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Are snacking patterns associated with risk of overweight among Kahnawake schoolchildren?

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Abstract

Objective: To understand more specifically how the quality, quantity and frequency of snack food consumption differs in different BMI categories.
Design: Four hundred and forty-nine school-aged children (grade 4–6) from a Kanien'kehaka (Mohawk) community provided a 24 h recall and their height and weight in 1994, 1998 and 2002, in three independent cross-sectional samples. Food consumed between two consecutive meals was defined as a snacking occasion. ANOVA and χ^2 tests were used to compare food choices between BMI categories according to food quality criteria and food groups in 2006. Logistic regression models were performed to compare results between normal-weight children and those at risk of overweight and between normal-weight and overweight children.
Results: Energy intake from snacks tended to be higher for children at risk of overweight, compared with the other two BMI categories. Food groups with a higher energy density were also consumed more frequently by these children, with larger average portions of cereal bars ($P < 0{\cdot}05$). Except for dessert consumption, which was less frequent among overweight children, no other variable distinguished risk of overweight in the two logistic regression models tested.
Conclusions: Differences detected in snack food intake between normal-weight children and children at risk of overweight could explain in part the relationship between food choices and risk of overweight. Studies of dietary differences in conjunction with body weight would benefit from considering children at risk of overweight and normal-weight children, rather than children with excess weight only.

Keywords
Childhood obesity
Energy intake
Eating behaviours
Weight
Native Americans

The prevalence of overweight among children in most industrialized countries is of concern[1]. In Canada, the proportion of overweight children 2–17 years of age grew from 15 % to 26 % between 1979 and 2004[2] and in a 2002 survey, as many as 52 % of First Nations children aged 2–11 years living on reserve developed excess body weight[3]. Changes in food consumption patterns associated with increased average body weight are little understood[2,4–7].

A study of the relationship between snacking and childhood obesity seemed worth undertaking since nearly all children in North America eat snacks[5,8,9]. Studies of the relationship between snack food intake and overweight in children and adolescents produce contradictory results[10–17].

Since 1994, the Kahnawake Schools Diabetes Prevention Project (KSDPP) based on the promotion of healthy eating and physical activity has been in place in the schools and community of Kahnawake, a Kanien'kehaka (Mohawk) community of 7200 inhabitants near Montréal, Québec, Canada[18]. The project also includes a research component along with the intervention. A recent analysis of 24 h recalls indicated that overweight in the community's school-aged children was associated with overall increased consumption of French fries and potato chips (crisps)[19]. The purpose of the present study was to understand more specifically how the quality, quantity and frequency of snack food consumption differs in different BMI categories, to improve the approach of the ongoing community programme.

Methods

As part of the KSDPP research, a total of 449 school-aged children (grade 4–6) provided a 24 h recall and their height and weight in 1994, 1998 and 2002, in three independent cross-sectional surveys. The 24 h recalls were all collected in the month of October by trained dietitians using the same methods and were coded using

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the Canadian Nutrient Files (1997), a data set largely based on the US Department of Agriculture database, Handbook No. 8, with adjustments and additions made to reflect Canadian fortification and regulatory standards as well as Canadian-only foods (www.dietsoftware.com/Canada.html). This 1997 database (rather than the most recent 2007 version) was selected since it is close to the mid-point period of data collection (1994–2002) and may therefore better reflect the composition of foods actually available at those times. Snacks were defined by the interviewer based on time of day and whether the food was consumed between two consecutive meals.

Anthropometric measurements were obtained for children wearing light indoor clothing without shoes. Height was measured to the nearest 0·1 cm using a portable wooden measuring board (I.J. Shorr, Olney, MD, USA) and weight to the nearest 0·1 kg using the same numeric scales (model 770 Alpha; SECA Co., Columbia, MD, USA) which were periodically calibrated with standard weights. BMI (kg/m^2) was categorized as between the 5th and the 85th percentile (normal weight, *n* 266), between the 85th and the 95th percentile (at risk of overweight, *n* 75) or above the 95th percentile (overweight, *n* 103) based on the National Center for Health Statistics (2000) sex- and age-specific reference population[20]. Five children with BMI below the 5th percentile for their age were excluded, leaving a total of 444 children (151 in 1994, 144 in 1998 and 149 in 2002) for the analysis. The variables of age and gender were also considered in the study.

