Meal-Skipping Behaviors and Body Fat in 6-Year-Old Children

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Objective To assess the prospective associations of breakfast, lunch, and dinner skipping at age 4 years with body fat (ie, percent fat mass, body mass index [BMI], and weight status) at age 6 years.

Study design Data were analyzed from 5913 children participating in the Generation R Study, a population-based prospective cohort study in Rotterdam, The Netherlands. Meal-skipping behaviors were assessed through parent-report questionnaires. Children's weight and height were objectively measured and converted to BMI SDSs. Weight status (ie, overweight or normal weight) was defined according to age- and sex-specific cutoff points. At age 6 years, percent fat mass was assessed by dual-energy X-ray absorptiometry. Linear and logistic regression analyses were performed, adjusting for covariates and BMI at age 4 years.

Results Breakfast skipping at age 4 years was associated with a higher percent fat mass at age 6 years (β = 1.38; 95% CI, 0.36-2.40). No associations were found with BMI or weight status. Furthermore, no associations were found between lunch and dinner skipping at age 4 years and body fat at age 6 years.

Conclusion Breakfast skipping at age 4 years is associated with a higher percent fat mass at age 6 years. Further prospective studies, including intervention studies, are warranted to extend the evidence base on the directionality and causality of this association. *(J Pediatr 2016;168:118-25)*.

The childhood overweight epidemic has coincided with a decline in daily breakfast consumption,[1] leading to the hypothesis that breakfast skipping may be involved in the etiology of childhood overweight. This hypothesis is supported by observational studies showing positive associations between breakfast skipping and the risk of childhood overweight[2-6]; however, most of these studies used a cross-sectional design, which hinders the ability to draw conclusions about the directionality of the association.[7,8] Moreover, few studies have examined the associations of lunch skipping and dinner skipping with children's body fat.[9,10]

Studies on the associations between meal-skipping behaviors and childhood overweight have generally used body mass index (BMI) or weight status (overweight vs normal weight) as measures of children's body fat.[2-4,6,9,10] Even though BMI is widely used, owing to its feasibility and correlation with other body fat measures, it does not discriminate between fat mass and lean mass and thus is a measure of excess weight rather than excess body fat.[11] In contrast, percent fat mass as measured by dual-energy X-ray absorptiometry (DXA) is considered a more accurate measure of body fat in children.[11]

The aims of the present study were to assess the prevalence and tracking of children's meal-skipping behaviors between age 4 and 6 years, and to assess the prospective associations of meal-skipping behaviors at age 4 years with body fat at age 6 years.

Methods

This study was embedded in the Generation R Study, a population-based prospective cohort study from fetal life onward.[12] The study was conducted in accordance with the guidelines proposed in the World Medical Association's Declaration of Helsinki and was approved by the Medical Ethical Committee of Erasmus Medical Center, University Medical Center Rotterdam. Written informed consent was obtained from parents of all participating children. Of the 9749 known live born children of the Generation R cohort, 8305 still participated in follow-up studies from 5 years. At age 6 years, 6690 children visited a dedicated research center in the Erasmus Medical Center, Sophia's Children's Hospital, where body fat data were collected.[12] Participants with missing information on BMI or fat mass (n = 330) were excluded from the current analyses. To avoid clustering of data, we also excluded second children (n = 441) and third children (n = 6) of the same mother, leaving a study population of 5913 participants.

Meal-skipping behaviors were assessed by parent-reported questionnaires when the children were 4 years old and again at 6 years old. At age 4 years,

BMI	Body mass index
DXA	Dual-energy X-ray absorptiometry

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children's weekly consumption of breakfast, lunch, and dinner was assessed with answer categories including "never," "1-2 days per week," "3-4 days per week," "5-6 days per week," and "every day" (coded as 1-5). At age 6 years, the number of days on which children consumed breakfast, lunch, and dinner was assessed separately for weekdays (coded as 0-5) and weekend days (coded as 0-2), and the scores were summed to calculate total weekly consumption (0-7). Because of highly skewed distributions, meal skipping was defined as consumption <7 days per week.

BMI was measured at age 4 years and 6 years. At age 4 years, weight and height were measured at community child health centers by trained staff following standard schedules and procedures. Height was measured in a standing position without shoes using a Harpenden stadiometer (Holtain Ltd, Crymych, United Kingdom). Weight was measured without clothing and shoes using a mechanical personal scale (Seca, Hamburg, Germany). BMI was calculated as weight divided by height squared (kg/m^2). Using the Growth Analyzer program (Growth Analyzer 3.0; Dutch Growth Research Foundation, Rotterdam, The Netherlands), BMI SDS adjusted for age and sex were constructed based on Dutch reference growth curves.[13] At age 6 years, height and weight (in lightweight clothes and without shoes) were measured in the Generation R research center in the Erasmus Medical Center, Sophia's Children's Hospital. Children's weight status (overweight, including obesity, vs normal weight) was defined according to age- and sex-specific cutoff points proposed by the International Obesity Task Force.[14]

DXA scans (iDXA; GE Healthcare, Wauwatosa, Wisconsin) were performed to obtain percent fat mass. Children were scanned while supine with the feet together in a neutral position and hands flat by the sides. All DXA scans were obtained using the same device and software (enCORE2010; GE Healthcare) and were performed by well-trained and certified research staff.

