



Early Life Characteristics Associated with Appetite-Related Eating Behaviors in 7-Year-Old Children

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Objective To assess early life characteristics associated with appetite-related eating behaviors in 7-year-old children.

Study design The participants are children from the population-based birth cohort Generation XXI. Data on sociodemographics, health, and lifestyles and anthropometrics were collected at birth, and 4- and 7-year-old evaluations. A Portuguese version of the Children's Eating Behavior Questionnaire was completed by mothers ($n = 3562$ children) with children aged 7 years old. A 2-factor solution was identified: factor 1—appetite restraint and factor 2—appetite disinhibition. Associations were estimated through generalized linear models adjusted for maternal age, education, body mass index (BMI) before birth, family structure, number of siblings, and child's sex (β regression coefficients and 95% CIs).

Results Higher appetite restraint at 7 years old was associated with higher maternal age and educational level, families with both parents (1- vs 2-parent: $\beta = -0.074$, 95% CI $-0.140, -0.007$) and no siblings (≥ 2 vs 0: $\beta = -0.152$, 95% CI $-0.224, -0.081$), and more sedentary lifestyles at 4 years old. It was also associated with lower child and maternal BMI and waist circumference at 4 years old. In contrast, higher appetite disinhibition was associated with lower maternal educational background, having a 1-parent family, more sedentary behaviors (≥ 120 vs <120 min/d of media: $\beta = 0.055$, 95% CI $0.018, 0.093$), and higher BMI and waist circumference at 4 years old.

Conclusions Higher maternal age and education, and a family with both parents at 4 years old seem to influence higher appetite restraint, but less appetite disinhibition at 7 years old. More sedentary lifestyles at 4 years old were associated with higher appetite restraint and appetite disinhibition scores later in childhood. These results can be useful for the development of prevention guidelines and educational strategies aimed at improving healthy eating behaviors. (*J Pediatr* 2017;180:38-46).

Eating behaviors develop early in life and result from an interplay between genetic predisposition, natural food responses and preferences, and environmental influences.^{1,2} Individual differences in eating behaviors and appetite have been previously associated with differences in children's weight.³⁻⁵ Obese children show more positive responses toward food, hypothesized to promote food intake, and leaner children express more sensitivity to internal cues of satiety and food fussiness (consumption of an insufficient amount or inadequate variety of food through rejection of food items),⁶ which is likely to reduce food intake.^{4,5,7,8}

Some birth-related and early infancy characteristics have been proposed as potential influencers on the development of eating behaviors. Low birth weight,⁹⁻¹¹ preterm birth, and restrictive intrauterine growth¹² have been associated with later eating difficulty, pickiness, and a higher risk of low appetite and food enjoyment in childhood. Breastfeeding, hypothesized to promote early self-regulation of energy intake, has been associated with higher satiety responsiveness,^{13,14} in contrast to formula feeding, which is associated with picky eating¹⁵ (the consumption of an insufficient amount or inadequate variety of food through rejection of food items⁶) and neophobia.¹⁶

The familial environment also has a strong influence. Children who tend to overeat are more likely to be male, live in a single-parent home, and have both parents overweight or obese.¹⁰ In this study, family income was associated with both overeating and picky eating. In other studies, younger maternal age and parental financial problems have been identified as risk factors for picky eating,^{10,15} and having siblings has been shown to be both protective⁶ and a risk factor¹⁵ for developing picky eating. The aim of this prospective study is to assess early life characteristics associated with appetite-related eating behaviors at 7 years old.

BMI	Body mass index
CEBQ	Children's Eating Behavior Questionnaire
ICC	Intraclass correlation
PCAs	Principal component analyses
P-CEBQ	Portuguese version CEBQ
WC	Waist circumference

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Methods

This study includes children from Generation XXI, a prospective population-based birth cohort.¹⁷ Participants (8495 mothers and their 8647 children) were recruited from public maternity units in Porto, Portugal between 2005 and 2006 and were all invited to attend the second (2009-2011) and third (2012-2014) cohort evaluations, when children were aged 4 and 7 years old (86% and 80% of participation, respectively).

Responses to the Children's Eating Behavior Questionnaire (CEBQ) were available for 5786 children. Of these, 4485 questionnaires were entirely completed, and after retrieving missing data, 5449 were considered valid. Data were recovered in questionnaires that were missing <50% of data items, by replacement for the average of the remaining questions within each subdomain of the participant. Spearman-Brown prophecy formula showed that 50% of the items was enough to obtain a reliability of 0.7 (**Appendix**; available at www.jpeds.com). The sample was further restricted to 1 twin per family, randomly selected (103 children excluded, 1.19% of the initial sample), and to participants with complete information on the variables of interest (1887 children excluded, 21.8% of the initial sample), a total of 3562 participants.

We compared the study sample ($n = 3562$) characteristics with the remaining cohort ($n = 5085$) at baseline, and mothers in this study were slightly older (mean = 29.85; SD = 5.22 vs mean = 28.47; SD = 6.26; $P < .001$) and more educated (mean = 11.27; SD = 4.25 vs mean = 9.88; SD = 4.17; $P < .001$) than mothers in the remaining cohort.

All the study phases complied with the Ethical Principles for Medical Research Involving Human Subjects expressed in the Declaration of Helsinki. The study was approved by the University of Porto Medical School/S. João Hospital Center ethics committee and a signed informed consent, in accordance with Helsinki, was required for all participants, and signed by their legal guardian.

