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Dietary Adequacy among Multi-Ethnic Urban Youth in Edmonton: Findings from the Wellness and Health in Youth – Aboriginal and All Communities in Transition NOW (WHY ACT NOW) Project

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ABSTRACT

Objective: The development of obesity and chronic diseases in adulthood often results from a childhood pattern of dietary excesses. This study aimed to identify dietary inadequacies and excesses of multiethnic youth in Edmonton.

Methods: A cross-sectional survey of a convenience sample of 473 multiethnic youth between 11 and 18 years was conducted in 12 schools in Edmonton between October 2013 and March 2014. Data were analyzed to determine for each participant mean daily energy and nutrient intakes, dietary adequacy, and nutrient densities. Participants were divided by self-identified ethnicity (Indigenous, European, African and Middle Eastern, and Asian).

Results: For all nutrients examined, the mean percentage of calories from fat was higher among European (31.7%) and Indigenous youth (31.8%) compared to African and Middle Eastern (28.3%) and Asian youth (29.0%), while Asian youth had the highest percentage of calories from protein (17.7%) compared to other ethnic groups (Indigenous = 15.5%; African & Middle Eastern = 16.5%; European = 16.2%). The majority of youth fell below the recommended values for dietary fiber (83.3–92.0%), vitamins D (84.4–90.2%), and E (89.5–92.0%). More than 50% fell below the dietary reference intakes (DRIs) for vitamin A, vitamin B5, calcium, and magnesium; >30% were below the DRI for folate, zinc, and vitamins B6, and C. The diet of girls contained a greater density of fiber compared to boys (9.3 vs. 8.0 g/1000 kcal; p-value = 0.002).

Conclusions: Inadequate dietary intake is evident among the majority of multiethnic youth in Edmonton. There is a need to develop strategies to reduce the burden of poor nutrition status for youth.

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Multiethnic populations; youth; dietary adequacy; dietary excess; Edmonton

Introduction

Chronic diseases are the most important contributors to premature death and health care costs in Canada (1). Treatment of chronic disease – primarily cardiovascular disease, diabetes, and cancer is CAD$68 billion, representing two-thirds of all direct health care costs (2). Poor nutrition is one of the main risk factors for chronic diseases (3–6). Dietary habits and food preferences formed in childhood often extend into adulthood (7–10). Children and adolescents with unhealthy dietary habits are more likely to be obese and develop other chronic diseases in adulthood (11, 12). Chronic diseases in adulthood are often the result of the pattern of dietary excesses in childhood, particularly foods high in fats and added sugars, and may increase morbidity and mortality due to diabetes, cardiovascular disease, hypertension, and cancer (13–17).

In 2014, 29% of boys and 17% of girls between 12–17 years old were overweight or obese in Canada (18). Obesity and chronic diseases disproportionately affect subsets of the Canadian population (19). Among all Canadians, the Indigenous population had the highest prevalence rate of obesity (16, 20). Evidence from epidemiological studies suggests that age-standardized mortality rates for all chronic diseases were lower for foreign-born Canadians than Canadian-born individuals (21, 22), but with increasing years in Canada, the health of immigrant Canadians converge to Canadian-born levels and the "healthy immigrant effect" diminishes (23).

Adolescents and young adults should follow a healthy, balanced diet to maintain optimal growth, and reduce the risk of chronic diseases (9, 20, 24, 25). There is substantial evidence to show that many youth follow unhealthy eating habits and do not comply with Health Canada's dietary guidelines (26–29). These habits include a high consumption of fast foods, non-nutrient-dense foods (NNDFs), and sugar-sweetened beverages, and a low consumption of fresh fruit and vegetables, irregular eating, and breakfast skipping (28–31). A national survey showed that one-third of

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Canadian youth had high calorie intakes, but did not meet the requirements for vitamin A, vitamin D, magnesium, and calcium (26). Dietary intake and food consumption patterns vary across different ethnic groups (32–38). Schools make a convenient and effective setting to implement nutrition interventions targeting children and adolescents (39–41) to improve eating habits (42, 43). In particular, implementing culturally appropriate health-promotion programs was suggested as an effective strategy to promote health and wellness with Indigenous youth (44). Given the changing demographics of Canadian cities and limited access to traditional foods, especially in schools, there is a need for current dietary intake information. The goal of the current study is to explore the dietary inadequacies and nutrient density of the diets of urban multiethnic youth in Edmonton.

Methods

Study setting, participant recruitment, and data collection

In the Wellness and Health in Youth – Aboriginal and All Communities in Transition NOW (WHY ACT NOW) study, 12 schools and institutions in Edmonton, Alberta, Canada with large numbers of Indigenous and/or new Canadian students were selected. The population in Edmonton is increasingly diverse; foreign-born immigrants comprise 25% of the population, and those people who identify as Indigenous (First Nations, Métis, or Inuit) make up 5%. With median ages lower than the national average, both Indigenous and immigrant populations are comparatively young. In total, the study recruited a convenience sample of 557 multiethnic youth between 11 and 23 years of age. Dietary patterns and dietary adequacies are influenced by different factors throughout childhood and adolescence (45) and need to be distinguished according to age; therefore, 473 multiethnic youth between 11 and 18 years of age were included in these analyses.

Posters, school newsletters, and in-class advertisements were used to recruit participants. Several teachers and school staff volunteered to be points of contact on site for students to receive more information about the study and express interest in participating. Easily identifiable research team members wearing project t-shirts also appeared at the schools regularly during the recruitment phase and students could discuss the study with the team members and indicate interest. On average, 49 students from each school, representing 5.4% of the total student population from each of the 12 schools and institutions, participated; one school, which mainly serves Indigenous students and has a smaller number of total students, had a higher participation rate of 29.4%. Research team members were trained in the standardized methods to use when administering the questionnaires and collecting anthropometric data. Trained researchers administered one-on-one interviews using a specifically designed questionnaire between October 2013 and March 2014. The schools and institutions provided private spaces where participants felt comfortable (e.g. empty classrooms, unused staff rooms) and allowed students to be interviewed during class or between class time. Each interview took 45–60 minutes to finish and was composed of anthropometric measurements and questions regarding demographics, ethnicity, family environment, material possessions (as an indicator of social economic status), physical activity, dietary supplement intake, and a 24-hour dietary recall. After data collection was completed, the data were examined by the project coordinator. The participants were re-contacted by the interviewer to obtain any missing information. Pregnant and breastfeeding youth were not included in this study due to the difference in dietary and nutritional requirements.