Based on earlier studies on risk factors of childhood overweight,[7,15,16] the child's sex, age, ethnic background (ie, native Dutch, other Western, or non-Western),[17] family socioeconomic position (ie, maternal educational level [high, mid-high, mid-low, low],[18] maternal employment status [paid job, no paid job], household income [<€2000/month, €2000-€3200/month, >€3200/month]),[19] paternal BMI, and children's lifestyle behaviors were considered important covariates. Maternal prepregnancy BMI was calculated on the basis of self-reported prepregnancy weight and measured height at enrollment. Paternal BMI was calculated on the basis of measured weight and height at enrollment. Children's physical activity behaviors (ie, sports participation, outdoor play, active transport to/from school), sedentary behaviors (ie, television viewing, computer game use), and dietary behaviors (ie, consumption of sugar-containing beverages and high-calorie snacks) were assessed in parent-reported questionnaires at age 4 and 6 years.

Statistical Analyses

Descriptive statistics were used to characterize the study population. Differences between boys and girls were assessed using the χ^2 test for categorical variables and 1-way ANOVA for normally distributed continuous variables. The McNemar test was used to compare the prevalences of meal skipping at age 4 and 6 years. Two-year tracking of children's meal-skipping behaviors was evaluated in 2 ways.[20] First, Spearman rho correlation coefficients were calculated to assess the correlation between children's relative rank positions in number of days of meal skipping at 4 years and 6 years. Second, tracking patterns were generated using cross-tabulation of (dichotomized) meal-skipping behaviors at age 4 and 6 years, in which children were allocated to 1 of 4 categories: stable meal consumption (ie, meal consumption at both time points), stable meal skipping (ie, meal skipping at both time points), decrease in meal skipping (ie, meal skipping at age 4 years and meal consumption at age 6 years), and increase in meal skipping (ie, meal consumption at age 4 years and meal skipping at age 6 years).

Associations between meal-skipping behaviors at age 4 years and body fat at age 6 years were assessed using a series of multiple linear and logistic regression models. Separate crude models contained meal-skipping behaviors at age 4 years as the independent variable and indicators of body fat at age 6 years as dependent variables. In the first set of models, associations were adjusted for the first group of covariates, including family socioeconomic position, ethnic background, and parental BMI. In the second set of models, associations were additionally adjusted for other meal-skipping behaviors. In the third set of models, associations were additionally adjusted for children's lifestyle behaviors that may act as mediators is the associations between meal-skipping behaviors and children's body fat. In the final set of models (full models), BMI at age 4 years was added to the models. The same analyses were performed using tracking patterns as the independent variable. Interaction effects of meal-skipping behaviors with child's sex, BMI at age 4 years, and ethnic background were assessed by adding separate interaction terms to the full models.

In addition, 2 sensitivity analyses were conducted. First, tests for trends were examined by repeating the analyses using meal-skipping variables at age 4 years as continuous independent variables. Second, cross-sectional analyses were performed using meal-skipping behaviors and body fat indicators measured at age 6 years.

Multiple imputation was applied to handle missing data in the meal-skipping behaviors, potential confounders, and BMI at age 4 years.[21] Five imputed datasets were generated using a fully conditional specified model, thus taking into account the uncertainty of the imputed values. Pooled estimates from these 5 imputed datasets were used to report β values, ORs, and their 95% CIs. Imputations were based on the relationships among all of the variables included in this study. All analyses were conducted with SPSS version 21.0 for Windows (IBM, Armonk, New York). A P value <.05 was considered to indicate a significant association.

Results

The majority of children (56.1%) had a Dutch ethnic background (Table I). Slightly less than one-half (45.6%) of the children had a mother with a low or mid-low educational level, and slightly more than one-half (51.6%) of the children lived in households with a middle or low household income. The prevalence of meal skipping ranged from 3.1% (dinner skipping at age 6 years) to 10.3% (lunch skipping at age 6 years). Significant differences between boys and girls were found for breakfast skipping at both ages (more often in girls) and for dinner skipping at age 4 years (more often in boys). At age 6 years, children less often skipped breakfast ($P < .001$), more often skipped lunch ($P < .01$), and less often skipped dinner ($P < .001$) compared with age 4 years.

Table II shows tracking of meal-skipping behaviors for children with data on both time points. Spearman rho coefficients for tracking were 0.30 (moderate) for breakfast skipping, 0.21 (weak) for lunch skipping, and 0.12 (weak) for dinner skipping (all $P < .001$). The majority of children were stable meal consumers, ranging from 86% (lunch) to 91% (dinner). Approximately three-quarters of children (77%) were stable consumers for all 3 dietary behaviors (data not shown).

Associations between meal-skipping behaviors at age 4 years and body fat at age 6 years are presented in Table III and the Figure (available at www.jpeds.com). No interaction effects were observed; therefore, results are presented for the total study population. Breakfast skipping at age 4 years was associated with all indicators of body fat

Table I. Characteristics of the study population and according to child's sex (n = 5913)

