Public Health Nutrition: 12(1), 19–28 doi:10.1017/S1368980008001894

Breakfast skipping is associated with differences in meal patterns, macronutrient intakes and overweight among pre-school children

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Submitted 8 May 2007: Accepted 5 January 2008: First published online 18 March 2008

Abstract

Objectives: To examine the association between skipping breakfast, daily energy, macronutrients and food intakes, and BMI in pre-school children.

Design: A cross-sectional study using information on children's food consumption and measured height and weight. Energy and macronutrient intakes of the children were derived from parent/day-care attendant's responses to 24 h recall interviews and eating behaviour questionnaires.

Setting: Data obtained from a representative sample (*n* 2103) of children born in Quebec (Canada) in 1998.

Subjects: One thousand five hundred and forty-nine children, with a mean age of 49 (SD 3·12) months.

Results: Ten per cent of children ate breakfast on fewer than 7 days per week. This behaviour was associated with a lower diet quality and concentrated energy intakes through higher protein intakes at lunch and the consumption of snacks higher in energy and carbohydrate in the afternoon and evening; yet total daily energy intakes were not significantly different from those of pre-school children who ate breakfast every day. Breakfast skippers' mean BMI increased as intake of energy, carbohydrates or servings of grain products increased; however, this was not the case for breakfast eaters. When Cole's cut-off for overweight/obesity was used, overweight/obesity in breakfast skippers was related to the dinner-time consumption of approximately 3000 kJ (700 kcal) or more for energy intake, approximately 100 g or more of carbohydrates, or approximately 3 servings or more of grain products.

Conclusions: Eating breakfast every day is associated with having a healthy body weight, likely due to a more even distribution of energy intake across meals throughout the day.

Keywords
Breakfast
Body weight
Nutrition
Children

The prevalence of overweight and obesity among children has increased markedly around the globe[1–4]. In Canada, 26% of 2–17-year-olds were classified as overweight or obese in 2004[4]. Furthermore, overweight and obesity in childhood has been shown to track into adulthood[5], having significant impacts on overall psychosocial health[6] and predisposing individuals to many causes of morbidity and mortality including diabetes, CVD and hypertension[7,8].

Although causal mechanisms of childhood obesity remain unclear, it is well established that dietary factors play an important role in regulating an overall energy balance, thereby influencing body weight[9]. Breakfast eating is one aspect of diet proposed to play a role in the maintenance of a healthy body weight. The authors have reported elsewhere that 9·8% of pre-school children from the present study's population in Quebec (Canada) ate breakfast on fewer than 7 days per week and that overweight was positively associated with this behaviour[10]. However, other studies show conflicting results, with some revealing a positive association between breakfast skipping and overweight in populations of school children[11,12] and adolescents[13–16], while other studies found no significant relationship between breakfast skipping and increased BMI[17,18]. In fact, a recent review suggested that the results remain inconclusive[19]. Furthermore, this association has not been extensively researched in pre-school populations.

One possible mechanism mediating an association between breakfast skipping and overweight is differences

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in meal patterns and total daily nutrient and energy intakes between individuals who skip breakfast and individuals who eat breakfast every day. Certain studies find support for such differences, indicating that 'breakfast eaters' tend to have higher overall energy intakes than 'breakfast skippers', suggesting that the latter do not make up for these differences at other meals during the day[20,21]. Skipping breakfast has also been linked to poorer nutritional habits[22,23]. One study showed that children who skipped breakfast consumed fewer grain, fruit and milk products than breakfast eaters[24]. Other findings showed that children who skipped breakfast consumed a greater amount of energy and protein at lunch than their peers who ate breakfast[25], while yet other studies suggest that breakfast skipping is associated with increased snacking and larger meal portions for the rest of the day[26]. Evidence for supporting the relationship between nutritional adequacy and breakfast eating is moderately strong; however, again, these associations have not been well examined in a pre-school population. Additionally, more research is needed to examine how these associations relate to the development of overweight and obesity in pre-school children.

With reports indicating a 5 % decline in breakfast consumption for pre-school children from 1965 levels in the USA[16] and similar rates of breakfast skipping in the UK[27], it is important to properly examine how breakfast eating is associated with regulating healthy dietary habits and maintaining a healthy body weight. For this reason, the present study examined the association between breakfast skipping and daily energy and nutrient intakes, and how these are associated with overall BMI in a population-based sample of pre-school children. It was hypothesized that, after controlling for important covariates, pre-school children who ate breakfast on fewer than 7 days per week would also be found to have a lower diet quality and a higher prevalence of overweight and obesity in comparison with pre-school children who ate breakfast every day.

Methods

The present study used data from the Longitudinal Study of Child Development in Quebec (1998–2012) (LSCDQ), conducted by Santé Québec, a division of the Institut de la Statistique du Québec (ISQ) in Canada[28,29]. The LSCDQ followed a representative sample (*n* 2103) of children born in 1998 in the province of Quebec (total population over 7 million, with approximately 70 000 newborns per year). To ensure geographic representation and minimize seasonality effects, children born throughout the year in each public health geographic area of the province were randomly selected. Twins and children with major diseases or handicaps at birth were excluded from the study. Children and their parents were first seen at 5 months (adjusted for gestational age) and subsequently at one-year intervals. Each testing point involved standardized, questionnaire-based, face-to-face interviews with the person deemed most knowledgeable of the child, generally the mother.