A stadiometer (SECA 213, SECA, Hamburg, Germany) and a scale (5738BL 06.08, TAYLOR, Oak Brook, USA) were used to measure height and weight to the nearest one-tenth of a centimeter and kilogram, respectively. Measurements were obtained three times only if the first and second attempts were more than 0.5 cm (for height) or 0.5 kg (for weight) apart. If participants declined to be measured, self-reported measurements were recorded (for height $n = 18$; for weight $n = 24$). Before measuring, interviewers asked participants to remove heavy clothing and shoes. By noting the heaviness of clothing, weight was adjusted by subtracting 1 kg for light, 1.5 kg for medium, and 2 kg for heavy clothing from the measurement. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared. The World Health Organization (WHO) growth reference for 5–19 years old was used to determine age- and sex- appropriate BMI z-scores (46); participants were categorized as underweight (BMI < -2 Standard Deviations (SDs)), normal weight (-2 SD $\leq$ BMI $\leq$ 1 SD), overweight (1SD $<$ BMI $\leq$ 2 SD), or obese (BMI $>$2 SD).

Research Ethics Board approval was obtained from the University of Alberta Health Research Ethics Board. The Cooperative Activities Program with the University of Alberta, Faculty of Education and the Research Proposal Review Committee with Edmonton Public Schools approved this project. Research participants provided written informed consent before the interview. Participants below the age of 18 years also provided parental or guardian consent.

24 -hour dietary recall

A 24-hour dietary recall was administered by a trained interviewer with each participant. To best estimate the amount of foods and beverages consumed, three-dimensional food models (NASCO Company, 901 Jamesville Ave, Fort Atkinson, Wisconsin 53538) and common household units (e.g. bowls, mugs, and spoons) were provided as examples. Detailed information regarding the time of consumption, preparation/cooking methods, description of the food (e.g. brand names), and amount of all food and beverage items consumed in the preceding 24 hours was collected. Items that might have been easily missed (e.g. additions to hot drinks, condiments, and water) were confirmed by a checklist and added to the recall if necessary. When the participant was on a special diet, such as gluten-free or

Table 1. General characteristics of multiethnic youth, aged 11–18 years (by ethnicity).

Variables	Indigenous n = 87	African & Middle Eastern n = 82	Asian n = 124	European n = 180	Total n = 473	*p-value*[a]
Age (Mean ± SD)	15.8 ± 1.8	16.0 ± 1.8	16.1 ± 1.1	16.3 ± 1.2	16.1 ± 1.4	NS
		n (%)				
Sex						
Female	54 (62.1)	52 (63.4)	72 (58.1)	112 (62.2)	290 (61.3)	
Male	33 (37.9)	30 (36.6)	52 (41.9)	68 (37.8)	183 (38.7)	NS
Living status						
With parent/s	63 (74.1)	82 (100)	113 (91.1)	167 (93.3)	425 (90.4)	
Alone	3 (3.5)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.6)	
With relatives	15 (17.7)	0 (0.0)	4 (3.2)	7 (3.9)	26 (5.5)	
With others	4 (4.7)	0 (0.0)	7 (5.7)	5 (2.8)	16 (3.4)	<.0001
BMI (kg/m^2)[b]						
Underweight	1 (1.2)	2 (2.5)	9 (7.7)	2 (1.2)	14 (3.1)	
Normal	57 (67.1)	49 (62.0)	84 (71.8)	137 (81.1)	327 (72.7)	
Overweight	14 (16.5)	24 (30.4)	15 (12.8)	18 (10.7)	71 (15.8)	
Obesity	13 (15.3)	4 (5.1)	9 (7.7)	12 (7.1)	38 (8.4)	<.0001
Material Style of Life (MSL)[c]						
0–5	2 (2.5)	3 (3.9)	1 (0.8)	0 (0.0)	6 (1.4)	
6–9	34 (42.0)	22 (28.6)	31 (25.8)	26 (15.6)	113 (25.4)	
10–12	45 (55.6)	52 (67.5)	88 (73.3)	141 (84.4)	326 (73.3)	<.0001
Physical activities (hours/week)						
<4	27 (31.0)	24 (29.3)	53 (42.7)	45 (25.0)	149 (31.5)	
≥4 and <8	21 (24.1)	20 (24.4)	38 (30.7)	54 (30.0)	133 (28.1)	
≥8 and <12	13 (14.9)	14 (17.1)	18 (14.5)	34 (18.9)	79 (16.7)	
≥12	26 (29.9)	24 (29.3)	15 (12.1)	47 (26.1)	112 (23.7)	0.02

[a]Welch ANOVA test was applied to detect the difference in mean age by ethnicity. Pearson chi-square test was performed to provide measures of association between ethnicity and sexes, living status, Body Mass Index (BMI), Material Style of Life (MSL), and physical activities (hours/week).

[b]BMI was calculated as weight in kilograms divided by height in meters squared. Age- and sex specific BMI z scores were computed based on the WHO growth reference for 5–19 years old (46); participants with BMI less than two standard deviations (SDs), greater than one SD, and greater than two SDs were categorized as underweight, overweight or obese, respectively.

[c]MSL 0–5 is low possession score, 6–9 is medium possession score, and 10–12 is high possession score. Possession score was defined as having a cellphone, video game console, digital camera, DVD player, deep freezer, boat, satellite dish/cable, car or truck, motorbike, washing machine, bicycle or computer in working condition in the home, in the past 30 days.

vegetarian, this was indicated at the end of the 24-hour recall. All dietary data from 24-hour dietary recalls were entered and analyzed in Nutribase Clinical Nutrition Manager Version 11 (Cybersoft Inc., Phoenix, AZ, USA), a computerized dietary database using the Canadian Nutrient File.