Characteristics	Total (n = 5913), n (%)	Missing, n (%)	Boys (n = 2939), n (%)	Girls (n = 2974), n (%)	*P* value*
Sociodemographic characteristics					
Ethnic background					
Native Dutch	3232 (56.1)	155 (2.6)	1608 (56.1)	1624 (56.2)	.38
Other-Western	522 (9.1)		246 (8.6)	276 (9.5)	
Non-Western	2004 (34.8)		1013 (35.3)	991 (34.3)	
Maternal educational level					
High	1360 (27.2)	915 (15.5)	674 (27.0)	686 (27.4)	.62
Mid-high	1360 (27.2)		688 (27.6)	672 (26.9)	
Mid-low	1609 (32.2)		814 (32.6)	795 (31.8)	
Low	669 (13.4)		320 (12.8)	349 (13.9)	
Maternal employment status					
Paid job	3536 (74.8)	1186 (20.1)	1755 (74.3)	1781 (75.3)	.46
No paid job	1191 (25.2)		606 (25.7)	585 (24.7)	
Household income					
>€3200	2281 (48.4)	1196 (20.2)	1140 (48.3)	1141 (48.4)	.92
€2000-<€3200	1257 (26.6)		624 (26.5)	633 (26.8)	
<€2000	1179 (25.0)		595 (25.2)	584 (24.8)	
Meal-skipping behaviors (4 y)					
Breakfast skipping					
No	3426 (92.1)	2193 (37.1)	1714 (93.0)	1712 (91.2)	<.05
Yes	294 (7.9)		129 (7.0)	165 (8.8)	
Lunch skipping					
No	3429 (92.6)	2210 (37.4)	1704 (93.0)	1725 (92.2)	.34
Yes	274 (7.4)		128 (7.0)	146 (7.8)	
Dinner skipping					
No	3416 (92.9)	2237 (37.8)	1676 (92.1)	1740 (93.8)	<.05
Yes	260 (7.1)		144 (7.9)	116 (6.2)	
Meal-skipping behaviors (6 y)					
Breakfast skipping					
No	4665 (93.5)	925 (15.6)	2358 (94.5)	2307 (92.6)	<.01
Yes	323 (6.5)		138 (5.5)	185 (7.4)	
Lunch skipping					
No	4394 (89.7)	1015 (17.2)	2196 (89.7)	2198 (89.7)	.99
Yes	504 (10.3)		252 (10.3)	252 (10.3)	
Dinner skipping					
No	4679 (96.9)	1082 (18.3)	2334 (96.5)	2345 (97.2)	.19
Yes	152 (3.1)		84 (3.5)	68 (2.8)	
Body fat (6 y)					
Percent fat mass					
Mean (SD)	25.0 (5.7)	0	22.7 (5.0)	27.2 (5.4)	<.001
BMI SDS					
Mean (SD)	0.3 (0.9)	0	0.3 (0.9)	0.3 (1.0)	.46
Weight status					
Normal weight	4870 (82.4)	0	2508 (85.3)	2362 (79.4)	<.001
Overweight	1043 (17.6)		431 (14.7)	612 (20.6)	

The Table is based on a nonimputed dataset.
**P* values are derived from the χ^2 test for categorical variables and 1-way ANOVA for normally distributed continuous variables comparing boys and girls.

Table II. Tracking of meal-skipping behaviors from age 4 years to 6 years*

	Meal consumption at 6 y	Meal skipping at 6 y
Breakfast (n = 3472)		
Meal consumption at 4 y, n (%)	3118 (89.8)	93 (2.7)
Meal skipping at 4 y, n (%)	193 (5.6)	68 (2.0)
Spearman rho	0.30 ($P < .001$)	
Lunch (n = 3402)		
Meal consumption at 4 y, n (%)	2928 (86.1)	236 (6.9)
Meal skipping at 4 y, n (%)	166 (4.9)	72 (2.1)
Spearman rho	0.21 ($P < .001$)	
Dinner (n = 3333)		
Meal consumption at 4 y, n (%)	3039 (91.2)	65 (2.0)
Meal skipping at 4 y, n (%)	208 (6.2)	21 (0.6)
Spearman rho	0.12 ($P < .001$)	

The Table is based on a nonimputed dataset.
*Stable meal consumption: meal consumption at both time points; stable meal skipping: meal skipping at both time points; decrease in meal skipping: meal skipping at age 4 years and meal consumption at age 6 years; increase in meal skipping: meal consumption at age 4 years and meal skipping at age 6 years.

at age 6 years in the crude models. After adjustment for covariates and BMI at age 4 years, breakfast skipping was significantly associated with percent fat mass only (β = 1.38; 95% CI, 0.36-2.40). Similar results were found when tracking patterns were used as independent variables; compared with stable breakfast consumers, children in all 3 breakfast-skipping categories had a significantly increased percent fat mass at age 6 years (Table IV). The largest difference was found between stable breakfast consumers and stable breakfast skippers (β = 1.80; 95% CI, 0.75-2.85). Children who decreased in breakfast skipping or increased in breakfast skipping did not differ significantly from stable breakfast skippers (data not shown). Trend analyses showed that continuously measured breakfast skipping at age 4 years was associated with a higher percent fat mass (β = 0.64; 95% CI, 0.41-0.88) and a higher BMI (β = 0.08; 95% CI, 0.02-0.13) at age 6 years (Table V; available at www.jpeds.com). Cross-sectional analyses yielded associations of breakfast skipping with percent fat mass (β = 1.55; 95% CI, 0.87-2.23), BMI (β = 0.18; 95% CI, 0.06-0.30), and overweight (OR, 1.59; 95% CI, 1.10-2.29) (Table VI; available at www.jpeds.com). No other associations were observed.

Discussion

The prevalence of breakfast skipping is similar to that found in previous studies conducted in 4- to 7-year-old children,[2,3,16,22] but lower compared with that reported in studies of older school-aged children and adolescents.[9,23-28] Research on lunch skipping and dinner skipping in young children is scarce; however, studies of older children show a higher prevalence of lunch skipping and dinner skipping.[9,26,27] Because meal skipping is known to increase as children move into and through adolescence and young adulthood,[23,25] the discrepancy in results may be explained by any age difference among the study populations.