Data were collected during face-to-face interviews by trained researchers. At baseline, maternal age and education, smoking habits during pregnancy, type of delivery, children's sex, birth weight, and gestational age were recorded. Weight for gestational age was defined according to the sex-specific population-based Kramer growth standards (cut points: 10th and 90th percentiles; standards refer only to single births).¹⁸

At the 4-year-old evaluation, the number of siblings, family structure, any breastfeeding duration, physical activity, and number of media screening hours (television, computer, or game devices) were asked about. The timing of introduction to complementary feeding and the first food eaten in this period were asked about at 7 years old.

Height, weight, body fat, and waist circumference (WC) were measured at 4 and 7 years old according to standard procedures. The children's body mass index (BMI) was classified according to the age- and sex-specific BMI standard z-scores developed by the World Health Organization¹⁹ and recoded into

under/normal weight (BMI <2 SD) and overweight/obese (BMI \geq 2 SD). WC was measured at the umbilicus level, to the nearest 0.1 cm. This variable was recoded into tertiles (<50.5 cm; 50.5-53.5 cm; \geq 53.6 cm). Bioelectric impedance analysis was performed using a tetra-polar device (BIA 101 Anniversary; Akern, Florence, Italy). Fat-free mass was determined using the equation published by Schaefer et al²⁰; fat mass was derived accordingly and recoded into tertiles (<12.8%; 12.8%-19.5%; \geq 19.5%).

Maternal height and weight before pregnancy were self-recorded at birth and measured at children's 4-year-old follow-up. Maternal BMI was classified according to the World Health Organization criteria into under/normal weight (BMI <24.9 kg/m²) and overweight/obese (BMI \geq 25.0 kg/m²).²¹ BMI change represents the change in maternal BMI between the prepregnancy period and 4 years after birth.

Children's Eating Behaviors

Eating behaviors were assessed using the CEBQ, completed by parents at the 7-year-old evaluation (94% were answered by mothers). The original CEBQ²² includes 35 items related to eating styles among children, and is answered on a 5-point Likert scale, ranging from 1 = never to 5 = always. This questionnaire consists of 8 subdomains related to distinct eating behaviors: satiety responsiveness, slowness in eating, enjoyment of food, food responsiveness, food fussiness, desire for drinks, emotional overeating, and emotional undereating. The CEBQ has demonstrated stability over time and good psychometric properties.²²⁻²⁹ A version of this questionnaire has been previously validated and adapted to Portuguese children,²³ but in that version children were aged 3-13 years old, and some items were slightly different from those in the original scale. We opted for retranslating the original CEBQ into Portuguese (**Table I**; available at www.jpeds.com), resulting in a new Portuguese version CEBQ (P-CEBQ). The psychometric properties of this most recent version (including 7-year-old children) were tested in the present study (**Appendix** and **Table II**). A 2-factor solution was identified, explaining 62% of the total variance: factor 1—appetite restraint and factor 2—appetite disinhibition, explaining 35% and 26% of the total variance, respectively. The subdomains food fussiness, enjoyment of food, slowness in eating, and satiety responsiveness loaded mostly on factor 1 (loadings: 0.64; -0.78; 0.74 and 0.88) and the subdomains food responsiveness, emotional overeating, emotional undereating, and desire for drinks loaded mostly on factor 2 (loadings: 0.65, 0.82, 0.66, and 0.65) (**Table II**). Thus, appetite restraint was more related to subdomains measuring internal cues of satiety and food fussiness, on which loaded mostly food fussiness, enjoyment of food, slowness in eating, and satiety responsiveness, and appetite disinhibition was more related to subdomains measuring external food cues and emotional responses toward foods, on which loaded mostly food responsiveness, emotional overeating, emotional undereating, and desire for drinks. A short version was proposed for further application in future research.

Table II. Factor loadings from the principal components analysis for the 35 items of the CEBQ resulting in the original 8-factor structure and the 2-factor final solution of the P-CEBQ used in 7-year-old children (n = 4485)

#	Items	Original 8-factor structure					Two-factor solution	
		Subdomain	Loading	α	Mean	SD	Loading factor 1	Loading factor 2
7	My child refuses new foods at first.	FF	-0.80	0.84	2.95	0.76	0.64	0.19
10	My child enjoys tasting new foods.		0.87					
16	My child enjoys a wide variety of foods.		0.63					
24	My child is difficult to please with meals.		-0.32					
32	My child is interested in tasting food s/he hasn't tasted before.		0.87					
33	My child decides that s/he doesn't like food, even without tasting it.		-0.73					
	Explained variance:		10%					
12	My child's always asking for food.	FR	0.41	0.85	2.06	0.78	-0.48	0.66
14	If allowed to, my child would eat too much.		0.58					
19	Given the choice, my child would eat most of the time.		0.75					
28	Even if my child is full up, s/he finds room to eat his/her favourite food.		0.64					
34	If given the chance, my child would always have food in his/her mouth.		0.77					
	Explained variance:		10%					
1	My child loves food.	EF	0.67	0.83	3.03	0.79	-0.78	0.32
5	My child is interested in food.		0.74					
20	My child looks forward to mealtimes.		0.30					
22	My child enjoys eating.		0.67					
	Explained variance:		9%					
4	My child finishes his/her meal very quickly.	SIE	-0.82	0.81	2.92	0.86	0.74	-0.05
8	My child eats slowly.		0.86					
18	My child takes more than 30 minutes to finish a meal.		0.81					
35	My child eats more and more slowly during the course of a meal.		0.63					
	Explained variance:		8%					
2	My child eats more when worried.	EOE	0.81	0.79	1.83	0.63	-0.09	0.81
13	My child eats more when annoyed.		0.84					
15	My child eats more when anxious.		0.83					
27	My child eats more when s/he has nothing else to do.		0.33					
	Explained variance:		8%					
3	My child has a big appetite.	SR	-0.12	0.74	2.70	0.68	0.88	0.13
17	My child leaves food on his/her plate at the end of a meal.		0.69					
21	My child gets full before his/her meal is finished.		0.81					
26	My child gets full up easily.		0.69					
30	My child cannot eat a meal if s/he has had a snack just before.		0.57					
	Explained variance:		8%					
9	My child eats less when s/he is angry.	EUE	0.78	0.76	2.46	0.76	0.47	0.66
11	My child eats less when s/he is tired.		0.79					
23	My child eats more when s/he is happy.		0.63					
25	My child eats less when s/he is upset.		0.73					
	Explained variance:							
6	My child is always asking for a drink.	DD	0.77	0.82	2.21	0.81	0.12	0.64
29	If given the chance, my child would drink continuously throughout the day.		0.89					
31	If given the chance, my child would always be having a drink.		0.89					
	Explained variance:							
	Total explained variance:		67%				62%	