Data analyses

Descriptive statistics included age, BMI, accommodation status (with parents, alone, with relatives or siblings, or with others), physical activity (<4, ≥4 and <8, ≥8 and <12, or ≥12 hours/week), and measures of Material Style of Life (MSL) (0–5 = low, 6–9 = medium, or 10–12 = high possession score). Possession score was defined as having a cellphone, video game console, digital camera, DVD player, deep freezer, boat, satellite dish/cable, car or truck, motorbike, washing machine, bicycle, or computer in working condition in the home during the past 30 days.

Mean and SD of daily energy and nutrient intakes were determined from the 24-hour recall data. Age- and sex-specific Dietary Reference Intakes (DRIs) were used to assess the adequacy of nutrient intakes. Intakes were compared to the sex-specific Estimated Average Requirements (EARs) for the age groups 9–13 and 14–18 years (47). If the EAR was not available, as for dietary fiber, vitamin B_5, potassium, and sodium, the Adequate Intake (AI) was used instead. Participants were divided by self-identified ethnicity (Indigenous, European, African and Middle Eastern, and Asian) for further analyses. Students' t-test and one-way ANOVA were used to perform analyses and identify statistically significant differences in mean daily energy and nutrient intakes, dietary adequacy, and nutrient densities (per 1000 kcal) by sex and ethnicity. A multiple comparison test (Tukey-Kramer) was utilized to determine whether the four ethnic groups' means differed significantly in an analysis of variance. The standard deviations of mean intake for some nutrients were heterogeneous (detected by Levene's test) by ethnicity; therefore, Welch's ANOVA and Games-Howell tests were applied instead of ANOVA. Pearson chi-square test was performed to provide measures of association for sexes and ethnic groups with nutrient adequacy. All tests and *p-values* were two-sided and differences were considered statistically significant if the *p-value* < 0.05. All statistical analyses were carried out using the Statistical Analysis Software (SAS version 9.4).

Results

Of 473 participants, 87 were Indigenous, 82 were African and Middle Eastern, 124 were Asian, and 180 were European. The mean age was 16.1 years old and 61.3% of the participants were female; there were no significant differences in age or sex between ethnic groups. There were significant differences between ethnic groups for the variables of living status (*p-value* < 0.0001), BMI (*p-value* < 0.0001), MSL (*p-value* < 0.0001), and physical activities (*p-value* = 0.02) (Table 1).

Energy and nutrient intakes and nutrient density

Mean intakes of energy and selected nutrients, and nutrient density (per 1000 kcal) are presented by ethnicity in Table 2.

Table 2. Mean ± SD energy and selected nutrient intakes and nutrient density (per 1000 kcal) among multiethnic youth aged 11–18 years (n = 473).