Food categories

In all, 778 snacks were consumed by 444 children between the ages of 8 and 13 years including 306 different foods in eighteen categories described in Table 1. The food items consumed as snacks were grouped into categories that correspond to those already defined in the literature[14,21–23]. Some categories had to be modified since the database was based on 24 h recalls and not on a list of predefined food items on an FFQ[14]. When possible, food items were grouped to obtain a minimum frequency of five per BMI category as validity criterion for χ^2 tests.

Statistical analysis

ANOVA was used to describe the children's behaviour at mealtime and snack time according to gender, age and year of study, and to compare the children's BMI categories according to total energy intake and energy density of solid foods. Energy density of beverages was not calculated, since it is difficult to estimate how much water children drink (especially because of the availability of water fountains in schools). In the present study, milk was considered a solid food because of its nutritional value, because it is often consumed with cereal at breakfast and because it is an integral component of many recipes. When *P* values were significant between BMI groups, multiple comparison tests were conducted using the Tukey procedure to identify group differences and minimize the risk of type 1 errors associated with multiple comparisons. The χ^2 test was used to compare snacking frequency according to BMI category, gender, age group and year of study for the number of snacks per day (0 to 3 maximum) as well as the time of day (morning, afternoon and evening).

For each food category of snacks, frequency of consumption and average daily amounts consumed were compared by BMI category using the χ^2 test and ANOVA, respectively. When ANOVA results were significant, the Tukey procedure was used to identify differences of

Table 1 Food group composition

Food group	Examples of foods in food group classification*
Fruits and vegetables	Fresh fruit, canned fruit, compotes, dried fruit, vegetables, fruit juice and salsa
Juice	100 % pure, unsweetened fruit juice
Milk	Milk, chocolate milk, yoghurt drinks
Milk products	Yoghurts, cheese, pudding
Bread, rice and pastas	Bread of any kind, rice, pasta, rusks
Cereal bars and breakfast cereals	Commercial cereal bars and breakfast cereal
Crackers, popcorn and pretzels	Soda crackers, Ritz crackers, popcorn, puffed rice cakes, pretzels
Meats	Beef, chicken, scrambled eggs, meat-based dishes: lasagna, chilli con carne, meat loaf, shepherd's pie
Peanuts, nuts and seeds	Nuts, sunflower seeds, peanut butter
Cold cuts	Sausage, bacon, ham, jerky
Soups	Dry soup mix or canned soup, diluted. Instant noodles
Fast food	Pizza, burgers, fries, poutine, hot dogs, chicken wings, submarine sandwiches, breaded and fried chicken
Desserts	Cookies, cakes, pies, pastries, muffins, apple crisp, banana bread
Jello/ice cream	Jello, popsicles, sundaes, sherbet, milk shakes, frozen yoghurt
Sweet beverages	Regular soft drinks, fruit drinks, commercial iced tea, Gatorade-type beverages
Chips	Potato chips, tortilla chips, Cheetos
Chocolate and candies	Chocolate or chocolate bars, candy of any kind
Spreads and condiments	Fats such as dips, margarine, butter, mayonnaise. Sweet spreads such as jam, caramel, sugar, chocolate powder or syrup. Condiments such as ketchup, mustard and sauces

*On eleven occasions, children drank non-sweetened beverages such as mineral water or diet sodas which we excluded from the analyses along with water.

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$P < 0{\cdot}05$ between groups of children. Finally, food groups with frequency of consumption trends of $P < 0{\cdot}15$ and reported in Table 4 were introduced into two full logistic regression models adjusted for gender, age group and year of study. One model compared normal-weight children with those at risk of overweight, and the other compared normal-weight children with overweight children. Statistical significance was set at $P < 0{\cdot}05$ for the interpretation of results.

The SAS for Windows statistical software package version 8·2 (SAS Institute Inc., Cary, NC, USA) was used to analyse results.

Results

General snacking patterns

As previously described[19], there was no significant difference in distribution of BMI categories by gender or year of data collection. Table 2 indicates results of energy intake and energy density of solid food for meals and snacks by gender, age group and year of study for all three BMI categories. When all children are considered without regard to BMI (n 444), results show that boys and girls had different behaviours with girls consuming less energy during meals and more at snack times. As they get older, children increased their energy intake at meals while reducing energy density from snacks, without changing the amount of total energy.