The analyses presented herein are based on the fifth data collection. Children's mean age was 49 (SD 3.12) months with a range from 44 to 56 months. Of the 2103 infants at the first data collection point, 1944 remained at 4 years in 2002. Of this group, 1549 respondents volunteered to have their child take part in the nutrition component of the study. To ensure that data were longitudinally representative of infants born in 1998, data were weighted by a factor based on the inverse of the selection probability, the probability of non-response and the post-stratification and attrition rates[30]. Preliminary analyses indicated that these 1549 children participating in the nutrition survey were representative of the same-aged children in the population. Statistical analyses were based on 1520 pre-school children (98 % of the sample), all individuals with no missing values for any of the studied variables. Over half (51 %) of the children were boys, while 49 % were girls. With-and-without analyses were conducted to assess the impact of missing data. Given that missing observations did not have a significant impact on the results, they were excluded from the analyses.

Children's height and weight were measured twice by a trained nutritionist following a standardized protocol; these measures were used to derive children's BMI (calculated as weight (kg)/[height (m)]^2). Overweight was defined as: (i) having a BMI at or above the 95th percentile on the sex- and age-specific US Centers for Disease Control and Prevention (CDC) growth charts (at 4·5 years, a BMI cut-off of approximately 18·1 kg/m^2 for girls and 17·8 kg/m^2 for boys)[31]; and (ii) according to Cole's criteria, which provides age- and sex-specific cut-off points from 2 to 18 years for overweight and obesity (at 4·5 years, a BMI cut-off of 17·19 kg/m^2 for girls and 17·47 kg/m^2 for boys)[32].

Dietary methodology

The dietary assessment included an eating behaviour questionnaire and a 24 h dietary recall interview. The 24 h recall instrument was previously used in the nutrition survey of the Health and Social Survey of Québec Children and Adolescents, 1999. Pre-test of the ISQ 24 h recall available resulted in changes in the appearance of the instrument; however the content remained the same. All questionnaires and associated technical documents may be accessed through the ISQ website (http://www.jesuisjeserai.stat.gouv.qc.ca/default_an.htm).

Breakfast eating behaviour was measured by a standardized questionnaire[33] and pre-tested in a sample of children not included in the present cohort[34]. Parents were asked: 'Does your child eat breakfast in the morning?' Responses included: (1) yes, every morning; (2) regularly

https://doi.org/10.1017/S1368980008001894 Published online by Cambridge University Press

but not every day; (3) only on occasion; and (4) never. Children who ate breakfast on fewer than 7 days per week (categories 2 to 4) were classified as 'breakfast skippers', while 'breakfast eaters' included children who ate breakfast every morning (category 1). Responses for the breakfast eating behaviour question were compared with the 24 h recall. In the 24 h recall, breakfast was defined as the first food eaten as a meal between the hours of 06.00 and 09.00 and by the mother's evaluation (for each mentioned food, the mother was asked by the interviewer to indicate if it was part of a meal or a snack). Meal times are generally stable in Canada; breakfast covers generally the food eaten between 06.00 and 09.00 hours, lunch between 11.00 and 13.00 hours and dinner between 17.00 and 19.00 hours. For 2 % of the children, mothers said that children were eating breakfast every day but mentioned no breakfast items in the 24 h recall.

Energy, macronutrients, food consumption levels and meal patterns were derived from one 24 h recall interview administered in the home by a trained nutritionist. Mothers were asked to indicate foods (e.g. type, quantity, recipes) eaten during the 24 h period preceding the interview. All foods and beverages consumed by the child within the last 24 h were recorded by the nutritionist. Volume food models were used for determining food portion sizes and food labels were verified for nutrition information. A second 24 h recall, administered to half (n 696) the sample approximately 7 d after the first, allowed for adjustment of recall data for random intra-child variability to ensure representativeness of usual food consumption[35]. All analyses were conducted with adjusted data and the results are based on usual food consumptions.

For inconsistent reports between the breakfast eating behaviour questionnaire and the 24 h dietary recall, the second 24 h dietary recall, available for 50 % of the sample, was used. Except for one case, children who had no breakfast in the first 24 h recall had no breakfast in the second 24 h recall.

The 24 h recalls obtained for the dietary assessments are considered reasonably accurate for providing group mean estimates of children's intakes while being less burdensome and invasive than food records[36]. For children attending day care, nutritionists queried day-care administrative staff regarding the child's food intake (e.g. time, meal, quantity) for the same 24 h period. For most of the day-care centres, a double sampling procedure was used which involved having day centre staff reserve sample meals, including beverages, the child consumed on the day of interview. The 24 h recalls were administered evenly across all days in the week. Energy and macronutrient consumption, along with the servings of foods for each meal and for each child, were evaluated according to the Canadian Nutrient File 2001[37] and the US Department of Agriculture recipe file[38] which calculates usual consumption of foods in accordance with *Canada's Food Guide to Healthy Eating*[39]. Dietary data collected were managed using a validated nutrient analysis software package from Micro Gesta (Quebec, Canada; version 73) developed specifically for Canadian nutritional studies (www.microgesta.com). Final consumption and serving estimates were adjusted to minimize within-child variability[34]. More details on the study instruments and methodology can be found on the LSCDQ website (http://www.jesuisjeserai.stat.gouv.qc.ca).