	Total intake/day (Mean ± SD)					Total intake/1000 kcal (Mean ± SD)				
Nutrients	Indigenous	African & Middle Eastern	Asian	European	p-value[a]	Indigenous	African & Middle Eastern	Asian	European	*p*-value[a]
Energy (kcal)	2245 ± 1014	2250 ± 1025	2275 ± 894	2210 ± 900	NS	–	–	–	–	–
% kcal from carbohydrates	52.6 ± 12.1	55.2 ± 9.8	53.3 ± 11.0	52.0 ± 9.9	NS	–	–	–	–	–
% kcal from fat	31.8 ± 10.3	28.3 ± 7.7	29.0 ± 9.3	31.7 ± 8.7	**0.004**[h,i]	–	–	–	–	–
% kcal from protein	15.5 ± 6.1	16.5 ± 6.4	17.7 ± 5.9	16.2 ± 5.2	**0.04**[e]	–	–	–	–	–
Carbohydrate (g)	306 ± 147	323 ± 158	312 ± 135.3	299 ± 131	NS	138 ± 30	144 ± 24	138 ± 28	137 ± 27	NS
Fat (g)	79.7 ± 45.0	70.3 ± 40.9	72.9 ± 39.4	77.9 ± 41.7	NS	34.8 ± 11.2	30.7 ± 8.6	31.4 ± 10.3	34.6 ± 9.8	**0.002**[d,h,i]
Protein (g)	84.4 ± 45.7	87.3 ± 44.5	97.4 ± 50.8	86.8 ± 48.1	NS	38.1 ± 14.6	40.2 ± 15.4	43.7 ± 14.3	39.5 ± 12.3	NS
Sugars (g)	140.6 ± 92.1	130.8 ± 83.8	108.0 ± 64.8	135.5 ± 81.5	**0.01**[e,i]	62.7 ± 30.3	57.3 ± 22.1	47.8 ± 21.6	61.9 ± 25.0	**<0.0001**[e,g,i]
Fiber (g)	16.4 ± 9.0	18.9 ± 11.2	18.4 ± 10.6	20.2 ± 12.3	NS	8.0 ± 4.8	9.0 ± 4.4	8.5 ± 4.4	9.4 ± 4.7	NS
Saturated Fat (g)	26.9 ± 16.8	23.9 ± 15.5	23.3 ± 14.3	27.3 ± 15.9	NS	11.7 ± 4.5	10.4 ± 3.8	9.9 ± 4.1	12.2 ± 4.9	**<0.0001**[e,h,i]
Monounsaturated Fat (g)	24.8 ± 17.5	17.7 ± 11.8	19.9 ± 15.8	20.9 ± 15.5	**0.02**[d]	10.6 ± 5.3	7.7 ± 3.8	8.5 ± 5.2	9.2 ± 4.9	**0.001**[d,e]
Polyunsaturated Fat (g)	12.5 ± 9.7	9.3 ± 6.6	10.6 ± 7.1	11.0 ± 10.3	NS	5.6 ± 4.9	4.1 ± 2.2	4.8 ± 2.9	4.8 ± 3.3	**0.04**[d]
Omega 3 (g)	0.3 ± 0.7	0.2 ± 0.4	0.5 ± 1.5	0.3 ± 1.0	NS	0.2 ± 0.5	0.1 ± 0.2	0.2 ± 0.7	0.2 ± 0.4	NS
Omega 6 (g)	2.3 ± 5.4	1.0 ± 1.7	2.0 ± 3.2	1.9 ± 6.7	NS	1.2 ± 4.0	0.5 ± 0.8	0.9 ± 1.4	0.7 ± 2.0	NS
Cholesterol (mg)	246 ± 179	252 ± 224	280 ± 196	227 ± 199	NS	110 ± 76	116 ± 106	121 ± 71	102 ± 72	NS
Vitamin A[b] (µg)	579 ± 473	614 ± 695	564 ± 563	574 ± 524	NS	275 ± 256	337 ± 688	260 ± 309	259 ± 210	NS
Vitamin B1 (mg)	1.8 ± 1.2	1.6 ± 0.9	1.6 ± 1.2	1.6 ± 1.0	NS	0.8 ± 0.4	0.7 ± 0.4	0.7 ± 0.5	0.7 ± 0.4	NS
Vitamin B2 (mg)	1.7 ± 1.5	1.8 ± 1.1	1.7 ± 1.2	1.8 ± 1.5	NS	0.7 ± 0.4	0.8 ± 0.4	0.8 ± 0.5	0.8 ± 0.6	NS
Vitamin B3 (mg)	22.3 ± 16.1	20.5 ± 13.1	21.4 ± 13.6	19.0 ± 16.0	NS	10.0 ± 5.2	9.6 ± 5.8	9.5 ± 4.8	8.7 ± 6.3	NS
Vitamin B5 (mg)	5.0 ± 3.2	4.9 ± 3.2	5.1 ± 2.9	7.5 ± 39.0	NS	2.3 ± 1.2	2.3 ± 1.2	2.3 ± 1.0	3.0 ± 11.4	NS
Vitamin B6 (mg)	1.6 ± 1.2	1.5 ± 1.3	1.8 ± 1.8	1.6 ± 1.8	NS	0.7 ± 0.4	0.7 ± 0.5	0.8 ± 0.8	0.7 ± 0.7	NS
Folate (µg)[c]	431 ± 311	462 ± 334	378 ± 276	370 ± 248	NS	190 ± 91	204 ± 122	173 ± 116	170 ± 90	NS
Vitamin B12 (µg)	4.1 ± 6.1	3.4 ± 2.6	4.0 ± 5.4	5.4 ± 16.2	NS	1.6 ± 1.7	1.6 ± 1.3	1.8 ± 2.5	2.2 ± 5.1	NS
Iron (mg)	14.2 ± 8.1	14.1 ± 7.3	14.0 ± 7.9	14.0 ± 8.1	NS	6.7 ± 3.3	6.6 ± 2.9	6.2 ± 2.7	6.5 ± 2.8	NS
Vitamin C (mg)	130 ± 175	158 ± 171	131 ± 112	134 ± 125	NS	63.0 ± 94.8	77.4 ± 82.8	62.3 ± 53.1	63.0 ± 57.9	NS
Vitamin D (µg)	4.0 ± 4.5	4.2 ± 3.8	4.7 ± 6.4	5.1 ± 6.1	NS	1.7 ± 1.5	2.0 ± 2.2	2.1 ± 3.3	2.2 ± 2.3	NS
Vitamin E (mg)	5.4 ± 4.4	4.8 ± 4.0	6.1 ± 8.0	5.2 ± 5.5	NS	2.5 ± 1.9	2.3 ± 2.3	2.7 ± 3.4	2.3 ± 2.0	NS
Calcium (mg)	956 ± 714	1001 ± 587	909 ± 665	1156 ± 783	**0.02**[i]	432 ± 221	498 ± 291	430 ± 278	542 ± 277	**0.001**[f,i]
Magnesium (mg)	258 ± 141	275 ± 166	285 ± 153	271 ± 186	NS	124 ± 54	140 ± 93	138 ± 68	132 ± 63	NS
Potassium (mg)	2448 ± 1468	2557 ± 2008	2457 ± 1407	2442 ± 1565	NS	1139 ± 537	1194 ± 688	1139 ± 548	1123 ± 503	NS
Sodium (mg)	3819 ± 2110	3186 ± 1499	3429 ± 2121	3315 ± 1687	NS	1896 ± 1112	1570 ± 524	1592 ± 834	1599 ± 561	**0.01**[d,e,f]
Selenium (µg)	106 ± 71	103 ± 63	113 ± 66	85 ± 56	**0.001**[i]	47 ± 22	47 ± 28	51 ± 26	38 ± 18	**<0.001**[f,h,i]
Zinc (mg)	9.3 ± 6.6	9.1 ± 6.5	10.3 ± 8.7	9.2 ± 6.8	NS	4.1 ± 2.0	4.2 ± 2.5	4.4 ± 2.8	4.1 ± 2.1	NS

[a]One-way or Welch's ANOVA and multiple comparison tests (Turkey-Kramer or Games-Howell) were performed to determine significant differences in daily energy and nutrient intake among ethnic groups.
[b]As Retinol Activity Equivalent.
[c]As dietary folate equivalents.
Boldface indicates statistical significance:
[d]Significant difference between Indigenous and African & Middle East youth;
[e]Significant difference between Indigenous and Asian youth;
[f]Significant difference between Indigenous and European youth;
[g]Significant difference between African & Middle East and Asian youth;
[h]Significant difference between African & Middle East and European youth;
[i]Significant difference between Asian and European youth.

Table 3. Mean ± SD energy and selected nutrient intakes and nutrient density (per 1000 kcal) among multiethnic youth aged 11–18 years by sex (n = 473).