Overall, there was no significant difference in energy intake and energy density from meals by BMI group. On the other hand, energy intake from snacks tended to be higher for the children at risk of overweight, compared with the other two categories, in nearly all analyses (except for 2002 where there was no difference). A negative association between energy density of snacks and BMI could be observed in boys.

Table 3 describes behaviour associated with the number of snacks and snacking occasions by BMI category, gender, age group and year of study. Only forty children (9 %) out of 444 had not had a snack in the 24 h recall. Neither the number of snacks nor the number of meals per day (data not shown) was associated with BMI. Children at risk of overweight consumed evening snacks in greater numbers ($P = 0{\cdot}01$). Girls consumed a greater number of snacks overall and also at different times of the day than boys, except in the afternoon. Age did not appear to influence the number and time of snacking occasions. Considering the number of snacks and snacking occasions by year of study, the results show that there might be a shift since 1994 towards consuming more morning snacks *v.* later in the day.

Snacking patterns according to food groups

Of the eighteen food groups listed in Table 1, there were no tendencies ($P < 0{\cdot}15$) towards differences in intake between BMI categories save for a few exceptions reported in Tables 4 and 5. Food groups with a higher energy density were consumed significantly more frequently by children at risk of overweight (chips and fast food), as were larger average portions of cereal bars and breakfast cereals. Normal-weight children more frequently selected crackers, popcorn and pretzels, which have lower energy density than chips. Only the mean portion size of milk showed a positive association with BMI.

Finally, when all of the variables from Table 4 were included in a logistic regression model together with age, gender and year of study, the only significant effect left was for desserts, with overweight children consuming them less frequently than normal-weight children ($P = 0{\cdot}04$).

Discussion

Snacking is a common eating habit for the majority of schoolchildren in Kahnawake, contributing approximately 20 % of their total energy intake, a finding similar to other studies carried out in North America[5,8,9,17]. Like Nicklas *et al.*[11] but contrary to another study[8], no increase was observed in energy intake from or energy density of snacks since 1994. This could be explained by the fact that the increase in the energy contribution from snacks was observed, at least for the USA, in the early 1990s, before our study, suggesting that this trend was therefore over[7,8]. Rather, we observed a shift in the timing of snacks, with an increase in morning snacks and a decrease in afternoon and evening snacks. We also observed that girls consumed more snacks than boys, in agreement with Forslund *et al.*[21] and Ovaskainen *et al.*[24] but contrary to Field *et al.*[12] and Jahns *et al.*[8], suggesting that those observations may be highly context-dependent and require more data.

Our results also showed that, as they get older, children increase their energy intake at meals while reducing energy density from snacks, without changing the amount of total energy, number of snacks and time of snacking. The few differences we detected may be due to the narrow age range of our participants and could be expected to become larger with adolescence[25].

The main objective of the current study was to better understand the snacking patterns of children across different body weight categories in order to contribute to the ongoing community programme in Kahnawake. Contrary to the results of several other studies[11–14], our study clearly shows that children at risk of overweight consumed a greater number of snacks than the other two BMI categories without differences in total energy intake, energy from fats, energy density or diet diversity, as it was recently reported[19].

As for types of snacks, normal-weight children consumed more crackers, popcorn and pretzels than heavier children. Children in the at risk of overweight group

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Table 2 Mean energy intake and energy density from meals and snacks by BMI category for gender, age group and year of study: school-aged children (grade 4–6) from a Kanien'kehaka (Mohawk) community, Canada