In the present study, we found a small decline in breakfast skipping between age 4 and 6 years. In The Netherlands, children can enter primary school from 4 years onward, with compulsory education starting at age 5 years.[29] With the transition from preschool or home care to primary school, family life may become more structured, thereby facilitating daily breakfast consumption. Furthermore, breakfast consumption may become a more important meal for young primary school children, owing to the need for academic performance. Further transition into adolescence and young adulthood may lead to an increase in breakfast skipping as adolescents become more independent or use breakfast

Table III. Crude and adjusted associations of meal-skipping behaviors at age 4 years with body fat at age 6 years (n = 5913)

	Crude model, β (95% CI)	Model 1*, β (95% CI)	Model 2†, β (95% CI)	Model 3‡, β (95% CI)	Full model§, β (95% CI)
Percent fat mass¶					
Breakfast skipping (yes)	**2.61 (1.80 to 3.42)**	**1.40 (0.63 to 2.17)**	**1.36 (0.54 to 2.17)**	**1.34 (0.50 to 2.18)**	**1.38 (0.36 to 2.40)**
Lunch skipping (yes)	**1.73 (1.02 to 2.44)**	**0.65 (0.05 to 1.26)**	0.20 (−0.58 to 0.98)	0.20 (−0.59 to 0.98)	−0.31 (−0.99 to 0.36)
Dinner skipping (yes)	0.55 (−0.66 to 1.76)	0.37 (−0.58 to 1.31)	−0.09 (−1.10 to 0.91)	−0.14 (−1.11 to 0.83)	0.04 (−0.69 to 0.77)
BMI SDS					
Breakfast skipping (yes)	**0.25 (0.11 to 0.38)**	0.11 (−0.05 to 0.27)	0.10 (−0.08 to 0.29)	0.11 (−0.08 to 0.31)	0.13 (−0.05 to 0.32)
Lunch skipping (yes)	**0.25 (0.16 to 0.33)**	**0.10 (0.01 to 0.19)**	0.09 (−0.04 to 0.22)	0.09 (−0.04 to 0.22)	−0.06 (−0.15 to 0.04)
Dinner skipping (yes)	0.06 (−0.12 to 0.23)	−0.02 (−0.16 to 0.13)	−0.08 (−0.23 to 0.08)	−0.06 (−0.21 to 0.08)	−0.01 (−0.09 to 0.07)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Overweight (including obesity)**					
Breakfast skipping (yes)	**1.82 (1.29 to 2.57)**	1.24 (0.73 to 2.11)	1.18 (0.68 to 2.02)	1.19 (0.68 to 2.10)	1.28 (0.51 to 3.26)
Lunch skipping (yes)	**1.97 (1.61 to 2.42)**	**1.34 (1.03 to 1.74)**	1.34 (0.96 to 1.88)	1.38 (0.99 to 1.93)	1.05 (0.67 to 1.66)
Dinner skipping (yes)	1.22 (0.71 to 2.09)	1.00 (0.57 to 1.74)	0.83 (0.47 to 1.47)	0.84 (0.49 to 1.43)	0.87 (0.48 to 1.60)

The Table is based on an imputed dataset. Bold print indicates statistical significance ($P < .05$).
*Model 1: Adjusted for family socioeconomic position, ethnic background, and parental BMI.
†Model 2: Model 1 + adjusted for other meal skipping behaviors at age 4 years.
‡Model 3: Model 2 + adjusted for children's lifestyle behaviors.
§Full model: Model 3 + adjusted for BMI at age 4 years.
¶All models (except for crude models) adjusted for child's sex, child's age, and child's height.
**All models (except for crude models) adjusted for child's sex and child's age.

Table IV. Crude and adjusted associations of meal skipping tracking patterns with body fat at age 6 years