Nutrients	Total intake/day (Mean ± SD)			Total intake/1000 kcal (Mean ± SD)		
	Boys	Girls	p-value[a]	Boys	Girls	p-value[a]
Energy (kcal)	2576 ± 1017	2029 ± 822	<0.0001	–	–	–
% kcal from carbohydrates	52.4 ± 11.2	53.4 ± 10.3	NS	–	–	–
% kcal from fat	30.0 ± 9.4	30.7 ± 8.9	NS	–	–	–
% kcal from protein	17.5 ± 6.5	15.9 ± 5.3	0.006	–	–	–
Carbohydrate (g)	348 ± 150	282 ± 126	<0.0001	137 ± 28	140 ± 27	NS
Fat (g)	86.0 ± 46.5	69.1 ± 36.8	<0.0001	32.7 ± 10.4	33.4 ± 10.0	NS
Protein (g)	109.6 ± 58.6	76.4 ± 34.0	<0.0001	42.8 ± 15.6	38.7 ± 12.5	0.003
Sugars (g)	144.6 ± 88.5	118.2 ± 73.8	0.001	56.1 ± 25.4	58.5 ± 25.5	NS
Fiber (g)	20.0 ± 12.6	18.1 ± 10.1	NS	8.0 ± 4.4	9.3 ± 4.6	0.002
Saturated Fat (g)	29.5 ± 17.7	23.1 ± 13.7	<0.0001	11.2 ± 4.5	11.2 ± 4.5	NS
Monounsaturated Fat (g)	24.1 ± 16.8	18.7 ± 14.3	0.0004	9.2 ± 5.1	8.9 ± 4.9	NS
Polyunsaturated Fat (g)	12.1 ± 10.4	10.1 ± 7.7	0.02	4.7 ± 3.2	4.9 ± 3.6	NS
Omega 3 (g)	0.4 ± 0.9	0.3 ± 1.1	NS	0.1 ± 0.3	0.2 ± 0.6	NS
Omega 6 (g)	2.2 ± 6.6	1.6 ± 3.8	NS	0.8 ± 2.0	0.8 ± 2.4	NS
Cholesterol (mg)	320 ± 234	204 ± 160	<0.0001	125 ± 86	102 ± 74	0.003
Vitamin A (μg)[b]	688 ± 642	511 ± 485	0.002	294 ± 483	264 ± 272	NS
Vitamin B1 (mg)	1.9 ± 1.1	1.4 ± 1.0	<0.0001	0.8 ± 0.4	0.7 ± 0.4	NS
Vitamin B2 (mg)	2.2 ± 1.6	1.5 ± 1.1	<0.0001	0.9 ± 0.6	0.7 ± 0.4	0.01
Vitamin B3 (mg)	25.2 ± 18.5	17.5 ± 11.3	<0.0001	10.0 ± 6.8	8.8 ± 4.8	0.04
Vitamin B5 (mg)	8.8 ± 38.6	4.2 ± 2.6	NS	3.2 ± 11.2	2.1 ± 1.1	NS
Vitamin B6 (mg)	2.0 ± 2.0	1.4 ± 1.3	0.0002	0.8 ± 0.7	0.7 ± 0.6	NS
Folate (μg)[c]	462 ± 333	359 ± 243	0.0003	181 ± 112	179 ± 98	NS
Vitamin B12 (μg)	6.6 ± 16.3	3.1 ± 4.2	0.006	2.4 ± 5.1	1.5 ± 1.9	0.03
Iron (mg)	16.6 ± 9.0	12.5 ± 6.7	<0.0001	6.6 ± 2.9	6.4 ± 2.8	NS
Vitamin C (mg)	147 ± 144	130 ± 139	NS	59.6 ± 60.6	68.9 ± 74.7	NS
Vitamin D (μg)	5.7 ± 6.2	4.0 ± 5.1	0.001	2.2 ± 2.3	2.0 ± 2.6	NS
Vitamin E (mg)	5.8 ± 5.5	5.1 ± 6.1	NS	2.3 ± 2.0	2.5 ± 2.8	NS
Calcium (mg)	1219 ± 839	907 ± 594	<0.0001	502 ± 281	474 ± 270	NS
Magnesium (mg)	319 ± 192	244 ± 141	<0.0001	138 ± 77	131 ± 64	NS
Potassium (mg)	2937 ± 1959	2170 ± 1221	<0.0001	1181 ± 583	1118 ± 537	NS
Sodium (mg)	3946 ± 2020	3081 ± 1686	<0.0001	1666 ± 715	1635 ± 798	NS
Selenium (μg)	120.4 ± 70.2	86.0 ± 55.0	<0.0001	47.8 ± 26.7	42.7 ± 21.2	0.03
Zinc (mg)	12.4 ± 9.2	7.7 ± 5.0	<0.0001	4.8 ± 2.7	3.8 ± 2.1	<0.0001

[a]Student t-tests were performed to determine significant differences in energy and nutrient intakes by sex.
[b]As Retinol Activity Equivalent.
[c]As dietary folate equivalents.

For all nutrients examined, the mean percentage of calories from fat was higher among European (31.7%) and Indigenous youth (31.8%) compared to African and Middle Eastern (28.3%) and Asian youth (29.0%), while Asian youth had the highest percentage of calories from protein (17.7%) compared to other ethnic groups (Indigenous = 15.5%; African & Middle Eastern = 16.5%; European = 16.2%). The mean daily intakes of sugar and monosaturated fat were higher among Indigenous youth (140.6 g and 24.8 g, respectively) compared to other ethnic groups (African and Middle Eastern = 130.8 g and 17.7 g, respectively; Asian = 108.0 g and 19.9 g, respectively; European = 135.5 g and 20.9 g, respectively). European youth had the highest intake of calcium (1156 mg/day) and lowest intake of selenium (85 μg/day) of all ethnic groups; Asian youth had a significantly lower intake of calcium and higher intake of selenium compared to other ethnic groups, at 909 mg/day and 113 μg/day, respectively. On average, higher densities (per 1000 kcal) of fat, sugar, saturated fat, and mono- and poly- unsaturated fats were observed among Indigenous and European youth compared to African and Middle Eastern and Asian youth. European, Indigenous, and Asian youth had higher calcium, sodium, and selenium consumption, respectively, compared to other ethnic groups.