Meal patterns were categorized into breakfast, lunch (including brunch), dinner, morning snacks (including before breakfast snacks), afternoon snacks and evening snacks. For purposes of the analyses, meals were also grouped into two time periods: (i) foods eaten up to and including lunch (including breakfast, brunch, morning snacks and lunch, covering the period between 06.00 and 13.00 hours); and (ii) foods eaten after lunch (including afternoon snacks, dinner and evening snacks, covering the period after 13.00 hours). Total food consumption from meals and snacks was also computed.

Level of physical activity

Each child's level of physical activity was determined through the mother's response to the question: 'In your opinion, is your child's level of physical activity less than or more than children of the same age and same sex?' Responses included: (1) much higher; (2) slightly higher; (3) equal; (4) slightly less; (5) much less than; (6) do not know; and (7) refused. The responses 'do not know' and 'refused' were coded as missing values.

Statistical analyses

Statistical analyses were conducted using the SAS statistical software package version 8.2 (SAS Institute, Cary, NC, USA). Weighted data, adjusted for within-child variability, were used in the analysis, and the significance level was set at 5 %. Energy, macronutrients and food servings were analysed as continuous variables and were square-root-transformed whenever normality was not achieved. Given that children's sex and mother's level of education were considered potential confounders, they were included in the analyses[20,22]. Odds ratios estimates, including confidence intervals, were determined through logistic regression analyses. Adjusted means were calculated by one-way ANOVA. The list of covariates included in the ANOVA model is noted in the table footnotes. These covariates were selected in correspondence with the literature to ensure proper adjustment for potential confounders (e.g. children's sex) to the main variables of interest.

Results

Characteristics of the population

Approximately 8·8 % of children in the cohort were overweight or obese according to the 2000 CDC growth

https://doi.org/10.1017/S1368980008001894 Published online by Cambridge University Press

charts[31] (age- and sex-specific curves), while 14·3 % of the children were classified as overweight or obese when Cole's criteria were used[32]. Almost half (47 %) of the children had one overweight or obese parent and 15·5 % had two. Only 14·4 % of children were from single parenting households. Ten per cent of children were from households with an annual income below $CAN 20 000. Over two-thirds of children were in day care (35 % at home day care, 34.2 % in day-care centre)[10]. The majority of respondents (91 %) completed the French questionnaires. Further details regarding the characteristics of the population have been described elsewhere[10,34].

Energy and macronutrient analyses

Ten per cent of children ate breakfast on fewer than 7 days per week, being classified as breakfast skippers. Table 1 compares the adjusted means of energy and macronutrient intakes from meals and snacks for breakfast skippers and daily breakfast eaters. On a daily basis, breakfast skippers consumed a lower amount of protein (in grams) and less energy from protein than did breakfast eaters. Breakfast skippers also consumed less energy at breakfast (when they had one) but more energy at lunch time and during afternoon and evening snacks in comparison with breakfast eaters. They also consumed fewer carbohydrates (total) at breakfast and at their morning snack (percentage of energy). More carbohydrates (total) were consumed in their afternoon and evening snacks and, in terms of percentage of energy intake, more carbohydrates were also consumed at dinner. Breakfast skippers also consumed less fat (total) at breakfast and less energy from fat at lunch time than regular breakfast eaters. Lastly, breakfast skippers ate less protein (total) at breakfast but more during their lunch and morning and afternoon snacks.

In terms of energy intake, breakfast skippers consumed less energy and less of each macronutrient (total) from meals, and more energy and more of each macronutrient (total) from snacks than did breakfast eaters. Breakfast skippers also consumed less energy and less of each macronutrient (total) in the pre-lunch period (up to and including lunch), and they consumed more energy and more carbohydrates (total and percentage of energy) in the post-lunch period (data not shown).

Food group serving analyses

Table 2 compares adjusted means of servings for different food groups consumed at meals and snacks for breakfast skipping and breakfast eating pre-school children. Table 3 describes serving sizes, weight (in grams) and energy values of some common foods in Canada[40]. In comparison with breakfast eaters, breakfast skippers consumed a lower mean number of servings from vegetables, grain products and milk products (Table 2). They consumed fewer servings of fruits at breakfast but more at lunch and dinner; fewer servings of vegetables at

Table 1 Adjusted† mean‡ energy and macronutrient consumption from daily meals and snacks by breakfast eating: pre-school children, Quebec, Canada