	Crude model, β (95% CI)	Model 1*, β (95% CI)	Model 2†, β (95% CI)	Model 3‡, β (95% CI)	Full model§, β (95% CI)
Percent fat mass¶					
Breakfast skipping (n = 3472)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	**3.90 (2.71 to 5.10)**	**2.44 (1.40 to 3.48)**	**2.48 (1.43 to 3.54)**	**2.42 (1.37 to 3.48)**	**1.80 (0.75 to 2.85)**
Decrease in meal skipping	**1.79 (1.06 to 2.51)**	**1.01 (0.38 to 1.64)**	**1.04 (0.39 to 1.70)**	**1.00 (0.35 to 1.66)**	**1.24 (0.56 to 1.92)**
Increase in meal skipping	**2.86 (1.84 to 3.88)**	**1.55 (0.67 to 2.42)**	**1.55 (0.67 to 2.42)**	**1.50 (0.63 to 2.38)**	**0.92 (0.11 to 1.74)**
Lunch skipping (n = 3402)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	**1.41 (0.24 to 2.58)**	0.36 (−0.63 to 1.35)	−0.08 (−1.09 to 0.94)	−0.10 (−1.11 to 0.91)	−0.33 (−1.24 to 0.58)
Decrease in meal skipping	**1.17 (0.39 to 1.95)**	0.26 (−0.42 to 0.94)	−0.13 (−0.84 to 0.58)	−0.15 (−0.86 to 0.56)	−0.59 (−1.26 to 0.08)
Increase in meal skipping	0.59 (−0.07 to 1.26)	0.33 (−0.24 to 0.90)	0.26 (−0.30 to 0.83)	0.23 (−0.34 to 0.80)	0.01 (−0.49 to 0.51)
Dinner skipping (n = 3333)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	0.27 (−1.88 to 2.42)	0.92 (−0.90 to 2.74)	−0.15 (−0.78 to 0.48)	0.24 (−1.58 to 2.06)	0.17 (−1.45 to 1.79)
Decrease in meal skipping	0.27 (−0.44 to 0.97)	0.21 (−0.38 to 0.81)	0.39 (−1.43 to 2.21)	−0.19 (−0.82 to 0.43)	−0.10 (−0.68 to 0.48)
Increase in meal skipping	**1.31 (0.08 to 2.54)**	**1.05 (0.01 to 2.10)**	1.01 (−0.03 to 2.05)	1.02 (−0.01 to 2.06)	0.65 (−0.39 to 1.68)
BMI SDS					
Breakfast skipping (n = 3472)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	**0.48 (0.28 to 0.69)**	**0.30 (0.10 to 0.50)**	**0.30 (0.09 to 0.51)**	**0.31 (0.11 to 0.52)**	0.13 (−0.09 to 0.34)
Decrease in meal skipping	0.10 (−0.02 to 0.23)	0.01 (−0.11 to 0.14)	0.01 (−0.12 to 0.14)	0.02 (−0.11 to 0.15)	0.12 (−0.03 to 0.27)
Increase in meal skipping	**0.29 (0.11 to 0.47)**	**0.18 (0.01 to 0.35)**	**0.18 (0.01 to 0.35)**	**0.19 (0.36 to 0.03)**	0.01 (−0.13 to 0.15)
Lunch skipping (n = 3402)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	0.12 (−0.08 to 0.32)	0.00 (−0.19 to 0.19)	−0.02 (−0.22 to 0.18)	−0.02 (−0.22 to 0.18)	−0.09 (−0.22 to 0.04)
Decrease in meal skipping	**0.18 (0.05 to 0.31)**	0.07 (−0.06 to 0.21)	0.06 (−0.08 to 0.20)	0.06 (−0.08 to 0.20)	−0.09 (−0.21 to 0.04)
Increase in meal skipping	0.11 (0.00 to 0.23)	0.07 (−0.04 to 0.18)	0.07 (−0.05 to 0.18)	0.07 (−0.04 to 0.19)	0.01 (−0.06 to 0.08)
Dinner skipping (n = 3333)					
Stable meal consumption (ref)	0.00	0.00	0.00	0.00	0.00
Stable meal skipping	0.18 (−0.19 to 0.54)	0.15 (−0.21 to 0.50)	0.10 (−0.26 to 0.45)	0.10 (−0.26 to 0.46)	0.09 (−0.14 to 0.33)
Decrease in meal skipping	0.05 (−0.07 to 0.17)	−0.01 (−0.13 to 0.11)	−0.05 (−0.17 to 0.07)	−0.04 (−0.17 to 0.08)	−0.00 (−0.10 to 0.10)
Increase in meal skipping	0.18 (−0.03 to 0.39)	0.14 (−0.06 to 0.34)	0.13 (−0.07 to 0.34)	0.14 (−0.06 to 0.34)	0.04 (−0.16 to 0.25)
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Overweight (including obesity)**					
Breakfast skipping (n = 3472)					
Stable meal consumption (ref)	1.00	1.00	1.00	1.00	1.00
Stable meal skipping	**3.16 (1.87 to 5.35)**	**1.98 (1.11 to 3.55)**	**1.89 (1.04 to 3.44)**	**1.97 (1.08 to 3.61)**	1.70 (0.60 to 4.83)
Decrease in meal skipping	1.41 (0.95 to 2.09)	1.01 (0.65 to 1.57)	0.95 (0.59 to 1.52)	0.95 (0.59 to 1.53)	1.07 (0.54 to 2.12)
Increase in meal skipping	**2.33 (1.44 to 3.77)**	1.64 (0.96 to 2.80)	1.61 (0.94 to 2.75)	1.61 (0.94 to 2.76)	1.00 (0.47 to 2.11)
Lunch skipping (n = 3402)					
Stable meal consumption (ref)	1.00	1.00	1.00	1.00	1.00
Stable meal skipping	1.71 (0.95 to 3.10)	1.20 (0.63 to 2.30)	1.20 (0.61 to 2.35)	1.23 (0.63 to 2.43)	0.88 (0.34 to 2.27)
Decrease in meal skipping	**2.03 (1.39 to 2.98)**	1.47 (0.95 to 2.28)	1.48 (0.93 to 2.35)	1.51 (0.95 to 2.41)	1.14 (0.54 to 2.39)
Increase in meal skipping	1.36 (0.95 to 1.96)	1.25 (0.84 to 1.85)	1.24 (0.84 to 1.85)	1.26 (0.84 to 1.88)	1.07 (0.65 to 1.76)
Dinner skipping (n = 3333)					
Stable meal consumption (ref)	1.00	1.00	1.00	1.00	1.00
Stable meal skipping	1.10 (0.32 to 3.75)	1.17 (0.31 to 3.35)	0.94 (0.24 to 3.61)	0.95 (0.24 to 3.68)	0.34 (0.05 to 2.20)
Decrease in meal skipping	1.20 (0.81 to 1.77)	0.99 (0.64 to 1.54)	0.81 (0.50 to 1.31)	0.79 (0.49 to 1.29)	0.81 (0.43 to 1.52)
Increase in meal skipping	1.34 (0.70 to 2.59)	1.23 (0.61 to 2.49)	1.21 (0.60 to 2.45)	1.20 (0.59 to 2.44)	0.95 (0.29 to 3.09)

The Table is based on an imputed dataset. Bold print indicates statistical significance ($P < .05$).
*Model 1: Adjusted for family socioeconomic position, ethnic background, and parental BMI.
†Model 2: Model 1 + adjusted for other meal skipping behaviors at age 4 years.
‡Model 3: Model 2 + adjusted for children's lifestyle behaviors.
§Full model: Model 3 + adjusted for BMI at age 4 years.
¶All models (except for crude model) adjusted for child's sex, age, and height.
**All models (except for crude model) adjusted for child's sex and age.

skipping as a weight loss strategy.[23,25,28] The same arguments may hold for our finding regarding a decrease in dinner skipping. Conversely, we found that lunch skipping increased between age 4 years and 6 years. An explanation for this finding may be that with the transition to primary school, a substantial proportion of the children start eating lunch at school instead of at home with their families, and thus parents may be less able to exert control over their child's eating. Further research on changes in meal-skipping behaviors during important life transitions is merited.