Mean intakes and nutrient densities (per 1000 kcal) of energy and selected nutrients are presented by sex in Table 3. Boys reported an average energy intake of 2576 kcal, whereas girls had a mean energy intake of 2029 kcal (*p-value* = <0.0001). Macronutrient distributions were very similar between boys and girls, although boys obtained a slightly higher percentage of energy from protein (17.5% vs. 15.9%, *p-value* = 0.006). The mean daily intakes of carbohydrates, fat (of all types: total, saturated, monounsaturated and polyunsaturated), protein, sugar, cholesterol, vitamins A, D, B_1, B_2, B_3, B_6, and B_{12}, folate, iron, calcium, magnesium, potassium, sodium, selenium, and zinc were significantly higher among boys than girls (all p-$values < 0.05$). When we compared the nutrient densities (nutrient intake per 1000 kcal) between boys and girls, significant differences were observed only for protein, cholesterol, vitamins B_2, B_3, and B_{12}, selenium and zinc, in which all densities were higher among boys (all p-$values < 0.05$). In contrast, the diet of girls contained a greater density of fiber (9.3 g/1000 kcal) compared to boys (8.0 g/1000 kcal) (*p-value* = 0.002).

The percentage of participants not meeting the dietary recommendations

The percentage of youth who did not meet the Canadian dietary recommendations (47) varied by ethnic group and sex (Table 4). The majority of youth fell below the recommended values for dietary fiber (83.3–92.0%), vitamin D

Table 4. Percentage of participants NOT meeting the Dietary Reference Intakes[a] in multiethnic youth, aged 11–18 years (by ethnicity and sex).

	Ethnicity, n (%)					Sex, n (%)		
Nutrient	Indigenous	African and Middle Eastern	Asian	European	*p*-value[b]	Boys	Girls	*p*-value[b]
Fiber (g)	80 (92.0)	71 (86.6)	105 (84.7)	150 (83.3)	NS	168 (91.8)	238 (82.1)	0.003
Vitamin A (µg)[c]	48 (55.2)	47 (57.3)	78 (62.9)	113 (62.8)	NS	106 (57.9)	180 (62.1)	NS
Vitamin D (µg)	78 (89.7)	74 (90.2)	109 (87.9)	152 (84.4)	NS	151 (82.5)	262 (90.3)	0.01
Vitamin E (mg)	80 (92.0)	74 (90.2)	111 (89.5)	165 (91.7)	NS	163 (89.1)	267 (92.1)	NS
Vitamin B1 (mg)	25 (28.7)	25 (30.5)	30 (24.2)	50 (27.8)	NS	40 (21.9)	90 (31.0)	0.03
Vitamin B2 (mg)	27 (31.0)	17 (20.7)	30 (24.2)	56 (31.1)	NS	46 (25.1)	84 (29.0)	NS
Vitamin B3 (mg)	22 (25.3)	22 (26.8)	34 (27.4)	64 (35.6)	NS	42 (23.0)	100 (34.5)	0.008
Vitamin B5 (mg)	52 (59.8)	46 (56.1)	72 (58.1)	125 (69.4)	NS	85 (46.5)	210 (72.4)	<0.0001
Vitamin B6 (mg)	32 (36.8)	31 (37.8)	41 (33.1)	72 (40.0)	NS	53 (29.0)	123 (42.4)	0.003
Vitamin B12 (µg)	34 (39.1)	25 (30.5)	46 (37.1)	77 (42.8)	NS	49 (26.8)	133 (45.9)	<0.0001
Folate (µg)[d]	45 (51.7)	37 (45.1)	67 (54.0)	98 (54.4)	NS	83 (45.4)	164 (56.6)	0.02
Vitamin C (mg)	45 (51.7)	27 (32.9)	41 (33.1)	66 (36.7)	0.03	75 (41.0)	104 (35.9)	NS
Calcium (mg)	54 (62.1)	50 (61.0)	88 (71.0)	102 (56.7)	NS	92 (50.3)	202 (69.7)	<0.0001
Magnesium (mg)	64 (73.6)	57 (69.5)	77 (62.1)	132 (73.3)	NS	113 (61.7)	217 (74.8)	0.003
Iron (mg)	14 (16.1)	14 (17.1)	30 (24.2)	32 (17.8)	NS	26 (14.2)	64 (22.1)	0.03
Zinc (mg)	45 (51.7)	40 (48.8)	56 (45.2)	87 (48.3)	NS	68 (37.2)	160 (55.2)	0.0001
Selenium (µg)	11 (12.6)	12 (14.6)	18 (14.5)	45 (25.0)	0.03	23 (12.6)	63 (21.7)	0.01
Potassium (mg)[e]	10 (11.5)	4 (4.9)	7 (5.7)	15 (8.3)	NS	25 (13.7)	11 (3.8)	<0.0001
Sodium (mg)[e]	79 (90.8)	74 (90.2)	105 (84.7)	165 (91.7)	NS	171 (93.4)	252 (86.9)	0.02

[a]The Estimated Average Requirement (EAR) or Adequate Intake (AI) from the Dietary Reference Intakes table was used.
[b]Chi-square test was performed.
[c]As Retinol Activity Equivalent.
[d]As dietary folate equivalents.
[e]The number and proportion of those whose intake exceeded the AI.

(84.4–90.2%), and vitamin E (89.5–92.0%). More than 50% of youth fell below the DRIs for vitamin A, vitamin B_5, calcium, and magnesium; more than one-third were below the DRI for folate, zinc, and vitamins B_6, and C. The proportion of Indigenous youth (51.7%) who fell below the recommended values for vitamin C was significantly higher compared to other ethnic groups (African and Middle Eastern = 32.9%; Asian = 33.1%; European youth = 36.7%; *p-value* = 0.03); while the proportion of European youth (25.0%) who did not meet the dietary recommendations for selenium was significantly higher compared to other ethnic groups (Indigenous = 12.6%; African and Middle Eastern = 14.6%; Asian = 14.5%; *p-value* = 0.03). The proportions of girls who did not meet the dietary recommendations for folate, vitamins B_1, B_3, B_5, B_6, B_{12}, and D, calcium, magnesium, iron, selenium and zinc were significantly higher than boys (all p-$values < 0.05$); however, a higher proportion of boys did not meet the dietary recommendations for fiber (91.8% vs. 82.1%) and potassium (13.7% vs. 3.8%) compared to girls (all p-$values = 0.05$). The majority of youth (84.7–91.7%) exceeded the AI value for sodium across all ethnic groups, while the proportion of boys exceeding the AI value for sodium was significantly higher than girls (93.4% vs. 86.9%; *p-value* = 0.02).