	All children (*n* 444)			Normal weight (*n* 266)			At risk of overweight (*n* 75)			Overweight (*n* 103)			
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	*P* value BMI* (ANOVA)
Gender: Female (*n* 223)													
Meals													
Energy intake (kJ/d)	6648†	2356	223	6648	2439	136	6724	2423	41	6569	2075	46	NS
Energy intake (kcal/d)	1589†	563		1589	583		1607	580		1570	496		
Energy density of solids (kJ/g)	6·15	2·22	223	6·02	2·30	136	6·36	1·92	41	6·19	2·18	46	NS
Energy density of solids (kcal/g)	1·47	0·53		1·44	0·55		1·52	0·46		1·48	0·52		
Snacks													
Energy intake (kJ/d)	1983‡	1715	223	2042[a,b]	1715	136	2452[b]	2134	41	1397[a]	1021	46	0·01
Energy intake (kcal/d)	474‡	410		488[a,b]	410		586[b]	510		334[a]	244		
Energy density of solids (kJ/g)	8·70	6·36	201	8·49	6·19	124	9·08	6·02	37	8·95	7·20	40	NS
Energy density of solids (kcal/g)	2·08	1·52		2·03	1·48		2·17	1·44		2·14	1·72		
Gender: Male (*n* 221)													
Meals													
Energy intake (kJ/d)	7372†	2678	221	7372	2807	130	7021	2213	34	7590	2657	57	NS
Energy intake (kcal/d)	1762†	640		1762	671		1678	529		1814	635		
Energy density of solids (kJ/g)	6·15	1·88	221	6·07	1·88	130	6·19	2·01	34	6·32	1·88	57	NS
Energy density of solids (kcal/g)	1·47	0·45		1·45	0·45		1·48	0·48		1·51	0·45		
Snacks													
Energy intake (kJ/d)	1648‡	1523	221	1690	1552	130	2054	1778	34	1310	1218	57	0·07
Energy intake (kcal/d)	394‡	364		404	371		491	425		313	291		
Energy density of solids (kJ/g)	8·62	6·32	186	10·88[b]	6·57	110	8·74[a,b]	5·56	30	6·61[a]	4·77	46	0·04
Energy density of solids (kcal/g)	2·06	1·51		2·60[b]	1·57		2·09[a,b]	1·33		1·58[a]	1·14		
Age (years): 8–10 (*n* 275)													
Meals													
Energy intake (kJ/d)	6824§	2573	275	6828	2657	174	6686	2293	46	6925	2573	55	NS
Energy intake (kcal/d)	1631§	615		1632	635		1598	548		1655	615		
Energy density of solids (kJ/g)	6·44	2·13	275	5·98	2·26	174	6·03	1·84	46	6·40	2·01	55	NS
Energy density of solids (kcal/g)	1·54	0·51		1·43	0·54		1·44	0·44		1·53	0·48		
Snacks													
Energy intake (kJ/d)	1828	1569	275	1904[a,b]	1648	174	2113[b]	1665	46	1356[a]	1059	55	0·03
Energy intake (kcal/d)	437	375		455[a,b]	394		505[b]	398		324[a]	253		
Energy density of solids (kJ/g)	9·08‖	6·44	240	9·04	6·40	152	9·87	6·32	42	8·41	6·78	46	NS
Energy density of solids (kcal/g)	2·17‖	1·54		2·16	1·53		2·36	1·51		2·01	1·62		
Age (years):11–13 (*n* 169)													
Meals													
Energy intake (kJ/d)	7309§	2477	169	7330	2607	92	7134	2381	29	7368	2318	48	NS
Energy intake (kcal/d)	1747§	592		1752	623		1705	569		1761	554		
Energy density of solids (kJ/g)	6·23	1·92	169	6·15	1·84	92	6·61	2·13	29	6·15	2·01	48	NS
Energy density of solids (kcal/g)	1·49	0·46		1·47	0·44		1·58	0·51		1·47	0·48		
Snacks													
Energy intake (kJ/d)	1795	1728	169	1799[a,b]	1640	92	2523[b]	2406	29	1343[a]	1218	48	0·01
Energy intake (kcal/d)	429	413		430[a,b]	392		603[b]	575		321[a]	291		
Energy density of solids (kJ/g)	7·99‖	6·11	147	8·79	6·40	82	7·32	4·44	25	6·86	6·36	40	NS
Energy density of solids (kcal/g)	1·91‖	1·46		2·10	1·53		1·75	1·06		1·64	1·52		