#, item's position in the original CEBQ; α , Cronbach alpha; SIE, slowness in eating. Bold values indicate absolute factor loadings of 0.3 or higher (interpreted as having expressive part on each factor) and the respective explained variances.

Statistical Analyses

Descriptive statistics and generalized linear models (β regression coefficients and the respective 95% CIs) were performed to estimate the associations. Adjustments for sociodemographics, family structure, and maternal BMI before pregnancy were performed. Further adjustments for smoking during pregnancy, child's BMI z-score, and media screening were also tested, but did not change the magnitude of the associations (results not shown). An interaction of the child's sex in these associations was studied by conducting stratified analysis, but no significant interaction was found; thus, results are reported for both sexes together.

The significance level was set at $P < .05$. SPSS v 21.0 (SPSS Inc, Chicago, Illinois) was used to perform all the statistical

analyses, with the exception of the principal component analysis, which was conducted with the software R v 3.0.1 (R Foundation Statistical Computing, Vienna, Austria).

Results

Table III presents the participants' characteristics (n = 3562) and the appetite restraint and appetite disinhibition scores according to each characteristic (scores could range from 1 to 5). Approximately 51% were boys, most of them lived in a 2-parent home (89.1%), and they had no (46.7%) or 1 sibling (43.4%) at 4 years old. At baseline, most mothers were aged between 25 and 35 years (66.3%), had between 9 and 12 years

Table III. Descriptive statistics (mean, SD) of the 2 factors identified in the P-CEBQ according to children and maternal characteristics (n = 3562)

	N	%	Factor 1 Appetite restraint		Factor 2 Appetite disinhibition	
			Mean	SD	Mean	SD
Sociodemographics and family structure						
Maternal age						
<25 y	541	15.2	2.803	0.633	2.297	0.545
25-34 y	2361	66.3	2.905	0.597	2.116	0.510
≥35 y	660	18.5	2.914	0.603	2.094	0.495
Maternal education						
<9 y	944	26.5	2.824	0.592	2.174	0.550
9-11 y	1524	42.8	2.870	0.617	2.161	0.522
≥12 y	1094	30.7	2.979	0.588	2.079	0.476
Family structure at 4 y						
Two parents	3174	89.1	2.899	0.602	2.127	0.508
One parent	365	10.2	2.820	0.627	2.248	0.589
Other family structure	23	0.70	2.919	0.542	2.160	0.412
Number of siblings at 4 y						
0	1664	46.7	2.930	0.618	2.143	0.524
1	1545	43.4	2.872	0.588	2.142	0.512
≥2	353	9.90	2.789	0.600	2.112	0.512
Child's sex						
Girls	1755	49.3	2.916	0.608	2.115	0.518
Boys	1807	50.7	2.867	0.601	2.164	0.516
Birth characteristics						
Type of delivery						
Vaginal	2231	62.6	2.874	0.601	2.144	0.523
Cesarean	1331	37.4	2.920	0.610	2.131	0.507
Weight for gestational age						
Small	515	14.5	2.926	0.654	2.120	0.516
Adequate	2921	82.0	2.886	0.596	2.142	0.515
Large	126	3.50	2.871	0.601	2.152	0.570
Child's characteristics						
Any breastfeeding duration						
Never or <4 mo	1437	40.3	2.870	0.616	2.159	0.539
4-5 mo	452	12.7	2.913	0.605	2.164	0.513
≥6 mo	1673	47.0	2.903	0.595	2.116	0.498
Introduction to complementary feeding*						
<4 mo	240	6.7	2.896	0.583	2.161	0.573
4-5 mo	1737	48.8	2.926	0.614	2.148	0.500
≥6 mo	721	20.2	2.890	0.574	2.150	0.490
Complementary feeding — first food*						
Soup	981	27.5	2.847	0.602	2.171	0.530
cereals porridge/fruit/other	1687	47.4	2.947	0.595	2.132	0.487
Media screening at 4 y						
<120 min per d	2540	71.3	2.884	0.603	2.118	0.512
≥120 min per d	1022	28.7	2.909	0.610	2.192	0.526
Regular physical activity at 4 y						
No	1121	31.5	2.902	0.603	2.150	0.526
Yes	2441	68.5	2.886	0.605	2.135	0.513
Child's BMI z-score (WHO) at 4 y						
Under/normal weight	2445	68.6	3.011	0.589	2.079	0.479
Overweight/obese	1117	31.4	2.629	0.553	2.273	0.570
Child's WC at 4 y						
<50.5 cm	1192	33.5	3.092	0.590	2.055	0.490
50.5-53.5 cm	1201	33.7	2.915	0.563	2.112	0.503
≥53.6 cm	1169	32.8	2.661	0.583	2.255	0.551
Child's fat % at 4 y*						
<12.8%	973	27.3	2.994	0.566	2.088	0.486
12.8%-19.4%	1018	28.6	2.917	0.587	2.122	0.495
≥19.5%	1021	28.7	2.740	0.617	2.232	0.584
Maternal characteristics						
Maternal BMI before pregnancy						
Under/normal weight	2470	69.3	2.920	0.602	2.126	0.503
Overweight/obese	1092	30.7	2.825	0.606	2.171	0.546
Maternal BMI change from before pregnancy to 4 y after birth						
Maintaining under/normal weight or decreasing	1838	51.6	2.861	0.607	2.151	0.534
Maintaining high BMI or increasing	1724	48.4	2.923	0.601	2.127	0.499
Smoking during pregnancy						
Never smoker	2825	79.3	2.904	0.601	2.117	0.510
Ever smoker	737	20.7	2.839	0.616	2.226	0.536

WHO, World Health Organization.