		Daily consumption		Meals								Snacks							
		Total		Total		Breakfast		Lunch		Dinner		Total		Morning		Afternoon		Evening	
Nutrient	Daily breakfast eating§	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Energy (kJ)	Breakfast skippers	6514	88	4569*	138	1029*	54	2046*	71	2038	71	2050*	88	686	46	1038*	59	849*	50
	Breakfast eaters	6669	29	5197	50	1243	17	1883	25	2025	25	1669	29	607	17	854	21	674	21
Energy (kcal)	Breakfast skippers	1557	21	1092*	33	246*	13	489*	17	487	17	490*	21	164	11	248*	14	203*	12
	Breakfast eaters	1594	7	1242	12	297	4	450	6	484	6	399	7	145	4	204	5	161	5
Carbohydrates (g)	Breakfast skippers	213	3	135·9*	4·5	35·7*	2·1	58·0	2·1	59·8	2.3	81·3*	3·5	28·4	1·8	41·4*	2·1	31·3*	1·9
	Breakfast eaters	215	1	156·1	1·6	44·5	0·6	53·8	0·7	56·3	0·8	66·7	1·2	26·1	0·6	33·9	0·7	24·3	0·7
Total fats (g)	Breakfast skippers	54·4	0·9	41·3*	1·7	8·0*	0·6	18·8	0·8	18·2	0·8	14·8*	0·9	4·2	0·5	7·4	0·6	6·9	0·6
	Breakfast eaters	55·9	0·3	46·9	0·6	9·3	0·2	17·5	0·3	18·5	0·3	12·1	0·3	3·5	0·2	6·2	0·2	5·4	0·2
Proteins (g)	Breakfast skippers	55·8*	1·0	46·3*	1·8	8·4*	0·5	21·3*	0·9	20·8	0·9	11·1*	0·7	3·9*	0·4	5·1*	0·4	5·1	0·4
	Breakfast eaters	58·7	0·3	52·4	0·6	9·8	0·2	19·1	0·3	22·0	0·3	9·0	0·2	3·1	0·1	4·2	0·1	4·4	0·2
Carbohydrates (% of energy)	Breakfast skippers	54·2	0·3	50·3	0·7	60·6	1·5	46·9	1·3	50·3*	1·2	67·2	1·4	67·5*	3·0*	70·6	2·1	63·5	2·4
	Breakfast eaters	53·7	0·1	50·1	0·3	61·3	0·4	49·0	0·4	47·6	0·4	67·8	0·5	75·7	1·0	73·5	0·7	64·3	0·9
Total fats (% of energy)	Breakfast skippers	31·2	0·2	32·7	0·6	27·5	1·2	29·3*	1·0	32·9	1·0	24·3	1·1	18·0	1·7	24·6	1·6	28·8	1·7
	Breakfast eaters	31·5	0·1	33·1	0·2	27·4	0·3	34·3	0·3	34·2	0·3	23·8	0·4	16·7	0·6	23·1	0·5	27·3	0·6
Proteins (% of energy)	Breakfast skippers	14·1*	0·1	17·0	0·4	13·7	0·5	16·1	0·7	17·8	0·7	8·5	0·5	8·2	0·7	8·2	0·6	10·6	0·8
	Breakfast eaters	14·5	0·1	16·7	0·1	13·3	0·1	17·2	0·2	19·0	0·2	8·4	0·2	7·1	0·3	7·5	0·2	11·3	0·3

*Mean values were significantly different from those of daily breakfast eaters ($P \leq 0·05$).
†Adjusted for children's sex and mother's education level (one-way ANOVA).
‡Means calculated among those having eaten the considered meals/snacks.
§Breakfast skipping is defined as eating breakfast on fewer than 7 days per week; breakfast eating is defined as eating breakfast every day.

Table 2 Adjusted† mean‡ servings of different food groups in daily meals and snacks by breakfast eating: pre-school children, Quebec, Canada

		Daily consumption		Meals								Snacks							
		Total		Total		Breakfast		Lunch		Dinner		Total		Morning		Afternoon		Evening	
Food group	Daily breakfast eating§	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Fruits	Breakfast skippers	2·34	0·108	1·38	0·12	0·32*	0·06	0·52*	0·05	0·49*	0·05	1·44	0·13	0·53	0·07	0·56	0·07	0·42	0·06
	Breakfast eaters	2·28	0·037	1·32	0·04	0·45	0·02	0·37	0·02	0·32	0·02	1·33	0·04	0·62	0·02	0·56	0·02	0·31	0·02
Vegetables	Breakfast skippers	1·14*	0·046	1·27	0·09	0·03*	0·01	0·47	0·04	0·61	0·04	0·12	0·03	0·04	0·02	0·04	0·02	0·03*	0·01
	Breakfast eaters	1·24	0·016	1·33	0·03	0·01	0·00	0·53	0·01	0·62	0·01	0·10	0·01	0·03	0·01	0·05	0·01	0·01	0·00
Grain products	Breakfast skippers	3·93*	0·071	2·91*	0·16	0·81*	0·07	1·38*	0·08	1·22	0·08	0·92*	0·08	0·30	0·05	0·54*	0·06	0·32	0·05
	Breakfast eaters	4·09	0·024	3·63	0·05	1·15	0·02	1·18	0·03	1·16	0·03	0·72	0·03	0·23	0·02	0·38	0·02	0·24	0·02
Milk products	Breakfast skippers	1·77*	0·058	1·02*	0·08	0·48	0·04	0·39	0·04	0·35*	0·04	0·79*	0·06	0·29*	0·03	0·28	0·03	0·41	0·04
	Breakfast eaters	1·98	0·020	1·52	0·03	0·53	0·01	0·47	0·01	0·46	0·01	0·61	0·02	0·18	0·01	0·22	0·01	0·35	0·02
Meat and alternatives	Breakfast skippers	1·91	0·045	2·17	0·11	0·16	0·03	0·96*	0·05	0·88	0·05	0·08	0·02	0·01	0·01	0·04	0·01	0·04	0·01
	Breakfast eaters	1·90	0·015	2·07	0·04	0·15	0·01	0·79	0·02	0·94	0·02	0·05	0·01	0·02	0·00	0·03	0·00	0·01	0·00