Table 2 *Continued*

	All children (*n* 444)			Normal weight (*n* 266)			At risk of overweight (*n* 75)			Overweight (*n* 103)			
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	*P* value BMI* (ANOVA)
Year of study: 1994 (*n* 151)													
Meals													
Energy intake (kJ/d)	7284¶	2523	151	7364	2448	93	6427	2682	22	7602	2573	36	NS
Energy intake (kcal/d)	1741¶	603		1760	585		1536	641		1817	615		
Energy density of solids (kJ/g)	5·94	2·01	151	5·82	1·97	93	6·40	2·34	22	5·86	1·88	36	NS
Energy density of solids (kcal/g)	1·42	0·48		1·39	0·47		1·53	0·56		1·40	0·45		
Snacks													
Energy intake (kJ/d)	1916	1703	151	2063[a]	1753	93	2356[a]	2067	22	1276[b]	1088	36	0·02
Energy intake (kcal/d)	458	407		493[a]	419		563[a]	494		305[b]	260		
Energy density of solids (kJ/g)	8·79	6·61	129	9·20	6·86	84	10·21	6·19	17	6·69	6·11	28	0·14
Energy density of solids (kcal/g)	2·10	1·58		2·20	1·61		2·44	1·48		1·60	1·46		
Year of study: 1998 (*n* 144)													
Meals													
Energy intake (kJ/d)	7096¶	2481	144	7058	2473	87	7766	2602	24	6715	2389	33	NS
Energy intake (kcal/d)	1696¶	593		1687	591		1856	622		1605	571		
Energy density of solids (kJ/g)	6·23	2·22	144	6·23	2·30	87	6·44	2·01	24	6·19	2·18	33	NS
Energy density of solids (kcal/g)	1·49	0·53		1·49	0·55		1·54	0·48		1·48	0·52		
Snacks													
Energy intake (kJ/d)	1929	1623	144	1791[a]	1318	87	3059[b]	2418	24	1469[a]	1301	33	<0·01
Energy intake (kcal/d)	461	388		428[a]	315		731[b]	578		351[a]	311		
Energy density of solids (kJ/g)	8·41	6·19	130	8·54	6·15	77	8·70	5·48	24	7·82	6·99	29	NS
Energy density of solids (kcal/g)	2·01	1·48		2·04	1·47		2·08	1·31		1·87	1·67		
Year of study: 2002 (*n* 149)													
Meals													
Energy intake (kJ/d)	6644¶	2607	149	6556	2966	86	6435	1502	29	7046	2381	34	NS
Energy intake (kcal/d)	1588¶	623		1567	709		1538	359		1684	569		
Energy density of solids (kJ/g)	6·23	1·97	149	6·11	2·09	86	5·98	1·63	29	6·78	1·88	34	NS
Energy density of solids (kcal/g)	1·49	0·47		1·46	0·50		1·43	0·39		1·62	0·45		
Snacks													
Energy intake (kJ/d)	1602	1544	149	1736	1812	86	1556	1125	29	1305	1017	34	NS
Energy intake (kcal/d)	383	369		415	433		372	269		312	243		
Energy density of solids (kJ/g)	8·79	6·28	128	9·08	6·28	73	8·28	5·86	26	8·49	6·74	29	NS
Energy density of solids (kcal/g)	2·10	1·50		2·17	1·50		1·98	1·40		2·03	1·61		

Normal weight, BMI between 5th and 85th percentile; at risk of overweight, BMI between 85th and 95th percentile; overweight, BMI > 95th percentile.
[a,b] Mean values within a row with unlike superscript letters were significantly different ($P < 0·05$).
*P values <0·15 are shown.
†Significant difference between genders for energy intake from meals ($P < 0·01$).
‡Significant difference between genders for energy intake from snacks ($P = 0·03$).
§Significant difference between age groups for energy intake from meals ($P = 0·05$).
‖Difference between age groups for nutrient density of snacks ($P = 0·11$).
¶Difference for energy intake from meals between 1994 and 2002 ($P = 0·08$).