In agreement with earlier findings,[9,10,26] breakfast skipping was more prevalent in girls, and dinner skipping was more prevalent in boys. Girls may skip breakfast more often owing to societal pressure and expectations,[2] but this seems unlikely in this age group. Some studies have reported that boys are more likely than girls to be fussy eaters,[30-32] that is, highly selective about the range of foods accepted,[32] and fussy eating has been associated with a decreased intake of whole-grain products, vegetables, fish, and meat.[31] Because these foods are consumed mainly during dinner, higher levels of fussy eating could be an explanation for our finding. More research on the determinants of meal skipping in this young age group is warranted.

This study showed weak to moderate tracking coefficients (Spearman rho = 0.12-0.30),[33] with the largest tracking coefficient found for breakfast skipping. Tracking patterns showed that approximately 90% of children displayed similar meal-skipping behaviors between age 4 and 6 years, with most children being stable consumers. Taken together, these findings indicate that meal skipping, and breakfast skipping in particular, seem to track moderately during early childhood. It is possible that the factors underlying breakfast consumption are more structural than those underlying lunch or dinner skipping. For example, factors underlying breakfast skipping may be related to sleep duration and quality or household routines,[34,35] whereas skipping lunch or dinner may be more incidental in nature.

In the present study, we found an association between children's breakfast skipping at age 4 and percent fat mass, but not BMI or overweight, at age 6 years. We found similar results when using tracking patterns as the independent variable; compared with stable breakfast consumers, all other children had a significantly higher percent fat mass. Our results are in accordance with an Australian study that found breakfast skipping to be prospectively associated with overweight in 10- to 12-year-old children, but not in 5- to 6-year-old children.[4] Similarly, prospective studies in adolescents and young adults have shown positive associations of breakfast skipping with BMI[23,25,28,36] and overweight.[24,25] As suggested by other scholars breakfast consumption may be protective of overweight among older children and adolescents only.[4] It is also possible that that these studies conducted in older populations had greater power to detect associations with BMI or overweight status owing to higher rates of breakfast skipping and consequent use of different exposure variables (ie, categorical or continuous measures of breakfast skipping).[23-25,28,36] Our present finding of an association between breakfast skipping and percent fat mass (and not with BMI or weight status) may be explained by DXA's superior accuracy in estimating body fat in young children compared with weight-for-height measures.[11,37,38]

Proposed pathways to explain the association between breakfast skipping and body fat include increased consumption of unhealthy snacks, lower overall diet quality (eg, less grains and vegetables), irregular eating patterns, and late night eating among breakfast skippers.[3,8,39] Furthermore, energy intake during breakfast may help sustain or boost engagement in physical activity.[23,25] However, given that adjustment for dietary behaviors, sedentary behaviors, and physical activity behaviors attenuated the results only slightly, our findings do not suggest a substantial contribution of these factors in explaining the associations between breakfast skipping and body fat. One explanation would be that lifestyle behaviors were poorly measured in the present study, which would have resulted in an underestimation of mediated effects. Alternatively, other potential mediating variables not included in the present study may add to the explanation of the observed associations.

No associations were found between children's lunch or dinner skipping at age 4 years and body fat at age 6 years. Research on the associations between body fat and meal skipping behaviors other than breakfast skipping is scarce, and thus results cannot be easily compared.[9,10] In line with our findings, a cross-sectional study among 9- to 11-year-old Finnish children found no association between school lunch and dinner and BMI.[9] In contrast, a European study of children aged 0-12 years found that both breakfast skipping and dinner skipping were cross-sectionally associated with higher odds of being overweight.[10] Because these analyses were adjusted for child's sex and ethnicity only,[10] results may suffer from residual confounding.

Given the hypothesized mechanisms underlying the association between breakfast skipping and body fat (ie, lower diet quality and decreased physical activity), similar associations of lunch and dinner skipping with body fat might have been expected. It is possible that not breakfast consumption per se, but rather the types of food consumed during breakfast, are important determinants of adiposity trajectories.[23,40] In previous research, (ready-to-eat) cereal consumption during breakfast or other times of the day have been associated with lower BMI.[40-43] Alternatively, under the assumption that children's meal-skipping behaviors are causally related to body fat, a more prolonged exposure would result in higher levels of body fat; therefore, the observed association between breakfast skipping and body fat may be due to the (more) persistent nature of breakfast skipping.[23] This idea is substantiated by the gradients in percent fat mass, BMI, and weight status according to breakfast tracking patterns. Although children in the stable breakfast-skipping group did not significantly differ in percent fat mass from children in the unstable (increase in/decrease in) breakfast-skipping groups, low numbers of children in the latter groups, and hence less power, may explain why we were unable to detectind these differences. Moreover, given the definition of breakfast skipping (ie, less than daily consumption), the breakfast-skipping group and consequently the different groups of children composing the breakfast tracking patterns are heterogeneous, which may have diluted the effects. Finally, consumption of breakfast may be an important marker of an overall healthy lifestyle.[28] However, the associations between breakfast skipping and percent fat mass remained significant following adjustment for a range of covariates reducing the possibility that (residual) confounding by sociodemographic factors, parental BMI, or other meal-skipping behaviors explain our present results.