*Mean values were significantly different from those of daily breakfast eaters ($P \le 0.05$).
†Adjusted for children's sex and mother's education level (one-way ANOVA).
‡Means calculated among those having eaten the considered meals/snacks.
§Breakfast skipping is defined as eating breakfast on fewer than 7 days per week; breakfast eating is defined as eating breakfast every day.

breakfast and more during the evening snack; fewer servings of grain products at breakfast but more at lunch and in the afternoon snack; fewer milk products at dinner but more at the morning snack; and, finally, breakfast skippers consumed more meat and alternatives at lunch time. Globally, breakfast skippers consumed less grain and milk products from meals and more from snacks compared with breakfast eaters. They also consumed fewer servings of grain and milk products in the morning, and more servings of fruit after lunch (data not shown).

Breakfast skipping, energy and macronutrient intakes, and overweight

In order to examine the association between breakfast skipping and overweight (Table 4), a multivariate analysis was conducted. Results showed that the adjusted odds of being overweight at 4 years among pre-school children was double for breakfast skippers compared with those who ate breakfast every day (model 1). When energy consumption was included in the analysis (model 2), breakfast skipping remained significantly associated with being overweight and this relationship was strengthened. Furthermore, for every 418 kJ (100 kcal) increase in energy, the adjusted odds of being overweight was 1·22 (95 % CI 1·14, 1·31). When macronutrients or food groups were considered in a model, breakfast skipping and carbohydrate intake (model 3), and breakfast skipping and servings of grain products (model 4), were both associated with overweight, indicating that carbohydrate intake or intake of grain products may play an important role in the association between breakfast skipping and overweight in pre-school children. In model 3, the adjusted odds of being overweight for breakfast skippers was 2·27 (95 % CI 1·33, 3·88), while for every 10 g of carbohydrate intake the adjusted odds of being overweight was 1·13 (95 % CI 1·07, 1·20). In model 4, the adjusted odds of being overweight for breakfast skippers was 2·50 (95 % CI 1·45, 4·31), and for each added serving of grain products, the adjusted odds of being overweight was 2·11 (95 % CI 1·69, 2·64).

Further analyses were conducted to determine how energy and macronutrient consumption were related to BMI, while taking into account meal and snack patterns. From this analysis it was observed that dinner time was the period where differences in energy and macronutrient intakes between breakfast skippers and breakfast eaters were most strongly related to BMI. Figure 1 illustrates that intake of energy, carbohydrates and grain products were positively associated with mean BMI for breakfast skippers. More specifically, it was observed that the BMI of breakfast skippers increased as the intake of energy, carbohydrates or servings of grain products increased; however, this was not the case for breakfast eaters. When Cole's cut-off for overweight/obesity was used (BMI at 4·5 years of 17·19 kg/m^2 for girls and 17·47 kg/m^2 for boys)[32], overweight/obesity in breakfast skippers was

Table 3 Serving sizes, weight and energy values of some common foods in Canada†

Food	Serving size	Weight (g)	Energy (kJ)	Energy (kcal)
Bread, cereal and other grain products				
Bagel (10 cm diameter)	1	89	1025	245
Bread, whole wheat, commercial	1 slice	28	293	70
Bread, pita, white (16·5 cm diameter)	1	60	690	165
English muffin, plain	1 muffin	52	556	133
Oatmeal, quick	175 ml	146	414	99
Corn Flakes	250 ml	26	423	101
Cheerios, General Mills™	250 ml	24	410	98
Shreddies, Post™	175 ml	38	586	140
Rice Krispies, Kellogg's™	250 ml	29	460	110
Spaghetti, cooked	250 ml	148	874	209
Rice, white, long-grain, cooked	250 ml	185	883	211
Fruit				
Apples, raw, with skin (7 cm diameter)	1 apple	138	343	82
Bananas, raw	1 medium	115	439	105
Grapes, raw	10 grapes	50	151	36
Oranges, raw	1 fruit	311	259	62
Apple juice, canned	250 ml	262	515	123
Orange juice, canned	250 ml	263	464	111
Vegetables				
Broccoli, cooked	125 ml	97	113	27
Carrots, baby raw	10 carrots	100	159	38
Peas, green, cooked	125 ml	85	276	66
Potatoes, peeled, cooked (6·3 cm diameter)	1 potato	150	540	129
Tomato sauce, canned	125 ml	39	678	162
Tomatoes, raw (6.6 cm diameter)	1 tomato	123	109	26
Milk and milk products				
Milk, 2 % milk fat	250 ml	258	536	128
Yoghurt, fruit bottom, 1–2 % milk fat	250 ml	175	741	177
Cheese (5 cm×2 cm×0·5 cm)	4 slices	52	883	211
Cottage cheese, 2 % milk fat	125 ml	119	448	107
Meat and meat alternatives				
Egg, cooked	1 egg	50	326	78
Tuna, light canned in water	125 ml	79	385	92
Beef, ground, lean, cooked	1 patty	70	728	174
Chicken, drumstick, cooked	1 drumstick	49	310	74
Beans, baked, canned	250 ml	267	1243	297
Tofu, firm (4·5 cm×4 cm×4 cm)	1 piece	80	485	116
Peanut butter, natural	30 ml	32	774	185

