-known role of sex hormones on energy metabolism, body composition and inflammatory responses, we analyzed our population separately according to sex.

In our population we found an inverse relationship between risk of being overweight or obese and energy intake, which proved to be independently associated with EBW in the male group only. This is in contrast with the concept that dietary habits and physical activity are the main impacting factors on obesity, and that overweight and obese subjects consume more calories than lean individuals. However, these nutritional data need to be considered with caution even if not totally unexpected for the frequent underreporting and different perception of food intake by overweight-obese subjects. In fact, several previous studies have failed to detect associations between BMI and energy intake, specific nutrients, foods or dietary patterns [23,24]. In addition, other studies in overweight children and adolescents have repeatedly reported lower energy intake than their lean counterparts [25,26], suggesting a weight-dependent bias in self-estimating and reporting dietary intake. The rate of under-reporters varies between 5% and 50%, with higher values among the adolescent population and in overweight-obese versus

NW subjects [27,28]. A discrepancy between self-reported and objectively measured caloric intake in an adolescent population was estimated to reach an average 35% daily (range: 13–46%), with only a moderate relationship between objectively measured caloric intake and weight gain [29]. Furthermore, previous studies on the relationship between BMI and diet composition, physical activity, or other lifestyle-related factors in adolescent populations, showed conflicting results [30–35]. In order to ensure these data, we redrew the analyses comparing energy intake data between NW and EBW by adjusting for BMR values. Although the influence of BMR (which is always strongly linked to EBW) was removed, the effect of total energy intake in EBW vs. NW was confirmed negative (OR values lower than 1) in both males and females.

In addition in the present study we found no evidence, in either sex, of an association between BMI and percentage of energy intake from fat, carbohydrates and protein. Moreover, no significant differences between EBW and NW in physical activity levels, according to the Baecke questionnaire, and drug use (cannabis in male and female, or oral contraceptive in girls) were observed. Thus, our data support the concept that other factors do influence weight gain besides lifestyle.

In our male and female population, having one or both obese parents doubled the risk of being overweight/obese in both sexes, which may imply a role of genetic or epigenetic factors in determining the predisposition to develop EBW. This is not a new finding, since other studies, performed in others countries [36], confirmed that parental BMI was the strongest determinant of being overweight in children and adolescents. The complexity of potential factors responsible for the development of EBW in the adolescent is further amplified by the fact that socio-economic factors, that we included in the socio-environmental and the educational domains, were significantly associated with EBW, with some differences between male and female subjects. In fact, our data support the concept that the father's educational level is negatively correlated with EBW in males, whereas the mother's educational and occupational levels, as well as the type of school attended by the students have a significant impact on EBW in female adolescents. It is well known that socioeconomic disparity may play a critical role in determining EBW during childhood and adolescence [37]. Both overweight and obesity have been observed more frequently in the lower social classes of developed countries and in the upper social classes of poorer societies [38]. This may suggest that a higher level of education may provide specific knowledge about health and may therefore protect against the development of EBW [37]. Intriguingly, our data also support that both mother and father educational levels may play an important role during the transition phase from childhood years towards early adolescent years and also suggest that females seem to be more vulnerable than their male counterparts. In addition, education aside, it seems that other factors, such as parental occupation, may influence shared peer values and access to resources, therefore influencing weight control [39]. A protective role of advantaged education or higher personal educational attainment (which may be a consequence of attending a lyceum) on EBW in adolescence, considered as a single category [40,41] or stratified by sex [39,40] has been previously described.

Moreover, although we did not find a difference in energy intake between NW and EBW, our study shows an important influence of parental socio-economical status on body weight, in line with the recent results obtained in European adolescents by the Helena study group [42].

In Italy, the few and limited available data on this topic showed an higher prevalence of EBW in males than females generally with a gradient North-South (lower in the North and higher in the South) and with a negative association with a socio-demographic factors [6]. Each Italian region has a diverse economic pattern and food habits; in particular, Emilia-Romagna is economically one of the most advanced regions of Italy and, according to ISTAT data on adults, represents the northern region with the higher prevalence of EBW (45,1%) reaching values similar to the national average [11]. To our knowledge this is the first study conducted in Emilia-Romagna in a specific age range population (adolescents), showing similar results already observed in other Italian regions [7,19] and developed countries all around the world [5].

Overall, these findings support the need for well-defined long-term follow-up studies including both socio-environmental and educational factors in order to investigate the related risk of developing EBW in both males and females, in order to find whether a sex-specific pattern can emerge, as previously suggested [37].

In this study, we did not include the role of maladaptation to a chronic stress environment and individual perceived stress that have been repeatedly found to be potentially relevant in favoring the development of EBW and obesity in both adolescents and adult subjects [43–45]. The ability to adapt to chronic stress may differ according to sex, with specific pathophysiological events leading to the development of stress-related chronic diseases. This seems to be influenced by the regulatory effects of sex hormones [44].

Finally, the role of potential intercorrelations between variables may be likely excluded since we also made analyses that included the interactions between all variables showing similar results to what observed for simplicity merging the variables in four main domain.

Overall, this study has several strengths: (i) we examined a population of a specific Italian region, reflecting a particular socioeconomical status; (i) we enrolled a large sample size within a narrow age-range; (ii) we collected parental and adolescent anthropometric parameters and dietary intake by means of health professionals (iii); we used validated questionnaires to assess behaviors. However we are aware of several limitations. First, the observational nature of the data and the setting of the study (a specific Italian region with a group population in a determined age range) cannot be generalized (to the whole country population). Second, dietary intake and physical activity may have been misreported, therefore including potential drawbacks in the evaluation of the negative impact of the lifestyle domain on weight gain. On the other hand, the combination of multiple dietary recall, FFQ and Baecke's questionnaire have been validated and largely used as effective methods to collect data for large surveys [46]. Third, a possible bias related to body weight between the first and second levels of participations cannot be excluded, but not achievable for the unavailability of anthropometric data at the time of drop-out.

In conclusion, the approach based on the definition of different domains that we used in this study may help defining, apart from behavioral aspect related to food intake, the potential conditions represented by socio-environmental and educational factors correlated with EBW in both male and female students, able to determine synergistic effects favoring weight gain. Undoubtedly, these findings show the need of considering, together with the lifestyle behavior, the socio-environmental and educational factors when dealing with EBW in young adults.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.numecd.2018.11.009.

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