Are Eating Occasions and Their Energy Content Related to Child Overweight and Socioeconomic Status?

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The objectives of this study were: (i) to assess the relationships between childhood overweight (OW) and four eating behaviors: daily eating frequency, and the relative contribution of breakfast, main meals (lunch and dinner), and snacks to total daily energy intake (EI); (ii) to explore whether these eating behaviors are involved in the negative association between socioeconomic status (SES) and OW. A representative sample of French children aged 3–11 years (*n* = 748) was taken from the 1998–1999 cross-sectional French INCA1 (Enquête Individuelle et Nationale sur les Consommations Alimentaires) food consumption survey. Food intake was reported in a 7-day food record, and SES, physical activity, sedentary behavior (SED), weight, and height were reported by answering face-to-face questionnaires. After adjusting for EI, physical activity, and SED, OW was positively associated with the contribution of the main meals to EI (*P* = 0.03), not significantly associated with the contribution of breakfast to EI, and inversely correlated to the number of eating episodes (*P* = 0.009) and to the contribution of snacking episodes to EI (*P* = 0.007). Our data suggest that a combination of more frequent intake occasions and lower contribution of the main meals to total daily EI is associated with a smaller risk of OW in children. However, eating frequency was the only eating behavior that played a slight mediation role (contributing ~8%) in the inverse relationship between SES and OW.

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INTRODUCTION

Childhood overweight (OW) and obesity have become a major concern worldwide. Beyond the genetic predisposition with regard to weight gain, the overall rapid increase in OW rates in the past three decades primarily involves environmental and behavioral factors which need to be more clearly identified. Although there is growing evidence for the contribution of decreasing physical activity, several questions remain over the role of dietary factors (1). Partly due to methodological issues, notably potential bias toward underreporting of food intake (2), the majority of the studies assessing the relationships between either energy intake (EI) or macronutrient composition and weight status in children have failed to reach any consensus (3,4).

The imbalance between EI and energy expenditure, which results in weight gain, is the metabolic expression of eating and physical activity behaviors. A complementary issue to understand the influence of dietary intake on child OW is therefore to study how foods are consumed, i.e., the eating behaviors which surround and lead to food and nutrient intakes. Indeed, the rise in the prevalence of OW in the past three decades has occurred in parallel to a general change in lifestyle and dietary habits, such as greater away-from-home consumption (5), the trend toward larger portion sizes (6,7), the increasing prevalence of snacking and eating frequency (8), the decline in breakfast consumption (9), and the greater consumption of snacks, convenience foods, and prepared meals. But studies relating eating behaviors to OW in children are scarce and still controversial.

Regarding the environmental context in industrialized countries, adiposity in children has been found to be more frequent among lower socioeconomic status (SES) groups (10). Moreover, previous studies have shown that SES was positively related to healthy dietary patterns or indices of diet quality (11–15), but these findings mainly concerned adult populations. An important issue in the epidemiological research on childhood OW is whether dietary intake and eating behaviors mediate the reverse relationship between SES and adiposity.

The prevalence and severity of childhood OW is also on the rise in France, particularly in population groups with lower SES, as shown using data from the French INCA1 (Enquête Individuelle et Nationale sur les Consommations Alimentaires)

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food consumption survey (16). Previous research based on this data set failed to find a significant relationship between child OW and EI (16). However, intake of larger portions of sweetened pastries was observed in OW children, conversely to the portion size of liquid dairy products (17). Other studies conducted in children have found that a greater number of eating episodes each day was associated with a lower risk of obesity (18–20). Given this background, the current study aimed at focusing on two other eating behaviors among French children aged 3–11 years, i.e., the number of eating episodes and their relative contribution to total daily EI. We assessed the relationships between child OW and each of these eating behaviors accounting for the effects of total EI, physical activity, and sedentary behavior (SED), and explored whether these eating behaviors were involved in the inverse relationship of SES to OW. To our knowledge, this study is the first to examine the epidemiological relationships between eating behaviors and childhood OW at a national level and in such a large age range of French children, taking into account potential confounders such as EI and physical activity.