*These variables do not add to 3562 because of missing data.

of education (42.8%), and were under or of normal weight before pregnancy (69.3%).

Associations between children and maternal characteristics and eating behaviors assessed in 7-year-old children are described in **Table IV** (univariate model) and **Table V** (multivariate model). In multivariate analysis, older maternal age (≥ 35 vs < 25 years: $\beta = 0.127$, 95% CI 0.054, 0.201), higher maternal education (≥ 12 vs < 9 years: $\beta = 0.109$, 95% CI 0.055, 0.164), and having a mother with increased BMI from pregnancy to 4 years after birth or maintaining a high BMI during this period ($\beta = 0.043$, 95% CI 0.003, 0.083) were associated with higher appetite disinhibition scores at 7 years old. Children starting complementary feeding with foods other than soup ($\beta = 0.077$, 95% CI 0.030, 0.124) and watching at least 120 minutes of media per day at 4 years old ($\beta = 0.048$, 95% CI 0.004, 0.092) also showed higher appetite restraint scores at 7 years old. In contrast, girls, children living in a 2-parent family (1-parent vs 2-parent: $\beta = -0.074$, 95% CI -0.140 , -0.007) and with a lower number of siblings (≥ 2 vs 0: $\beta = -0.152$, 95% CI -0.224 , -0.081) were associated with higher appetite restraint scores at 7 years old. Not practicing regular physical activity at 4 years old (yes vs no: $\beta = -0.048$, 95% CI -0.091 , -0.005), lower BMI ($\beta = -0.368$, 95% CI -0.410 , -0.327), WC (third vs first tertile: $\beta = -0.418$, 95% CI -0.46 , -0.371), and fat mass percentage at 4 years old (third vs first tertile: $\beta = -0.276$, 95% CI -0.329 , -0.224) were also associated with higher appetite restraint scores at 7 years old.

The characteristics significantly associated with higher appetite disinhibition scores at 7 years old were living with 1 parent (1-parent vs 2-parent: $\beta = 0.090$, 95% CI 0.034, 0.147), being a boy ($\beta = 0.051$, 95% CI 0.018, 0.085), and watching at least 120 minutes of media per day ($\beta = 0.055$, 95% CI 0.018, 0.093). As regards anthropometric characteristics, higher BMI ($\beta = 0.183$, 95% CI 0.146, 0.219), WC (third vs first tertile: $\beta = 0.188$, 95% CI 0.147, 0.229), and fat mass percentage at 4 years old (third vs first tertile: $\beta = 0.160$, 95% CI 0.114, 0.206) were also associated with higher appetite disinhibition scores at 7 years old. Children of overweight/obese mothers before pregnancy ($\beta = 0.046$, 95% CI 0.009, 0.083) and smokers during pregnancy ($\beta = 0.082$, 95% CI 0.039, 0.124) also reported higher appetite disinhibition scores. In turn, higher maternal age (≥ 35 vs < 25 years: $\beta = -0.187$, 95% CI -0.250 , -0.125) and education (≥ 12 vs < 9 years: $\beta = -0.056$, 95% CI -0.102 , -0.009) were significantly associated with lower appetite disinhibition scores.

Discussion

In the present study, higher maternal education and a family with both parents at 4 years old seemed to influence higher appetite restraint, but less appetite disinhibition at 7 years old. More sedentary lifestyles at 4 years old were associated with higher appetite restraint and appetite disinhibition scores later in childhood. An association between high maternal education and low drive to eat in children has been described before¹² and, more recently, low maternal education and maternal age were associated with overeating in children,¹⁰ results that corroborate the negative association found in this study between

maternal age and education and the appetite disinhibition domain.

Children living in a 1-parent family at 4 years old reported more appetite disinhibition and less appetite restraint at 7 years old than did children living in a 2-parent family. Children with siblings at 4 years old also showed a lower likelihood of developing appetite restraint at 7 years old, an association that was stronger with a higher number of siblings. These findings are in line with previous studies.^{6,10} According to the literature, certain factors in single parenthood³⁰ may lead to emotional parenting and feeding practices, with significant impact on children's behavioral development (eg, emotional overeating^{10,31}). Having a higher number of siblings may also hypothetically decrease parental attention toward each child during mealtimes and pressure to eat, which, in turn, decreases the risk of developing pickiness^{6,32} (characteristic of the appetite restraint domain). Decreased parental attention during mealtimes may also be a consequence of single parenthood. Altogether, the present findings indicate that having a 2-parent family may be positively and negatively associated with appetite restraint and appetite disinhibition, respectively.