Primary food sources and food contribution to energy and nutrient intakes

The main food sources of key nutrients are described in Table 5. Meat and meat products were major contributors to energy among Indigenous youth (13.7%), Noodles, rice and pasta for African and Middle Eastern youth (12.3%) and Asian youth (18.8%), and Dairy products for European youth (13.3%). Meat and meat products were the top contributor to fat among Indigenous youth (20.7%), Asian youth (24.8%), and European youth (15.9%), while dessert was for African and Middle Eastern Youth (16.8%). The top contributor to fiber was grains and crackers among Indigenous youth (13.4%), and fresh and dried fruit and juice among African and Middle Eastern youth (19.8%), Asian youth (18.7%), and European youth (16.9%). Cereals and granola bars contributed the most to iron among Indigenous youth (22.8%) and European youth (22.0%), while grains and crackers among African and Middle Eastern youth (17.4%) and meat and meat products among Asian youth (15.4%). NNDFs were among the top five contributors of fat (Indigenous = 10.7%; African and Middle Eastern = 13.7%; Asian = 8.6%; European = 10.9%) across all ethnic groups. Soft drinks and sweetened juices were the top contributors to sugar (Indigenous = 45.1%; African and Middle Eastern = 30.1%; Asian = 25.3%; European = 29.7%) for all ethnic groups.

Discussion

This study presents essential data on the dietary adequacy of a sample of urban, multiethnic youth and corroborates other evidence that Canadian youth do not meet dietary recommendations (26–28). Our results also showed sweetened beverages and NNDFs were the top contributors to calories, sugar, and fat among youth. This study found that the majority of participants did not meet the requirements for dietary fiber, vitamins A, D, E, and B_5, calcium, and magnesium. Vitamins A and E are important for proper immune system function along with vitamin C (48), and inadequacies may play a role in the development of obesity (49). Vitamin D, calcium, and magnesium inadequacies can negatively affect bone health (50, 51). Dietary fiber is beneficial for weight control, bowel function, cholesterol control, and the prevention of type 2 diabetes (52, 53); an inadequate intake

Table 5. Top 5 food sources of energy and selected nutrients and relative contributions (%) to total intake in multiethnic youth aged 11–18 years.

Indigenous Food Group	% Energy	African & Middle Eastern Food Group	% Energy	Asian Food Group	% Energy	European Food Group	% Energy
Meat and meat products[f]	13.7	Noodles, rice & pasta	12.3	Noodles, rice & pasta	18.8	Dairy products[b]	13.3
Soft drink/sweetened juice[a]	12.2	Dessert	11.9	Meat and meat products[f]	14.9	Dessert	10.5
Dairy products[b]	10.5	Dairy products[b]	10.5	Dairy products[b]	9.0	Meat and meat products[f]	10.3
Noodles, rice & pasta	10.0	Grains & crackers[3]	9.2	Dessert	8.4	Grains & crackers[c]	9.2
Grains & crackers[c]	8.0	Meat and meat products[f]	8.8	Grains & crackers[c]	7.5	Soft drink/sweetened juice[a]	8.1
Total (%)	**54.4**		**52.7**		**58.6**		**51.4**
Food Group	Fat	Food Group	Fat	Food Group	Fat	Food Group	Fat
Meat and meat products[f]	20.7	Dessert	16.8	Meat and meat products[f]	24.8	Meat and meat products[f]	15.9
Dairy products[b]	12.5	Non-nutrient dense food[d]	13.7	Dessert	11.4	Dairy products[b]	14.6
Non-nutrient dense food[d]	10.7	Meat and meat products[f]	13.3	Dairy products[b]	10.7	Dessert	13.0
Dessert	8.5	Dairy products[b]	13.2	Non-nutrient dense food[d]	8.6	Non-nutrient dense food[d]	10.9
Pizza	8.4	Mixed dish & sandwich	7.7	Mixed dish & sandwich	8.6	Mixed dish & sandwich	5.7
Total (%)	**60.8**		**64.7**		**64.1**		**60.1**
Food Group	Sugar	Food Group	Sugar	Food Group	Sugar	Food Group	Sugar
Soft drink/sweetened juice[a]	45.1	Soft drink/sweetened juice[a]	30.1	Soft drink/sweetened juice[a]	25.3	Soft drink/sweetened juice[a]	29.7
Dairy products[b]	14.9	Fresh & dried fruit/juice	19.8	Fresh & dried fruit/juice	20.7	Dairy products[b]	18.9
Fresh & dried fruit/juice	10.0	Dairy products[b]	15.8	Dairy products[b]	17.3	Fresh & dried fruit/juice	14.9
Dessert	6.9	Dessert	14.9	Dessert	13.9	Dessert	12.3
Cereals & granola bars[e]	6.5	Cereals & granola bars[e]	4.9	Cereals & granola bars[e]	4.5	Cereals & granola bars[e]	6.9
Total (%)	**83.4**		**85.5**		**81.7**		**82.7**
Food Group	Fiber	Food Group	Fiber	Food Group	Fiber	Food Group	Fiber
Grains & crackers[c]	13.4	Fresh & dried fruit/juice	19.8	Fresh & dried fruit/juice	18.7	Fresh & dried fruit/juice	16.9
Vegetables	13.1	Grains & crackers[c]	16.7	Vegetables	16.3	Cereals & granola bars[e]	14.8
Fresh & dried fruit/juice	12.6	Vegetables	10.4	Grains & crackers[c]	14.4	Grains & crackers[c]	14.5
Cereals & granola bars[e]	11.9	Noodles, rice & pasta	9.2	Noodles, rice & pasta	9.3	Vegetables	12.4
Noodles, rice & pasta	9.1	Dessert	8.0	Mixed dish & sandwich	6.1	Noodles, rice & pasta	6.5
Total (%)	**60.1**		**64.1**		**64.8**		**65.1**
Food Group	Iron	Food Group	Iron	Food Group	Iron	Food Group	Iron
Cereals & granola bars[e]	22.8	Grains & crackers[c]	17.4	Meat and meat products[f]	15.4	Cereals & granola bars[e]	22.0
Meat and meat products[f]	13.8	Cereals & granola bars[e]	14.9	Noodles, rice & pasta	13.2	Grains & crackers[c]	16.9
Grains & crackers[c]	13.7	Noodles, rice & pasta	11.8	Grains & crackers[c]	12.9	Meat and meat products[f]	9.7
Noodles, rice & pasta	9.3	Dessert	9.2	Cereals & granola bars[e]	12.2	Dessert	8.1
Pizza	7.7	Meat and meat products[f]	8.0	Vegetables	10.4	Mixed dish & sandwich	6.5
Total (%)	**67.3**		**61.3**		**64.1**		**63.2**