Table 3 Percentage consuming snacks by BMI category, gender, age group and survey year: school-aged children (grade 4–6) from a Kanien'kehaka (Mohawk) community, Canada (*n* 444)

	Number of snacks/d (%)*					Snacking occasion (%)*		
	0	1	2	3	*P* value (χ^2)	Morning	Afternoon	Evening
BMI								
Normal weight (*n* 266)	8	29	41	21	NS	55	63	58
At risk of overweight (*n* 75)	7	21	43	29		60	68	67
Overweight (*n* 103)	13	34	35	18		54	59	46
P value (χ^2)						NS	NS	0·01
Gender								
Female (*n* 223)	6	25	41	28	<0·01	66	64	61
Male (*n* 221)	12	33	39	16		45	62	52
P value (χ^2)						<0·01	NS	0·05
Age group (years)								
8–10 (*n* 275)	8	29	43	20	NS	58	62	55
11–13 (*n* 169)	11	28	35	26		52	64	60
P value (χ^2)						NS	NS	NS
Year of study								
1994 (*n* 151)	7	31	40	23	NS	48	66	64
1998 (*n* 144)	8	23	44	26		57	70	60
2002 (*n* 149)	13	32	37	18		62	53	46
P value (χ^2)						0·06	<0·01	0·03

Normal weight, BMI between 5th and 85th percentile; at risk of overweight, BMI between 85th and 95th percentile; overweight, BMI > 95th percentile.
*Rounded to whole percentage.

Table 4 Food groups consumed at snacking occasions showing differences in frequency by BMI category*: school-aged children (grade 4–6) from a Kanien'kehaka (Mohawk) community, Canada (*n* 444)

	Normal weight (*n* 266)		At risk of overweight (*n* 75)		Overweight (*n* 103)		
	Frequency (%)†	*n*	Frequency (%)†	*n*	Frequency (%)†	*n*	*P* value (χ^2)
Chips	18·8	50	25·3	19	10·7	11	0·04
Desserts	26·7	71	30·7	23	16·5	17	0·06
Crackers, pop corn, pretzels	21·4	57	13·3	10	11·6	12	0·05
Fast food	7·5	20	10·7	8	2	2	0·05

Normal weight, BMI between 5th and 85th percentile; at risk of overweight, BMI between 85th and 95th percentile; overweight, BMI > 95th percentile.
*Only food groups from Table 1 showing differences in frequency between BMI categories at $P < 0·15$ are reported.
†Rounded at 0·1 %.

Table 5 Food groups consumed at snacking occasions showing differences in mean portion size between BMI categories*: school-aged children (grade 4–6) from a Kanien'kehaka (Mohawk) community, Canada (*n* 444)

	Normal weight (*n* 266)			At risk of overweight (*n* 75)			Overweight (*n* 103)			
	Portion size (g)			Portion size (g)			Portion size (g)			
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	*P* value (ANOVA)
Milk	212[a]	90	53	248[a,b]	175	14	292[b]	131	17	0·05
Cereal bars/breakfast cereals	34	11	30	59	59	9	28	7	7	0·04
Candies/chocolate	43	48	53	70	85	19	28	27	16	0·08
Fast food	91	61	20	165	149	8	227	209	2	0·08

Normal weight, BMI between 5th and 85th percentile; at risk of overweight, BMI between 85th and 95th percentile; overweight, BMI > 95th percentile.
[a,b] Mean values within a row with unlike superscript letters were significantly different ($P < 0·05$).
*Only food groups from Table 1 showing differences in mean portion size between BMI categories at $P < 0·15$ are reported.

stood out however by consuming more frequently evening snacks, high-energy-density foods like potato chips and larger portions of breakfast cereals and cereal bars. We had already reported higher consumption of potato chips among children at risk of overweight, but we can now further identify it as a snacking issue[19].

Results for milk consumption showed that overweight children do not consume milk more frequently, but in larger servings at snack time. Also, no difference was found in consumption of some food groups according to BMI category, such as sugar-sweetened beverages, while this association is increasingly noted in longitudinal

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studies[14,26,27]. In a previous study[28] of the same children from 1994 and 1998 only, our group had shown that lean children consumed more milk overall (snacks + meals), in keeping with other studies[29,30]. Further ANOVA were then performed (results not shown) in the milk and sugar-sweetened beverage categories: an important decline in consumption of both was observed between 1994 and 2002, especially with meals. Adjusted for age, gender and BMI, total daily average consumption has gone from 343 g to 224 g for milk, a downward trend confirmed elsewhere[23,26,31], and from 546 g to 332 g for sugar-sweetened beverages, a result contrary to the secular trend observed[23,26,31] and which could be attributed, at least in part, to the diabetes prevention programme in place in schools since 1994.