Boys reported lower appetite restraint and higher appetite disinhibition scores at 7 years old. Previous studies have reported that girls, relative to boys, have a decreased tendency to overeat, are less interested in food,^{10,33,34} have greater food fussiness,³³ and have more reported eating difficulties at 2 years of age.¹²

Our results revealed no consistent association between eating behaviors and feeding habits in early infancy. The association with breastfeeding duration was only significant in univariate analysis and showed that infants breastfed for 6 months or longer reported lower appetite disinhibition at 7 years old. Previous literature revealed increased satiety responsiveness in breastfed children,^{13,14,35} suggesting that breastfeeding may allow infants to learn how to regulate their appetite and respond to internal cues of satiety¹³ and, thus, protect them from susceptibility to external intake cues (maternal judgement of timing, volumes, and energy density at each feeding).

The type of food first consumed (but not the timing) at complementary feeding significantly predicted eating behaviors at 7 years old. Children who first consumed cereal porridge and fruit reported more appetite restraint at 7 years old than did children whose first food was vegetable soup. Recommendations³⁶ are increasing toward the prioritization of vegetable soup because of the higher energy density and sweetness of cereal porridge. Infants have an innate preference for sweet tastes,³⁷ and, thus, the introduction of these more pleasurable foods may be easily accepted, but compromise the development of self-regulation intake mechanisms,³⁸ thereby supporting the positive association between cereal porridge and other sweet foods and the appetite restraint domain found in our study. The absence of repeated exposure to vegetables and unsweetened fruits early in life may even induce a low capacity to taste different flavours later in life,³⁸ consequently promoting picky eating.

More sedentary behaviors (no regular practice of physical activity and a high media screening time) at 4 years old were

Table IV. Univariate associations of children and maternal characteristics with eating behaviors related to appetite of 7-year-old children (n = 3562)

	Appetite restraint			Appetite disinhibition		
	β	95% CI		<i>B</i>	95% CI	
Sociodemographics and family structure						
Maternal age						
<25 y	ref			Ref		
25-34 y	0.101*	0.045	0.158	-0.181*	-0.229;	-0.133
≥35 y	0.111*	0.042	0.179	-0.203*	-0.261;	-0.145
Maternal education						
<9 y	ref			Ref		
9-11 y	0.046	-0.003	0.095	-0.013	-0.055;	0.029
≥12 y	0.155*	0.102	0.207	-0.095*	-0.140;	-0.050
Family structure at 4 y						
Two parents	ref			Ref		
One parent	-0.079*	-0.144	-0.013	0.121*	0.065;	0.177
Other family structure	0.020	-0.228	0.268	0.033	-0.179;	0.245
Number of siblings at 4 y						
0	ref			Ref		
1	-0.058*	-0.100	-0.017	-0.001	-0.037;	0.035
≥2	-0.141*	-0.210	-0.072	-0.031	-0.091;	0.028
Child's sex						
Girls	ref			Ref		
Boys	-0.050*	-0.089	-0.010	0.049*	0.015;	0.083
Birth characteristics						
Type of delivery						
Vaginal	ref			Ref		
Cesarean	0.046*	0.005	0.087	-0.013	-0.048;	0.022
Weight for gestational age						
Small	ref			Ref		
Adequate	-0.041	-0.097	0.016	0.022	-0.026;	0.071
Large	-0.055	-0.173	0.062	0.032	-0.069;	0.133
Child's characteristics						
Any breastfeeding duration						
Never or <4 mo	ref			Ref		
4-5 mo	0.043	-0.021	0.107	0.005	-0.049;	0.060
≥6 mo	0.034	-0.009	0.076	-0.043*	-0.080;	-0.007
Introduction to complementary feeding [†]						
<4 mo	ref			Ref		
4-5 mo	0.030	-0.051	0.111	-0.012	-0.081;	0.056
≥6 mo	-0.007	-0.095	0.081	-0.010	-0.084;	0.063
Complementary feeding — first food [†]						
Soup	ref			Ref		
Cereals porridge/fruit/other	0.101*	0.054	0.148	-0.038	-0.078;	0.001
Media screening at 4 y						
<120 min per d	ref			Ref		
≥120 min per d	0.025	-0.018	0.069	0.073*	0.036;	0.111
Regular physical activity at 4 y						
No	ref			Ref		
Yes	-0.016	-0.059	0.027	-0.015	-0.052;	0.022
Child's BMI z-score (WHO) at 4 y						
Under/normal weight	ref			Ref		
Overweight/obese	-0.381*	-0.422	-0.340	0.194*	0.158;	0.230
Child's WC at 4 y						
<50.5 cm	ref			Ref		
50.5-53.5 cm	-0.177*	-0.224	-0.131	0.057*	0.016;	0.098
≥53.6 cm	-0.431	-0.478	-0.385	0.200	0.159;	0.241
Child's fat % at 4 y [†]						
<12.8%	ref			Ref		
12.8%-19.4%	-0.076*	-0.128	-0.025	0.034	-0.011;	0.079
≥19.5%	-0.254*	-0.306	-0.202	0.144	0.098;	0.189
Maternal characteristics						
Maternal BMI before pregnancy						
Under/normal weight	ref			Ref		
Overweight/obese	-0.095*	-0.138	-0.052	0.045*	0.008;	0.082
Maternal BMI change from before pregnancy to 4 y after birth						
Maintaining under/normal weight or decreasing	ref			Ref		
Maintaining high BMI or increasing	0.062*	0.023	0.102	-0.023	-0.057;	0.011
Smoking during pregnancy						
Never smoker	ref			Ref		
Ever smoker	-0.065*	-0.114	-0.016	0.110*	0.068;	0.151

*Significant associations are in bold type and marked with an asterisk.

†For these variables, sample sizes are lower (as described in Table I).