Strengths of this study include the large and ethnically diverse study population and the availability of a wide range of potential confounders. Furthermore, data on both meal-skipping behaviors and BMI were repeatedly measured, enabling longitudinal analysis of the data. Third, several objectively measured indicators of children's body fat were available for the present study, including DXA-derived percent fat mass, which is generally considered a sensitive measure of body fatness in young children.[38]

A limitation of this study is the use of parent-reported questionnaires to assess children's meal-skipping behaviors and covariates, which might have led to socially desirable answers. Moreover, the validity of the short items assessing meal-skipping behaviors has not been assessed. Furthermore, information on objectively measured total physical activity; total energy intake[3,5,23,28]; food items consumed during breakfast, lunch, or dinner[6,25]; and the context in which meal consumption occurred (eg, meal consumption during television viewing[4] or duration of meal), was not collected. Tracking of meal skipping behaviors was evaluated over a 2-year period, and further research is needed to assess tracking over a longer period. Finally, causation cannot be demonstrated owing to the study's observational design. Despite the adjustment for many potential confounders, residual confounding by unmeasured or poorly measured variables is still possible. However, the prospective association of children's breakfast skipping with percent fat mass between age 4 and 6 years found in the present study provides complimentary evidence to that found in earlier cross-sectional research. More prospective studies, including intervention studies, are warranted to extend the evidence base on the directionality and causality of this association. ■

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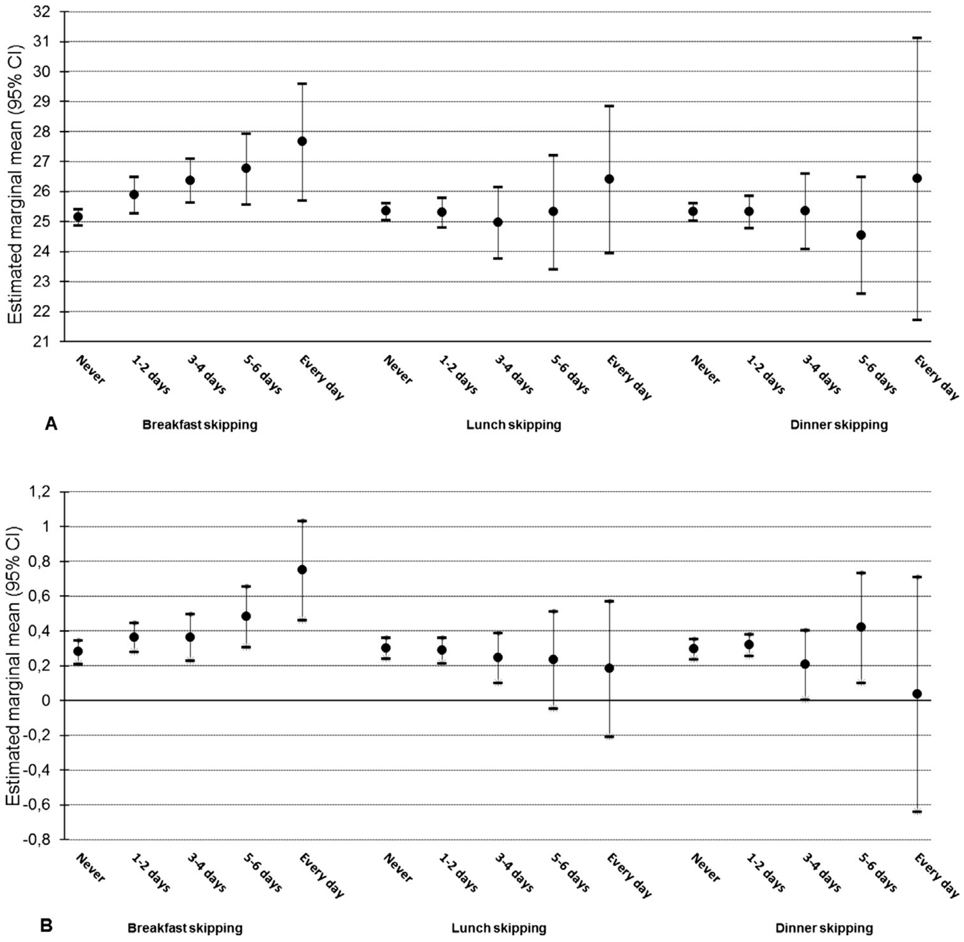

Figure. Fully adjusted associations of meal-skipping behaviors at age 4 years with body fat at age 6 years (n = 5913). Values are estimated marginal means derived from linear regression analyses (**A,** percent fat mass; **B,** BMI SDS). Models are adjusted for family socioeconomic position, ethnic background, parental BMI, other meal-skipping behaviors, children's lifestyle behaviors, and BMI at age 4 years. Models using percent fat mass as an outcome variable are also adjusted for child's sex, age, and height. Models using BMI as an outcome variable are also adjusted for child's sex and age.