†Source: *Nutrient Value of Some Common Foods*[40]. Serving sizes listed are for children over 6 years to adults; serving sizes suggested for children under 6 years old are approximately half the amounts given.

related to the dinner-time consumption of approximately 3000 kJ (700 kcal) or more for energy intake, approximately 100 g or more of carbohydrates, or approximately 3 servings or more of grain products.

Discussion

Breakfast skipping among young children is a concern given this meal provides a good source of essential nutrients and energy. One-tenth of pre-school children in the present population ate breakfast on fewer than 7 days per week, and pre-school children who skipped breakfast were significantly more likely to be classified as overweight or obese[10]. Few studies to date have examined whether the association between breakfast skipping and overweight/obesity in pre-school children is related to differences in the meal patterns, energy and macronutrients consumed by those who skip breakfast compared with those who eat breakfast every day.

The results of the present study indicate that pre-school children who ate breakfast every day generally had more servings of vegetables, grain and milk products throughout the day in comparison with pre-school children who regularly or occasionally skipped breakfast; this suggests that pre-school children who skip breakfast have a lower diet quality. This finding is in accordance with other research in children and adolescents, demonstrating that eating breakfast is associated with more healthful food choices and higher diet quality[21,41].

Although breakfast skippers were found to have lower diet quality, total daily energy intakes were comparable to those of pre-school children who ate breakfast every day, revealing that energy intake missed from skipping breakfast was compensated through foods consumed later in the day. Specifically, pre-school children who skipped breakfast had significantly higher energy intakes at evening snacks than pre-school children who ate breakfast every day. These results correspond with findings in adolescents demonstrating an association between

https://doi.org/10.1017/S1368980008001894 Published online by Cambridge University Press

Table 4 Adjusted† odds ratios and confidence intervals for breakfast skippers and overweight‡ by daily consumption of energy, macronutrients and food categories: pre-school children, Quebec, Canada

	Overweight children
	OR (95 % CI)
Model 1: Breakfast eating only	
Breakfast eaters§‖	1·00
Breakfast skippers§	2·00 (1·20, 3·35)*
Model 2: Breakfast eating and energy intake	
Breakfast eaters§‖	1·00
Breakfast skippers§	2·27 (1·34, 3·87)*
Energy intake (per 418.4 kJ/100 kcal)	1·22 (1·14, 1·31)*
Model 3: Breakfast eating and macronutrient intake	
Breakfast eaters§‖	1·00
Breakfast skippers§	2·27 (1·33, 3·88)*
Carbohydrates (per 10 g)	1·13 (1·07, 1·20)*
Total fats (g)	1·01 (0·99, 1·04)
Proteins (g)	1·01 (0·98, 1·03)
Model 4: Breakfast eating and food groups	
Breakfast eaters§‖	1·00
Breakfast skippers§	2·50 (1·45, 4·31)*
Vegetables and fruits (no. of servings)	1·06 (0·94, 1·21)
Grain products (no. of servings)	2·11 (1·69, 2·64)*
Milk products (no. of servings)	1·09 (0·83, 1·42)
Meat and alternatives (no. of servings)	1·17 (0·83, 1·64)

*Odds significantly different compared with the reference category ($P \leq 0{\cdot}05$, logistic regression analysis).
†Adjusted for children's sex, birth weight, mother's immigrant status, mother's education level, number of parents overweight/obese, mother's smoking status, inactivity index and all included variables in the current model. Models 3 and 4 are also adjusted for energy.
‡Children with BMI at or above the 95th percentile on the US CDC Growth curves (age- and sex-specific curves)[31].
§Breakfast eating is defined eating breakfast every day; breakfast skipping is defined as eating breakfast on fewer than 7 days per week.
‖Breakfast eaters comprise the reference category.