Table V. Multivariate associations of children and maternal characteristics with eating behaviors related to appetite in 7-year-old children (n = 3562)

	Appetite restraint			Appetite disinhibition		
	β^*	95% CI		β^*	95% CI	
Sociodemographics and family structure						
Maternal age						
<25 y	ref			Ref		
25-34 y	0.083*	0.024	0.142	-0.161*	-0.212;	-0.110
≥ 35 y	0.127*	0.054	0.201	-0.187*	-0.250;	-0.125
Maternal education						
<9 y	ref			Ref		
9-11 y	0.028	-0.021	0.078	-0.017	-0.059;	0.025
≥12 y	0.109*	0.055	0.164	-0.056*	-0.102;	-0.009
Family structure at 4 y						
Two parents	ref			ref		
One parent	-0.074*	-0.140	-0.007	0.090*	0.034;	0.147
Other family structure	0.007	-0.239	0.253	-0.001	-0.211;	0.209
Number of siblings at 4 y						
0	ref			ref		
1	-0.077*	-0.120	-0.040	0.028	-0.009;	0.064
≥2	-0.152*	-0.224	-0.081	-0.006	-0.067;	0.055
Child's sex						
Girls	ref			ref		
Boys	-0.053*	-0.092	-0.014	0.051*	0.018;	0.085
Birth characteristics						
Type of delivery						
Vaginal	ref			ref		
Cesarean	0.028	-0.013	0.069	0.002	-0.033;	0.037
Weight for gestational age						
Small	ref			ref		
Adequate	-0.039	-0.096	0.017	0.029	-0.019;	0.077
Large	-0.043	-0.160	0.074	0.042	-0.058;	0.142
Child's characteristics						
Any breastfeeding duration						
Never or <4 mo	ref			ref		
4-5 mo	0.029	-0.035	0.092	0.021	-0.033;	0.075
≥6 mo	0.021	-0.021	0.064	-0.025	-0.061;	0.012
Introduction to complementary feeding [†]						
<4 mo	ref			ref		
4-5 mo	-0.004	-0.084	0.077	0.008	-0.059;	0.076
≥6 mo	-0.026	-0.112	0.061	0.012	-0.067;	0.078
Complementary feeding — first food [†]						
Soup	ref			ref		
Cereals porridge/fruit/other	0.077*	0.030	0.124	-0.018	-0.057;	0.022
Media screening at 4 y						
<120 min per d	ref			Ref		
≥120 min per d	0.048*	0.004	0.092	0.055*	0.018;	0.093
Regular physical activity at 4 y						
No	ref			Ref		
Yes	-0.048*	-0.091	-0.005	0.005	-0.032;	0.042
Child's BMI z-score (WHO) at 4 y						
Under/normal weight	ref			Ref		
Overweight/obese	-0.368*	-0.410	-0.327	0.183*	0.146;	0.219
Child's WC at 4 y						
<50.5 cm	ref			Ref		
50.5-53.5 cm	-0.171*	-0.217	-0.125	0.052*	0.011;	0.092
≥53.6 cm	-0.418*	-0.465	-0.371	0.188*	0.147;	0.229
Child's fat % at 4 y [†]						
<12.8%	ref			Ref		
12.8%-19.4%	-0.092*	-0.144	-0.041	0.047*	0.002;	0.092
≥19.5%	-0.276*	-0.329	-0.224	0.160*	0.114;	0.206
Maternal characteristics						
Maternal BMI before pregnancy						
Under/normal weight	ref			Ref		
Overweight/obese	-0.077*	-0.12	-0.033	0.046*	0.009;	0.083
Maternal BMI change from before pregnancy to 4 y after birth						
Maintaining under/normal weight or decreasing	ref			Ref		
Maintaining high BMI or increasing	0.043*	0.003	0.083	-0.020	-0.055;	0.014
Smoking during pregnancy						
Never smoker	ref			Ref		
Ever smoker	-0.045	-0.095	0.004	0.082*	0.039;	0.124

*Significant associations are in bold type and marked with an asterisk.

†For these variables, sample sizes are lower (as described in Table I).

 β adjusted for maternal age, education, and BMI before birth, family structure, and number of siblings at 4 years old and child's sex.

associated with higher appetite restraint and appetite disinhibition at 7 years old. Accordingly, emotional and external eating have already been associated with increased screen time,³⁹ which could be explained by an association between screen time and less attentive eating.^{40,41}

Overweight, obese children and those with higher adiposity at 4 years old reported low appetite restraint and high appetite disinhibition at 7 years old. Obese children have been characterized by lower responsiveness to internal satiety cues^{42,43} and food fussiness,⁵ eating faster during the course of a meal,³ presenting more food enjoyment,^{4,5} sensitiveness to external food cues^{5,23,44} and emotional states,⁵ and higher desire for drinks⁵ than healthy-weight children. Consistent findings were reported in the previous Portuguese study conducted with children and adolescents.²³ Most of these studies have, however, a cross-sectional design and do not clarify the actual direction of these associations. Our findings add weight status/adiposity in preschool children as a possible determinant of appetite later in childhood.

Children of overweight mothers also had lower appetite restraint and higher appetite disinhibition at 7 years old, and children whose mothers smoked during pregnancy reported high appetite disinhibition in later childhood, which may indicate that unhealthy maternal lifestyles are predictors of problematic eating behaviors in children. Research has shown a tendency for overweight mothers to present individual eating concerns to develop more restrictive feeding styles when they perceive their children as overweight or at risk of developing weight problems.^{37,38,45-47} Contrasting results were found when we studied the maternal BMI before pregnancy. These conflicting findings may represent a wider link between parental weight, self-image, concerns about children's weight and feeding practices, and children's eating behaviors. Further investigation into the characteristics referred to should bring some insight into the present findings.