METHODS AND PROCEDURES

Subjects

The French INCA1 national food consumption survey was carried out between August 1998 and June 1999 by the Research Center for the Study and the Observation of Way of Life (CREDOC) and the French Food Safety Agency (AFSSA). This cross-sectional survey was primarily designed to assess food intake in French children and adults. A complex sampling design was used to obtain a nationally representative sample of people living in French households. The survey design and sampling frame have been described in more detail elsewhere (16,21). Briefly, the sample, composed of 1985 adults (aged ≥15 years) and 1,016 children (aged 3–14 years), was made representative of the French population diversity through stratification (region of residence, agglomeration size) and use of the quota method (age, gender, household size, head of household socioprofessional status) (22). We checked that the sample compared satisfactorily for age, sex, and socioprofessional category with the national census for 1998 published by the INSEE (French National Institute of Statistics and of Economic Studies).

The present study focused on children aged 3–11 years ($n = 748$), who were separated into two age groups of similar size, 3–6 ($n = 340$) and 7–11 years ($n = 408$), corresponding to the preschool and primary school levels in France. This stratification was based on the assumption that children may have different lifestyle patterns depending on their age and school environments.

Measurements

A 7-day record was used to collect information on all food and drink intake during the week of the survey. Self-reported and face-to-face questionnaires were used to gather other behavioral, anthropometrical, and sociodemographical variables.

The 7-day record and a self-administered questionnaire were delivered at home by a trained and certified investigator, who explained to the parents and their child during 30–45 min on how to fill them out. Children aged ≤10 years old were helped by their parents (or by the guardian who was primarily responsible for the target child) to complete all documents. Caregivers were encouraged to ask for a copy of the menus corresponding to the meals taken at school. Just after the survey week, the investigator came back and checked the accuracy of the information reported in both documents. An additional face-to-face questionnaire, including questions on socioeconomic aspects, physical activity, and SED, was administered partly to the child selected and partly to the adult caregiver. At this step, weight and height were self-reported.

Dietary data. In the 7-day record, subjects reported the type of eating occasion at which each food or beverage was consumed, i.e., meals and snacks. "Snacks" were defined as other eating episodes apart from breakfast and main meals (i.e., lunch and dinner). One line of the record corresponded to one item consumed (food or drink). Participants estimated portion sizes of each item by comparing their actual consumption with photographs in the Su.Vi.MAX (SUpplémentation en VItamines et en Minéraux AntioXydants) photographic booklet (23). These pictures represented increasing portion sizes of each dish. Macronutrient intake was evaluated using the French food composition tables (24), which included recipes for most composite dishes. In the present study, we assessed the average daily EI (in kcal/day), the daily eating frequency (number of eating occasions/day), and the contribution (%) of each eating occasion, i.e., breakfast, main meals, and snacks, to total EI. Additional variables were related to the regularity of eating the various meals, taken separately. Because a relatively low proportion of children ate fewer than six breakfasts during the week of the survey (i.e., 2.7 and 6.2% of the children aged 3–6 and 7–11 years, respectively), a child was considered to have skipped breakfast if at least one breakfast a week was not eaten. Similar reasoning was undertaken for lunch, dinner, and snacking events.

Physical activity data. The physical activity questionnaire was derived from the French translation (25) of the Modifiable Activity Questionnaire designed for adolescents by Kriska *et al.* (26) and adapted for children (27). It asked for the usual amount of time spent taking part in several out-of-school sport activities in an ordinary week. The physical activities taken into account were, first, informal ones such as cycling, roller-skating, or running, and second, more organized activities, such as dancing, team sports, or tennis. A physical activity indicator was derived from the average time (but not intensity) spent doing such activities (in hours/week) and used as a proxy of leisure time physical activity. SED was established from the time spent either watching television or playing video games in an ordinary week. An average daily time (in hours/day) was calculated and weighted from the values reported for each type of day, i.e., school or non-school days. In this article, "watching television and playing video games" is thus used as a proxy of SED.

SES. The head of household's occupation determined the SES of the child, which was divided into low, middle, and high. "High" was assigned to executive, top-management, and professional categories; "middle" to intermediate professions (employees, technicians, and similar); and "low" to the others (including unemployed people).