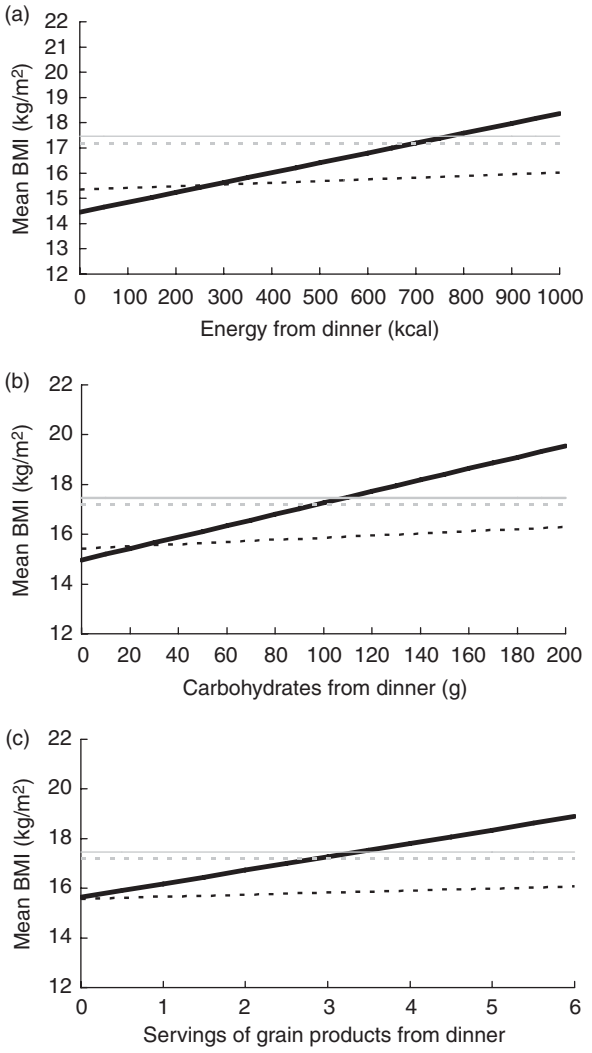

Fig. 1 Adjusted mean BMI (weight/height^2) and (a) daily energy from dinner, (b) carbohydrates from dinner and (c) grain servings from dinner for breakfast eaters (- - -) and breakfast skippers (——) among pre-school children, Quebec, Canada. BMI adjusted for children's sex, birth weight, number of parents overweight/obese, inactivity index and energy; additionally for carbohydrates, total fats and proteins in (b) and for vegetables and fruits, grain products, milk products and meat and alternatives in (c). Breakfast eating is defined as eating breakfast every day; breakfast skipping is defined as eating breakfast on fewer than 7 days per week. Also included on the plots are Cole's overweight/obese cut-offs for girls (- - -) and boys (——); a child who has a BMI above these lines is considered to be overweight or obese. Children who skip breakfast have a higher risk – and sooner – of being considered as overweight/obese by Cole's cut-off than children who eat breakfast every day. For example, a breakfast skipper will be reaching Cole's cut-off when his energy consumption is around 3140 kJ (750 kcal) while a breakfast eater may reach the same target after eating more than 4184 kJ (1000 kcal). To convert kcal to kJ, multiply by 4·184.

breakfast skipping and increased energy intakes from snacks[23]. However, one study in 10-year-old children contrasts the present study's findings pertaining to total energy intake, reporting that children who skipped breakfast had lower overall energy intakes than children who ate breakfast[25].

The present study also revealed differences in the macronutrient composition of snacks and overall diets of pre-school children who skipped breakfast compared with those who ate breakfast every day. Breakfast skippers' snacks contained more energy, with larger servings of grain, milk products, carbohydrates, total fats and proteins. However, on a daily basis, pre-school children who skipped breakfast consumed significantly less protein and less energy from protein in comparison with pre-school children who ate breakfast every day. Total daily carbohydrate intakes and total fat intakes were not found to differ significantly between breakfast skippers and breakfast eaters. We reported in an earlier publication that children in this cohort also consumed similar types of grain products, which were almost exclusively refined grain products (22 % of grain products) and few were whole-grain products (2 % of grain products)[34]. Although Nicklas *et al.*[25] did not find differences in the snack composition of 10-year-old children and adolescents who skipped or ate breakfast, and found differences in total daily carbohydrate and fat intakes between breakfast skippers and

https://doi.org/10.1017/S1368980008001894 Published online by Cambridge University Press

breakfast eaters, the association between breakfast skipping and lower total daily protein intake found in the present study is consistent with other research[20,42]. Differences in the findings across studies may result from differences in the age groups or populations studied.

A more important observation revealed from the present study was that the higher mean BMI found in breakfast skippers was significantly associated with increases in energy, carbohydrates and grain products consumed particularly at the dinner meal; yet this association was not observed for pre-school children who ate breakfast every day. This finding is a relevant one as it implies that the association between breakfast eating behaviours and overweight/obesity in young children may occur through possible interactions between meal patterns, timing of meals and the quantity of carbohydrates consumed in a meal. Several biological pathways may be proposed to explain this observation.

The first theory proposes a potential effect of meal frequency on energy balance. It is not known whether the effects on metabolism of eating regularly are independent of, or mediated by, energy intakes[43]. A review of studies examining this relationship reported that, although not all studies found a significant association, of the studies that observed significant results an inverse relationship was reported between meal frequency and body weight[43]. However, no association was observed in other reports[44]. Again, divergence in the results obtained across studies possibly arises from the differences in age and general makeup of the various populations examined[45]. Also, differences in findings among studies may be due to a variety of definitions used for meal patterns[44].

Another theory suggests a link between overweight and eating late in the day. In fact, Bellisle *et al.*[26] observed that obese and overweight children consumed more energy at the dinner meal than non-overweight children. Indeed, the results of the present study also indicate that breakfast skippers made up energy differences with higher energy intakes at snacks later in the day compared with breakfast eaters, particularly for the late evening snack. Although the directionality of the association cannot be determined from the present findings, it is possible that breakfast eating may be a simple strategy to help reduce energy intakes later in the day, when a child is less likely to be active and expend the energy consumed; this in turn may reduce the child's propensity to gain weight.