Smoking during pregnancy has been associated with higher overweight risk in children,⁴⁸ which has been suggested to be due to, and explained, in part, by, the intrauterine exposure to inhaled smoke products, which decreases appetitive learning of responsiveness to internal cues, by acting on neurotransmitters associated with reward.⁴⁹ Behavioral associations linking parental smoking habits with unhealthy lifestyles, particularly dietary habits, are also important to consider.⁴⁸

This study has some limitations. Self-administered questionnaires often present low response rates, and a relatively high number of children had incomplete or no information on the CEBQ. Compared with the entire cohort, the mothers in the current sample were slightly older and more educated. Selective response bias, however, is not of concern as these differences were not relevant. The Cohen effect size values were lower than 0.35 (low magnitude),⁵⁰ suggesting that differences were mostly because of the large sample size rather than to large differences between participants' characteristics. In addition, we were able to recover missing data in cases with more than 50% of the items completed. Nevertheless, we hope to overcome this barrier in future cohort evaluations by introducing

the shorter version defined in this study. In addition, the assessment of eating behaviors was based on parental report, which may introduce measurement error because of inherent subjectivity. Social desirability should not be of concern in this study because the CEBQ has shown good correspondence with objective measures.²⁶ Future research should clarify whether an acceptable level of restraint could have a beneficial effect on appetite. Finally, some variables were asked about at the 4- and 7-year-old follow-up assessments and measured retrospectively, depending on parents' memory, introducing a possible recall bias.

These results provide relevant insights into some early influences of appetite-related eating behaviors in children, which can be useful in future research and in support of the development of prevention guidelines and educational strategies involving families aimed at improving healthy eating behaviors and reducing childhood obesity. ■

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Appendix

Determination of P-CEBQ Psychometric Properties

Factor Analysis and Internal Consistency. Principal component analyses (PCAs) were performed twice in this study. A PCA with Oblimin rotation was first performed on all items of the CEBQ to understand if the original factor structure (with 8 factors, representing 8 subdomains) would be replicated in the present sample. An 8-factor structure that explained 67% of the total variance was identified (Table II). Most of the items loaded on the expected subdomains, as previously reported.¹⁻⁵

A second PCA was later conducted on the emerged subdomains, and the scree plot supported an alternative 2-factor solution (representing 2 domains), explaining 62% of the total variance, with factor 1 and factor 2 explaining 35% and 26% of the total variance, respectively. The items with absolute factor loading of 0.3 or higher were interpreted as having meaningful part on each factor. The subdomains food fussiness, enjoyment of food, slowness in eating, and satiety responsiveness loaded mostly on factor 1 (loadings: 0.64; -0.78; 0.74 and 0.88) and the subdomains food responsiveness, emotional overeating, emotional undereating, and desire for drinks loaded mostly on factor 2 (loadings: 0.65; 0.82; 0.66 and 0.65) (Table II). Factor 1 was subjectively named “appetite restraint” and factor 2 “appetite disinhibition.”

To assess the internal consistency of the CEBQ scale, Cronbach alpha coefficients for each subdomain and Pearson correlation coefficients between subdomains were calculated. Good internal consistency was defined by a Cronbach alpha of 0.7 or higher and a Pearson correlation of 0.4 or higher. Both PCAs revealed good internal consistency; in the first, Cronbach alpha for the different subdomains ranged from 0.74 to 0.85 and in the second, Cronbach alpha was 0.77 for “appetite restraint” and 0.64 for “appetite disinhibition.” The correlation between both domains was weak ($\rho = -0.013$), indicating that they are independent from each other, representing very different aspects of eating behaviors.

For each subdomain defined through the PCA, descriptive statistics (mean, SD) were calculated. A higher score in a subdomain indicated a higher presence of the eating behavior (Table II). The average score in appetite restraint was 2.88, SD = 0.61 and in appetite disinhibition was 2.15, SD = 0.52. In accordance with the original CEBQ, the scores of 5 items were reversed because of opposite phrasing (Appendix). In the 2-factor solution, only the score of the enjoyment of food subdomain was reversed (factor 1).

Construct Validity. Construct validity was assessed considering theoretical hypotheses based on previously described literature: as higher the children’s BMI, higher the emotional eating and responsiveness to external cues⁶⁻⁸ and lower the food fussiness^{1,2} and responsiveness to internal satiety cues. A similar relation was hypothesized with higher maternal BMI.⁹ It was performed on the 2 factors emerged in the second PCA. The mean values of each factor by children’s BMI and maternal prepregnancy BMI were compared using 1-way ANOVA. As expected, children’s BMI was negatively and significantly

associated with appetite restraint and positively associated with appetite disinhibition; overweight/obese children scored significantly lower on appetite restraint (mean = 2.60 [SD = 0.55] vs 3.05 [0.58]; $P < .001$) and higher on appetite disinhibition (2.07 [0.48] vs 2.28 [0.57]; $P < .001$). Regarding maternal BMI, children with overweight/obese mothers also scored significantly lower on appetite restraint (2.82 [0.61] vs 2.91 [0.60]; $P < .001$) and significantly higher on appetite disinhibition (2.17 [0.55] vs 2.14 [0.51]; $P = .026$). The referred associations were consistent with the theoretical hypothesis, supporting the construct validity of the P-CEBQ scale.

Reliability. Reliability was tested by analyzing the agreement between the subdomains in 2 time moments (CEBQ was answered again 35 days apart) using 2-way random intraclass correlation (ICC).¹⁰ ICC varies between 0 and 1, with higher values representing higher reliability. The mean ICC of the P-CEBQ ranged from 0.51 (desire for drinks subdomain) to 0.85 (food fussiness subdomain). Most subdomains presented good reliability (ICC \geq 0.7), except desire for drinks (ICC = 0.51) and emotional undereating (ICC = 0.58). Overall, the P-CEBQ presented a good reliability in this Portuguese sample of 7-year-olds (mean ICC = 0.73).