OW status. Weight and height were used to calculate the child's BMI (as weight/height^2, in kg/m^2). OW and obesity were then estimated according to the International Obesity Task Force age- and gender-specific child BMI cutoff points (28). These cutoff points were derived from a large international sample using regression techniques by passing a line through the health-related adult cutoff points at 18 years, i.e., BMI values of 25 (for OW) and 30 kg/m^2 (for obesity).

Statistical analysis

Data were analyzed using SAS 8.2 software (version 8.2; SAS Institute, Cary, NC). Bivariate descriptive analyses stratified by age category were performed to describe dietary and physical activity patterns of French children. All statistical inferences were drawn at a significance level of 5% with two-sided tests. Means were compared using Student's t-tests (taking into account unequal variance when necessary), and χ^2-tests were used to compare frequencies. Unconditional logistic regression analyses were performed to investigate the associations between OW (including obesity) and each of the four eating behaviors taken separately, i.e., daily eating frequency and the contribution of each of the three eating occasions to total EI (independent variables). The analyses were first conducted separately in the two age groups and adjusted for sex and age (introduced as a continuous variable to eliminate any remaining potentially confounding effect of age within each age category). The multivariate logistic regressions were controlled for EI, SED, and leisure time physical activity. All dietary and physical activity variables were divided into tertiles. Because these variables are strongly and positively correlated to age, the tertiles were assessed within the age categories.

To address the mediation hypothesis, we used the SAS macros recently developed by Jasti *et al*. (29), based on the methodology developed by MacKinnon and Dwyer (30) to test for mediation using logistic regression analyses. This method, which involves the estimation of two regression equations (**Figure 1**), standardizes the logistic coefficients. First, the coefficient b relating the mediator M to the outcome OW is estimated. Second, the coefficient a relating SES to M is computed. The product of these two parameters ab is the mediated or indirect effect (which is equivalent to $c - c'$). The coefficient relating SES to OW adjusted to the mediator c' is the nonmediated or direct effect. The Sobel test has been developed to test the null hypothesis that $ab = 0$ (ref. 31). In the analyses, M was alternatively each of the four eating behaviors, i.e., daily eating frequency and the contribution of each of the three eating occasions to total EI.

RESULTS

Characteristics

Of the 748 children included in the study, 24 observations were eliminated in the analyses because of incomplete data (behaviors: $n = 2$; anthropometry: $n = 22$). To limit potential misreporting, we also excluded five children from the data set whose log-transformed value of EI was less than mean −3 s.d. within the age groups. Taken together, these children represented 3.6% of the initial sample and did not differ from the others with regard to age, sex, or SES.

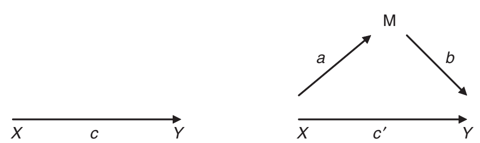

Figure 1 A mediation model. Adapted from ref. 57. X, dependent variable (socioeconomic status); *Y*, dependent variable (overweight); M, mediator; direct effect = c'; mediated effect = ab; total effect = $c' + ab$.

Prevalence of OW in children aged 3–6 and 7–11 years was 15.7 and 17.3% respectively, without statistically significant difference between the age groups. Characteristics of the OW and non-OW children are presented in **Table 1**. Regarding the average daily eating frequency among children aged 3–6 years, 33.4% had between three (included) and four (excluded) eating occasions during the day, and 63.9% of them had four or more eating occasions per day. These figures were respectively 46.9 and 48.6% in children aged 7–11 years. These results indicate a global regularity in eating frequency in the population studied. However, OW children aged 7–11 years tended to skip breakfast more frequently (22.9%) than their non-OW counterparts (16.3%), although the difference was not significant ($P = 0.19$) (**Table 1**). In addition, in the same age range, the proportion of children snacking an average of more than seven times per week was higher among OW children (52.9%) than in non-OW children (39.4%) ($P = 0.04$).

Association between eating behaviors and OW

The logistic regression analyses led to similar results in children aged 3–6 and 7–11 years. Consequently, the stratification on the two age categories was not maintained in the multivariate analyses and results are shown among children aged 3–11 years (**Table 2**). After adjusting for EI, SED, and leisure time physical activity, OW children had a significantly higher contribution to EI from main meals ($P = 0.03$), and similar trends were observed when the contributions of lunch and dinner to EI were considered independently (results not shown). Conversely, the contribution to EI from breakfast did not differ between OW and non-OW children. Finally, OW was inversely correlated to the number of eating episodes ($P = 0.009$) and to the contribution of snacking episodes to EI ($P = 0.007$).