Finally, in our multiple regression models, we found an inverse association between overweight and dessert consumption. Similar results have been reported in other studies. For example, in a systematic review including 137 000 children aged 10–16 years in thirty-four countries, Janssen *et al.*[1] reported a negative relationship between the intake of candies/chocolates and BMI in thirty-one of the thirty-four countries, even when controlled for being on a weight-loss diet. A nutritional survey of Québec children found a negative association between overall candy, chip and fruit drink consumption and overweight[32]. A low reporting of some food groups such as sweets and sugary foods found in those studies may also reflect recognition of their socially negative connotations, as observed by Klesges *et al.*[33] in young Afro-American girls aged 8–10 years. This further reduces chances of finding associations between the consumption of specific snack foods and the risk of overweight.

The lack of further differences in snacking behaviour among overweight children could be due to greater bias of under-reporting among overweight than among at risk of overweight children, as observed in adults[13,34,35]. We calculated Goldberg factors[36] across BMI categories. Indeed, these were 1·7 for normal-weight, 1·5 for at risk of overweight and 1·2 for overweight children, suggesting that under-reporting was present among heavier children but not to the extent of invalidating the data. Contrary to Moreno *et al.*[25], we observed no differences in under-reporting according to gender.

Apart from reporting bias, there may be other reasons for the relative lack of association between food consumption and body weight category. Perhaps we should not expect a dose–response relationship between at risk of overweight and overweight children because these two conditions could be associated with different behaviours. For example, overweight children might decrease their physical activity level as their body weight increases while at risk of overweight children might keep the same level of physical activity as their normal-weight peers. In the same way, overweight children may restrict their food intake as they are gaining weight while at risk of overweight children may not. In fact, other studies showed no differences in energy intake according to BMI or percentage body fat[12,14] and two studies showed an inverse association between energy from snacks and body weight in children and adolescents[16,17].

Our results must be considered with caution because of other limitations of our study. First, since it is a cross-sectional study, causal direction cannot be established. Second, food records included only one 24 h recall in which a misclassification bias may exist between meals and snacks, especially since children do not always eat three meals a day and may skip meals and consume several snacks[35]. Third, a relatively small sample size for some snack categories reduces the possibility of detecting differences with sufficient statistical power. Fourth, certain variables associated with risk of overweight in children linked to social environment, lifestyle and hereditary factors were not included in the scope of the study but may explain differences in results. For example, physical or sedentary activities, time spent in front of a computer screen, parents' weight, mother's education level, concern about weight, dieting or pubertal development were not accounted for in analysis. Finally, the results of our study apply only to Kahnawake children and cannot be generalized for other populations.

One of the factors making comparisons with other studies difficult is the very definition of what constitutes a snack or snacking occasion[7,8,10,11,14,15,21,23]. Also, there is no consensus at this time on a standardized method of classifying foods by group in relation to their nutrient intake[22]. This makes comparisons difficult, despite our attempt to classify foods into groups according to examples set by recent studies[14,21–23]. Gregori and Maffeis' call for a clearer definition of a snack is highly relevant[37] as a food classification system is needed to make food consumption data comparable[25].

The present study adds to previous studies by trying to establish an association between specific eating patterns and overweight. In our study, it was possible to detect differences in snack food intake in normal-weight and at risk of overweight children. In addition to an added focus on factors linked to under-reporting, this suggests that future studies of dietary differences associated with body weight would benefit from comparing children at risk of overweight, and not only overweight children, with normal-weight children.

From a practical standpoint, school interventions related to snacks are appropriate since children may have more control over their snack choices than they have at meals, which are generally overseen by parents. For this reason, teaching children to change their snack and/or sugar-sweetened beverage choices can be relevant[38]. This is also true for food policies that make healthier snack choices available and discourage less healthy choices[18,39]. In this regard, promoting the consumption of water, milk and other nutritional beverages, instead of

sugar-sweetened beverages, and fruits and vegetables, instead of energy-dense foods, is relevant. A particular attention to snacking patterns is also warranted since snacks can contribute important nutrients on a daily basis and snacking patterns highlighted in the present study are dynamic across time, gender and body weight categories.

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