A third hypothesis suggests that the glycaemic index of food consumed may also influence body weight[46,47]. However, the association between overweight and the glycaemic effect of foods among children is poorly understood. It is thought that different changes in glucose and/or insulin levels in response to carbohydrate intake may have subsequent effects on food intake or the promotion of overweight and obesity[48]. Observations from the present study indicate that a carbohydrate load beyond 100 g at the dinner meal was associated with a greater likelihood of being classified as overweight among breakfast skippers but not among breakfast eaters. It is not known whether the interaction of increased BMI and carbohydrates is due to the quality of carbohydrates ingested or to an altered response to carbohydrates arising from skipped meals[49]. Given that this finding raises many issues related to the macronutrient composition of meals, further research is warranted to disentangle the effects of different types of carbohydrates and meal frequency on body weight among pre-school children.

Finally, the increased prevalence of overweight among breakfast skippers may be argued to result from differences in patterns of energy expenditure between pre-school children who skipped breakfast compared with those who ate breakfast every day. In fact, studies in adolescent populations have shown an association between lower levels of physical activity and breakfast skipping[15,50]. Although the present study did not have an objective measurement of children's level of physical activity, the mother's perceptions of their child's level of physical activity were assessed. However, the results indicated there was no association between mother's perceptions of their child's level of physical activity and breakfast eating or skipping (data not shown). Moreover, results from the multivariate analysis showed that despite statistical adjustments for sedentary behaviour, breakfast skippers consumed more energy and carbohydrates in the post-lunch period, and were more likely to be classified as overweight in comparison with breakfast eaters. Further research among pre-school children investigating differences in the effects of meals, including frequency and timing of meals, is suggested.

The results of the present study must be considered in the light of certain limitations. First, owing to the cross-sectional nature of the data, it is recognized that no causal attributions can be assigned to the associations observed in the present report. Reverse causality remains possible, particularly in regard to the role of energy and food consumption. As breakfast skippers were observed to have higher energy intakes at snacks and the dinner meal, compressing energy intakes later in the day may consequently curb children's appetite for eating breakfast the next morning, further promulgating the cycle. Reverse causality also remains possible if it is the case that parents of children who are overweight intentionally try to restrict various aspects of the child's diet, one being the skipping of breakfast. Additional population-based longitudinal research is required to properly examine whether meal patterns, energy and macronutrient intakes increase pre-school children's likelihood of skipping breakfast, thereby promoting prospective weight gain, or whether parental influences and other underlying biological aspects of being overweight/obese predict an individual's meal patterns (including breakfast skipping) and distribution of energy and macronutrient intakes.

Second, given the self-reported nature of the data obtained for energy intakes from the 24 h recall, the effect of energy and macronutrient intakes on the association between breakfast skipping and overweight should be interpreted with caution. Some studies found that snack foods are more commonly under-reported than foods consumed at regular meals[51,52]. Another study found an under-reporting of energy intakes among overweight women[53]. However, there are no reasons to believe that possible biases in self-reported energy intakes are differential across breakfast eating/skipping groups. For this reason, the results are likely to have underestimated the strength of the true association between breakfast skipping, energy and macronutrient intakes, and BMI.

Despite these limitations, the present study has specific strengths. The large sample size and high response rates allow for high confidence in the study results. Strengths also lie in the representative nature of the sample of singletons born in the province of Quebec (Canada) in 1998. Furthermore, the present findings accounted for several important covariates to the main associations, thus controlling for possible inconsistencies found in the previous literature. Due to these strengths, the present study makes important contributions to the literature and furthers understanding of the association between breakfast skipping and overweight in pre-school children.

Conclusions

In summary, although the total daily macronutrient composition and energy intakes of breakfast skippers were similar to those of pre-school children who eat breakfast every day, breakfast skippers concentrated their energy intakes through higher protein intakes at lunch and the consumption of snacks higher in energy and carbohydrate in the afternoon and evening. These associations corresponded with a higher prevalence of overweight and obesity in pre-school children who skipped breakfast. Given that breakfast eating was found to be associated with the more even distribution of energy intake throughout the day, it is possible that breakfast eating may play a role in the maintenance of a normal weight status and improved diet quality. Public health messages targeting parents of young children need to emphasize the importance of developing healthy eating patterns at a young age, by promoting regular breakfast eating and healthy snack choices over energy-dense snacks for pre-school children.

Acknowledgements

All authors have seen and approved this manuscript and have met all requirements for authorship. There have not been any prior or duplicate publications or submissions for publications. No conflicts of interest are declared.

Sources of funding: The research work of L Dubois is supported by the Canada Research Chair Program. The study was partly financed by the Canadian Institute of Health Information, Population Health Initiative, and by the Canadian Institute of Health Research. The analyses were performed using data from the Longitudinal Study of Child Development in Quebec (1998–2002) (LSCDQ), conducted by Santé Québec, a division of the Institut de la Statistique du Québec (ISQ) and funded by the Ministry of Health and Social Services of Québec.

Authorship responsibilities: L.D. is the director of the study (questionnaire development, data analysis, interpretation of the data, etc.). M.G. planned and performed the statistical data analysis. M.P.K., A.F. and F.T.T. contributed to literature review, content analysis and writing of the manuscript.

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