Table 1 Diet and physical activity characteristics according to OW status and age

Age	3–6 years			7–11 years		
Weight status	Non-OW	OW	*P* value	Non-OW	OW	*P* value
n	278	53		320	70	
EI (kcal/day)	1,658 ± 419	1,613 ± 418	0.47	1,964 ± 491	1,957 ± 637	0.94
Eating frequency (number/week)	29.3 ± 4.4	27.7 ± 3.6	0.02	28.1 ± 4.1	27.3 ± 4.4	0.16
Contribution of breakfast to EI (%)	19.7 ± 7.0	20.0 ± 7.4	0.79	20.1 ± 7.1	19.3 ± 7.5	0.41
Contribution of main meals to EI (%)	59.2 ± 9.4	61.4 ± 9.8	0.12	62.2 ± 9.8	65.9 ± 10.0	0.005
Contribution of snacks to EI (%)	21.1 ± 8.7	18.6 ± 9.9	0.059	17.7 ± 8.25	14.9 ± 8.51	0.009
Breakfast skipping (%)	7.2 (4.5–10.9)	7.6 (2.1–18.2)	0.93	16.3 (12.4–20.8)	22.9 (13.7–34.4)	0.19
Lunch skipping (%)	11.5 (7.6–15.4)	7.6 (0–15.6)	0.40	9.7 (6.3–13.1)	14.3 (5.4–23.2)	0.26
Diner skipping (%)	10.4 (6.7–14.2)	9.4 (0.6–18.2)	0.83	11.3 (7.6–14.9)	10.0 (2.3–17.7)	0.76
Snacking <7 times per week (%)	31.7 (26.0–37.3)	41.5 (27.3–55.7)	0.16	39.4 (33.9–44.9)	52.9 (40.4–65.3)	0.04
LTPA (hours/week)	2.1 ± 3.3	2.2 ± 3.9	0.98	4.2 ± 4.4	3.9 ± 4.7	0.65
SED (hours/day)	1.7 ± 1.3	1.8 ± 1.0	0.58	1.9 ± 1.1	2.4 ± 1.4	0.005

$\bar{x}$ ± s.d. (all such values). Non-OW subjects include normal weight and underweight children.
EI, energy intake; LTPA, leisure time physical activity; OW, overweight; SED, sedentary behavior.

Table 2 Adjusted odds ratios (ORs; and 95% confidence intervals) for overweight (including obesity) by eating behaviors in children aged 3–11 years, using logistic regression analysis (*n* = 721)

	Age- and sex-adjusted OR[a]	Multivariate-adjusted OR[b]
Eating frequency		
T1[c]	1.0	1.0
T2[c]	0.80 (0.51–1.24)	0.90 (0.56–1.43)
T3[c]	0.38 (0.23–0.65)	0.44 (0.25–0.76)
P value	0.0014	0.009
P for trend	0.0004	0.004
Contribution of breakfast to EI		
T1[c]	1.0	1.0
T2[c]	0.62 (0.38–1.00)	0.63 (0.38–1.03)
T3[c]	0.76 (0.48–1.20)	0.76 (0.47–1.21)
P value	0.14	0.16
P for trend	0.22	0.23
Contribution of main meals[d] to EI		
T1[c]	1.0	1.0
T2[c]	1.16 (0.69–1.93)	1.10 (0.65–1.86)
T3[c]	1.91 (1.18–3.09)	1.80 (1.10–2.96)
P value	0.016	0.034
P for trend	0.007	0.016
Contribution of snacks to EI		
T1[c]	1.0	1.0
T2[c]	0.73 (0.46–1.15)	0.76 (0.48–1.22)
T3[c]	0.43 (0.26–0.72)	0.44 (0.26–0.74)
P value	0.005	0.007
P for trend	0.001	0.002