Short Version of the Scale. A Spearman-Brown prediction formula was conducted to estimate the hypothetical Cronbach alpha in a new version of the CEBQ scale with fewer items. It was set to retain in each subdomain only the necessary number of items to achieve a Cronbach alpha of at least 0.7. A total of 20 items (in replacement of the original 35 items) were retained in this short-version of the P-CEBQ. Our analysis showed that only 2 items would be enough to represent the subdomains enjoyment of food, food responsiveness, desire for drinks and slowness in eating, and 3 items would be enough to represent the subdomains emotional undereating, emotional overeating, satiety responsiveness, and food responsiveness. In this version, the Cronbach alpha ranged from 0.68 to 0.72, showing a good internal consistency. As there is no consensus on a method to define which items to retain (ie, to include in the short-version), we, therefore, suggest that this decision should be taken by each research group, concerning 2 main criteria: loadings and pertinence of the items in each subdomain.

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Table I. Correspondence between the original items of the CEBQ and the current P-CEBQ used in 7-year-old children

Original items of the CEBQ	Items of the P-CEBQ	CEBQ subdomains
1. My child loves food.	1. O meu filho(a) adora comida.	EF
2. My child eats more when worried.	2. O meu filho(a) come mais quando anda preocupado(a).	EOE
3. My child has a big appetite. R	3. O meu filho(a) tem muito apetite. R	SR
4. My child finishes his/her meal very quickly. R	4. O meu filho(a) termina as refeições muito rapidamente. R	SiE
5. My child is interested in food.	5. O meu filho(a) interessa-se por comida.	EF
6. My child is always asking for a drink.	6. O meu filho(a) anda sempre a pedir para beber.	DD
7. My child refuses new foods at first.	7. Perante novos alimentos o meu filho(a) começa por recusá-los.	FF
8. My child eats slowly.	8. O meu filho(a) come lentamente.	SiE
9. My child eats less when s/he is angry.	9. O meu filho(a) come menos quando está zangado(a).	EUE
10. My child enjoys tasting new foods. R	10. O meu filho(a) gosta de experimentar novos alimentos. R	FF
11. My child eats less when s/he is tired.	11. O meu filho(a) come menos quando está cansado(a).	EUE
12. My child's always asking for food.	12. O meu filho(a) está sempre a pedir comida.	FR
13. My child eats more when annoyed.	13. O meu filho(a) come mais quando está aborrecido(a).	EOE
14. If allowed to, my child would eat too much.	14. Se o deixassem o meu filho(a) comeria demais.	FR
15. My child eats more when anxious.	15. O meu filho(a) come mais quando está ansioso(a).	EOE
16. My child enjoys a wide variety of foods. R	16. O meu filho(a) gosta de uma grande variedade de alimentos. R	FF
17. My child leaves food on his/her plate at the end of a meal.	17. O meu filho(a) deixa comida no prato no fim das refeições.	SR
18. My child takes more than 30 minutes to finish a meal.	18. O meu filho(a) demora mais que 30 minutos para terminar uma refeição.	SiE
19. Given the choice, my child would eat most of the time.	19. Se tivesse oportunidade o meu filho(a) passaria a maior parte do tempo a comer.	FR
20. My child looks forward to mealtimes.	20. O meu filho(a) está sempre à espera da hora das refeições	EF
21. My child gets full before his/her meal is finished.	21. O meu filho(a) fica cheio/saciado(a) antes de terminar a refeição.	SR
22. My child enjoys eating.	22. O meu filho(a) tem prazer em comer.	EF
23. My child eats more when s/he is happy.	23. O meu filho(a) come mais quando está feliz.	EUE
24. My child is difficult to please with meals.	24. O meu filho(a) é difícil de agradar com as refeições.	FF
25. My child eats less when s/he is upset.	25. O meu filho(a) come menos quando anda chateado(a).	EUE
26. My child gets full up easily.	26. O meu filho(a) fica cheio/saciado(a) muito facilmente.	SR
27. My child eats more when s/he has nothing else to do.	27. O meu filho(a) come mais quando não tem nada para fazer.	EOE
28. Even if my child is full up, s/he finds room to eat his/her favourite food.	28. Mesmo se já está cheio o meu filho(a) arranja espaço para comer um alimento preferido.	FR
29. If given the chance, my child would drink continuously throughout the day.	29. Se tivesse oportunidade o meu filho(a) passaria o dia a beber continuamente.	DD
30. My child cannot eat a meal if s/he has had a snack just before.	30. O meu filho(a) é incapaz de comer a refeição se antes tiver comido alguma coisa.	SR
31. If given the chance, my child would always be having a drink.	31. Se tivesse oportunidade o meu filho(a) passaria a maior parte do tempo a beber.	DD
32. My child is interested in tasting food s/he hasn't tasted before. R	32. O meu filho(a) interessa-se por experimentar alimentos que nunca provou antes. R	FF
33. My child decides that s/he doesn't like food, even without tasting it.	33. O meu filho(a) decide que não gosta de um alimento mesmo que nunca o tenha provado.	FF
34. If given the chance, my child would always have food in his/her mouth.	34. Se tivesse oportunidade o meu filho(a) estaria sempre com comida na boca.	FR
35. My child eats more and more slowly during the course of a meal.	35. O meu filho(a) come cada vez mais devagar ao longo da refeição.	SiE

DD, Desire for drinks; EF, Enjoyment of food; EOE, emotional overeating; EUE, emotional undereating; FF, food fussiness; FR, food responsiveness; R, item with reversed scoring; SiE, slowness in eating; SR, satiety responsiveness.