Table V. Crude and adjusted associations of continuously measured meal-skipping behaviors at age 4 years with body fat at age 6 years (n = 5913)*

	Crude model, β (95% CI)	Model 1†, β (95% CI)	Model 2‡, β (95% CI)	Model 3§, β (95% CI)	Full model¶, β (95% CI)
Percent fat mass**					
Breakfast	**1.35 (1.00 to 1.71)**	**0.58 (0.25 to 0.90)**	**0.52 (0.20 to 0.84)**	**0.52 (0.20 to 0.84)**	**0.64 (0.41 to 0.88)**
Lunch	**1.27 (0.83 to 1.70)**	**0.44 (0.10 to 0.79)**	0.27 (−0.03 to 0.57)	0.26 (−0.05 to 0.57)	−0.01 (−0.35 to 0.33)
Dinner	0.36 (−0.30 to 1.02)	0.16 (−0.40 to 0.72)	−0.05 (−0.62 to 0.52)	−0.09 (−0.66 to 0.49)	−0.03 (−0.36 to 0.29)
BMI SDS					
Breakfast	**0.14 (0.07 to 0.22)**	0.04 (−0.04 to 0.12)	0.03 (−0.05 to 0.11)	0.04 (−0.04 to 0.11)	**0.08 (0.02 to 0.13)**
Lunch	**0.17 (0.09 to 0.24)**	**0.06 (0.00 to 0.13)**	0.06 (−0.01 to 0.12)	0.06 (−0.00 to 0.12)	−0.02 (−0.06 to 0.03)
Dinner	0.07 (−0.04 to 0.18)	0.01 (−0.09 to 0.11)	−0.02 (−0.11 to 0.08)	−0.01 (−0.11 to 0.09)	0.01 (−0.04 to 0.05)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Overweight (including obesity)††					
Breakfast	**1.46 (1.28 to 1.66)**	1.12 (0.95 to 1.32)	1.08 (0.92 to 1.28)	1.08 (0.91 to 1.28)	1.21 (0.98 to 1.49)
Lunch	**1.58 (1.35 to 1.84)**	**1.22 (1.03 to 1.44)**	**1.21 (1.02 to 1.44)**	**1.22 (1.03 to 1.45)**	1.02 (0.82 to 1.27)
Dinner	1.18 (0.97 to 1.43)	0.99 (0.81 to 1.21)	0.91 (0.73 to 1.13)	0.91 (0.74 to 1.13)	0.92 (0.72 to 1.19)

The Table is based on an imputed dataset. Bold print indicates statistical significance ($P < .05$).
*Meal-skipping behaviors coded as 1, never skipping; 2, skipping 1-2 days per week; 3, skipping 3-4 days per week; 4, skipping 5-6 days per week; 5, skipping every day.
†Model 1: Adjusted for family socioeconomic position, ethnic background, and parental BMI.
‡Model 2: Model 1 + adjusted for other meal-skipping behaviors at age 4 years.
§Model 3: Model 2 + adjusted for children's lifestyle behaviors.
¶Full model: Model 3 + adjusted for BMI at age 4 years.
**All models (except for crude models) adjusted for child's sex, age, and height.
††All models (except for crude models) adjusted for child's sex and age.

Table VI. Cross-sectional crude and adjusted associations of meal skipping behaviors with body fat at age 6 years (n = 5913)

	Crude model, β (95% CI)	Model 1*, β (95% CI)	Model 2†, β (95% CI)	Model 3‡, β (95% CI)
Percent fat mass§				
Breakfast skipping (yes)	**3.29 (2.58 to 4.01)**	**1.74 (1.17 to 2.31)**	**1.56 (0.89 to 2.24)**	**1.55 (0.87 to 2.23)**
Lunch skipping (yes)	**0.89 (0.41 to 1.37)**	0.29 (−0.12 to 0.71)	−0.17 (−0.59 to 0.26)	−0.17 (−0.61 to 0.27)
Dinner skipping (yes)	**1.83 (1.00 to 2.65)**	1.51 (0.73 to 2.29)	0.86 (−0.08 to 1.79)	0.89 (−0.04 to 1.81)
BMI SDS				
Breakfast skipping (yes)	**0.36 (0.24 to 0.47)**	**0.18 (0.08 to 0.28)**	**0.17 (0.05 to 0.29)**	**0.18 (0.06 to 0.30)**
Lunch skipping (yes)	**0.13 (0.05 to 0.21)**	0.04 (−0.04 to 0.12)	0.00 (−0.08 to 0.08)	0.00 (−0.08 to 0.08)
Dinner skipping (yes)	**0.20 (0.02 to 0.37)**	0.11 (−0.07 to 0.28)	0.03 (−0.18 to 0.23)	0.03 (−0.18 to 0.23)
Overweight (including obesity)¶				
Breakfast skipping (yes)	**2.45 (1.82 to 3.31)**	**1.58 (1.16 to 2.16)**	**1.56 (1.08 to 2.24)**	**1.59 (1.10 to 2.29)**
Lunch skipping (yes)	**1.37 (1.09 to 1.73)**	1.09 (0.83 to 1.43)	0.97 (0.73 to 1.27)	0.96 (0.72 to 1.29)
Dinner skipping (yes)	**1.63 (1.14 to 2.34)**	1.36 (0.90 to 2.05)	1.10 (0.69 to 1.76)	1.12 (0.70 to 1.79)

The Table is based on an imputed dataset. Bold print indicates statistical significance ($P < .05$).
*Model 1: Adjusted for family socioeconomic position, ethnic background, and parental BMI.
†Model 2: Model 1 + adjusted for other meal-skipping behaviors at age 4 years.
‡Model 3: Model 2 + adjusted for children's lifestyle behaviors.
§All models (except crude models) adjusted for child's sex, age, and height.
¶All models (except for crude models) adjusted for child's sex and age.