[a]Age- and sex-adjusted logistic regression analyses. [b]Multivariate logistic regression analysis adjusted for sex, age, leisure time physical activity, sedentary behavior, and energy intake (EI). [c]T1, tertile 1; T2, tertile 2; T3, tertile 3. Reference = T1. Cutoffs are the following: eating frequency (number/week), T1/T2 = 26.9, T2/T3 = 28.0 in children aged 3–6 years and T1/T2 = 25.7, T2/T3 = 27.6 in children aged 7–11 years; contribution of breakfast to EI (%), T1/T2 = 16.5, T2/T3 = 21.9 in children aged 3–6 years and T1/T2 = 16.9, T2/T3 = 22.4 in children aged 7–11 years; contribution of main meals to EI (%), T1/T2 = 55.9, T2/T3 = 63.1 in children aged 3–6 years and T1/T2 = 58.9, T2/T3 = 67.2 in children aged 7–11 years; contribution of snacks to EI (%), T1/T2 = 17.2, T2/T3 = 24.2 in children aged 3–6 years and T1/T2 = 13.3, T2/T3 = 20.3 in children aged 7–11 years. [d]Lunch and dinner.

Mediation effect of eating behaviors for the relationship between SES and OW

Among the four eating behaviors considered, only eating frequency partially mediated the relationship between SES and OW (Table 3). The percent mediated was low: 8.0% ($P = 0.05$).

DISCUSSION

Similar to what has been observed in other European countries over the past three decades (32), France is also affected by the development of OW, particularly in the 3–11-year-old age group, where rates are close to 17% (ref. 16). Although studies on the relationships between eating behaviors and childhood OW are limited (4), our results provide useful insights into some dietary risk factors likely to be associated with OW. OW children had a higher contribution of main meals to EI than non-OW children. Conversely, we found no significant relationship between OW and the contribution of breakfast to EI. Finally, OW children had a smaller number of eating episodes and a lower contribution of snacking to EI than non-OW children.

Table 3 Tests and measures of mediation for each of the four eating behaviors

Mediation variable	Indirect effect	s.e.	*P* value[a]	Percent (%) of the total effect that is mediated
Eating frequency	−0.0215	0.0111	0.05	8.0
Contribution of breakfast to EI	−0.0066	0.0071	0.36	2.4
Contribution of main meals[b] to EI	−0.0091	0.0082	0.27	3.0
Contribution of snacks to EI	0.0006	0.0091	0.95	0.4

EI, energy intake.
[a]Sobel test. [b]Lunch and dinner.

Several methodological limitations should be considered while interpreting these findings. According to Bellisle *et al.* (33), the inverse association between eating frequency and body weight often described in dietary surveys may possibly reflect greater levels of underreporting in obese subjects than in their lean counterparts. Potential bias due to underreporting of body weight, snacks, or more generally food intake should not be excluded. Nevertheless, these potential biases have mainly been described in obese adolescents and adults, for whom underreporting is more likely to concern specific food items, generally considered "unhealthy" (high-calorie, low-nutrient dense foods) (34–37). These patterns on underreporting have also been described in preadolescent girls, suggesting that as early as age 11 years, similar to adolescents and adults, certain girls may have an increased awareness of the dietary profiles qualified as "desirable" or "healthy" (38,39). Regarding children Livingstone and Robson (2) suggested in their review that children aged 3–10 years were less likely to underreport their food intake, compared to their older counterparts. Other authors also share this hypothesis (40), and that is the main reason why we restricted our sample in children aged 3–11 years. It is worthy to note that we undertook the same analyses, first excluding the strictly obese children (4.4% of the sample), and second excluding the implausible reporters identified according to Goldberg *et al.* (41) cutoffs for underreporting adapted for use in children (42,43) (8.8% of the sample). Both sets of analyses led to similar results (data not shown). Consequently, we consider that if underreporting occurred, it did not concern specifically the more OW children, and therefore, did not bias significantly the associations presented.

Owing to the cross-sectional design of the study, it is also possible that the lower eating frequency and the lower contribution of snacks to total EI reported by some OW children may reflect attempts to lose weight, even though dieting has again been described more often in adolescents and adults than in children (44). Additionally, this cross-sectional design did not allow us to take into account and assess when and how long the eating behaviors at risk toward OW exerted their influence.

In our data, daily eating frequency was shown to be inversely associated with OW in children, after adjusting for EI, physical activity, and SED. Other cross-sectional studies conducted in adults (33,45) and children (18,19) have also found that a greater number of eating episodes each day was associated with a lower risk of obesity. A recent longitudinal study has also indicated that meal frequency was inversely related to BMI for black and white girls between the ages of 9 and 19 years, after controlling for caloric intake, physical activity, and television viewing (46). One of the reasons pointed out in a recent review is that OW or obese children have been shown to skip breakfast more frequently (3). However, possibly due to the overall regularity toward breakfast consumption observed in our data and already described for 9–11-year-old French children (47), neither skipping breakfast nor the contribution of breakfast to total daily EI were significantly associated with the prevalence of OW in this study, contrary to other findings among children (48), adolescents (49), and adults (45).

Possible biological mechanisms have also been proposed to explain the reverse link between eating frequency and OW. After consumption of more meals and snacks, an increased daily overall thermogenesis might lead to a higher energy expenditure, but this metabolic pathway is still controversial (19). The differential stimulation of insulin depending on the frequency of eating could also play a role. Infrequent consumption of huge meals triggers higher concentration levels of insulin and glucose, which in turn are likely to stimulate lipogenesis (50), whereas "nibbling" and "grazing" regimens with the same final EI involve lower levels of insulin secretion (51). Indeed, we found that a higher contribution of main meals to EI was positively associated with OW in our children aged 3–11 years. This result could be related to the lifestyle pattern ascribed as "Big eaters at main meals" which we have found to be positively associated with child OW in previous findings (52). This pattern was mainly characterized by high consumption of meat, processed meat, starchy foods, vegetables, other fats, and water. It was significantly and positively correlated to EI, the percentage of EI ascribed to fats, and the contribution of lunch to EI, and inversely associated with the contribution of breakfast to EI. Other studies have also concluded that obese children consume a higher percentage of energy at main meals, such as dinner (49,53).

There is evidence that snacking frequency has increased in the past three decades, leading to a higher contribution of snacks to total EI in children, which in turn has been suggested to contribute to the development of OW (5,8). However, our results indicated that the contribution of snacking episodes to total EI was inversely related to OW. It should be noted that the afternoon snack is a traditional meal for most French children in these age groups (47), as it was confirmed in our data by the relatively high proportion of children having four intake occasions or more during the day. Two other studies have shown that obese children did not consume more snacks than their lean counterparts (20,54). It is likely that in the context of child growth, snacking habits, as long as they are balanced in terms of frequency, type of foods, and portion sizes (17), but also if EI compensation occurs during the meals, may have positive advantages in terms of overall energy balance (55).

In previous findings based on the same INCA1 survey, sedentary screen behavior has been shown to play a mediation role in the inverse relationship between SES and child OW (16). In the present study, only eating frequency slightly mediated the relationship between SES and OW. Other intermediate factors possibly include patterns of physical activity and diet that were not included in the present analyses. It should also be noted that we measured SES using the occupational status of the head of household, which is only one component of SES. In their recent review, Shrewsbury and Wardle (10) highlighted that childhood OW has been more consistently and strongly associated with SES defined as parental education. Earlier, Braveman *et al.* (56) suggested that the parental education level was more likely to influence literacy, knowledge on nutrition, and health behaviors (including eating behaviors), which in turn were involved in weight gain. Further studies aimed at exploring the mediation lifestyle factors involved in the reverse association between SES and childhood OW should include more comprehensive components of SES. Better understanding on the pathways that relate SES to child OW is indeed important for designing efficient prevention strategies.

In conclusion, these findings indicate that the current worldwide increase in childhood OW, which has also been described in France, may be driven not only by increased SED, but also by the shift in behaviors surrounding the consumption of food and beverages. Our results suggest that combining frequent intake occasions with a smaller contribution of the main meals to total daily EI is associated with a smaller risk of OW in children aged 3–11 years. It is conceivable that the number of eating episodes throughout the day is less important than the distribution of energy across those meals and snacks. Nevertheless, additional studies based on longitudinal design are needed to confirm our results and conclude in causality.

DISCLOSURE

The authors declared no conflict of interest.

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