[a]Soft drink/sweetened juice: Carbonated drinks, diet carbonated drinks; sugary fruit juices, fruit punch, iced tea, lemonade; smoothies, Slurpees; energy drinks; sports drinks.
[b]Dairy products: Milk, chocolate milk, hot chocolate, milkshakes, flavored lattes; cheese; yogurt, fruit yogurts, yogurt beverages.
[c]Grains & crackers: Variety of breads, whole wheat, whole grain, pita bread, tortillas, rolls, bagels, buns, pancakes; grains, crackers, salted crackers, vegetable crackers.
[d]Non-nutrient dense food: Sweeteners, sugar, honey, syrup, jam; potato chips, French fries, popcorn, pretzels; coffee whiteners, creamers; sauces, dressings, condiments.
[e]Cereal & granola bars: Sugary cereals, bran cereals; instant flavored oatmeal; granola bars, chocolate granola bars, fruit granola bars; protein bars.
[f]Meat and meat products: Beef, caribou, chicken, goat, moose, pork, seafood, and meat products including bacon, sausage and mixed dishes.

of dietary fiber is implicated in an increased risk of cancer and cardiovascular disease (51, 54). Most youth exceeded adequate sodium intake, which has been associated with elevated blood pressure (51).

Frequent snacking between meals, skipping breakfast, eating outside the home, disliking fruit and vegetables, and excessively consuming NNDFs, including sugar-sweetened beverages and fast foods, are examples of unhealthy dietary habits that contribute to nutritional inadequacies, excesses, and increased risk of obesity and chronic diseases (51, 55–58), which are concerns among youth (10, 28, 30, 31, 59–64). The importance of investigating dietary habits and improving diet among youth has been well articulated (65).

Despite the importance of healthy eating behaviors during adolescence, current eating patterns among Canadian youth have been found to be inconsistent with the dietary guidelines (27–29, 66). Additionally, as has been shown in previous literature (32–38), dietary intake and food consumption patterns varied based on ethnicity. Indigenous participants had the highest average daily sugar consumption, and were the least likely to meet the requirements for vitamin C. For all ethnic groups, soft drinks and sweetened juices were top contributors to sugar intake. Soft drinks and sweetened juices were among the top five energy sources for European and Indigenous youth. Excessive consumption of sugar-sweetened beverages is related to excess weight, dental caries, type 2 diabetes, dyslipidemia, nonalcoholic fatty liver disease, and hypertension (67–69). Sugars include both sugars that are naturally occurring in foods such as fruit and milk (65) and sugars that are added during food processing (70). A greater proportion of total sugars consumed by school-aged children and adolescents is from added sugar compared to sugars consumed by young children (65, 70), and adolescents are the top consumers of sugar-sweetened beverages (67), posing an avoidable intake of extra calories and related health implications as children age and become adolescents. NNDFs were among the top contributors to fat for all ethnic groups, contributing to saturated fat intake above the American Heart Association recommendation of <5% of total energy (71). Sodium intake for male participants was higher than for females, at over twice the recommended intake of 1500 mg per day (72). Additionally, female participants were significantly less likely to meet iron recommendations than males (73). These findings are consistent with this study.

Healthy eating behaviors during childhood are vital for optimal growth, intellectual development, and long-term health (9, 24, 25). Given that dietary habits of youth may persist as they age (7–10); the prevalent unhealthy dietary habits identified may continue into adulthood, predisposing youth in this study to adverse health impacts such as obesity, type 2 diabetes and chronic diseases (11, 12, 74–77). Additionally, adolescent obesity may be related to a risk for psychological co-morbidities such as poor quality of life, depression, and low self-esteem (78, 79). Due to the high risk of chronic disease and related conditions, overweight and obese children may in turn access the healthcare system more often, requiring more per-capita healthcare costs (80).

This study does have some limitations. While the 24-hour dietary recall enables researchers to collect detailed dietary information with a relatively small commitment from each participant (81), there is a potential risk of not accurately representing the usual energy (82) and nutritional intakes (83). Moreover, collecting highly accurate dietary recall data from youth may have challenges including limited ability to remember details, use proper vocabulary to describe foods, or identify various foods and cooking methods (84). In addition, significant differences between ethnic groups in living status, BMI, MSL, and physical activity may have impacted diet, as well as differences in the availability of certain foods, or different nutrition needs. We collected a single 24-hour dietary recall, which does not encompass variations in diets over multiple days and may not provide the most accurate dietary data; however, this is more practical to obtain dietary information from youth. In addition, we utilized food models to improve accuracy and collected additional dietary intake data by asking about easily forgotten foods. The purposive sampling of schools with a large number of multiethnic students may not guarantee generalization of the study findings to any one specific ethnic group, or to the Edmonton Public School District as a whole.

Conclusions

This study explored the dietary adequacies and nutrient density in the diets of urban multiethnic youth in a Canadian city. The results identified that a majority of youth are not meeting nutrient requirements for several key vitamins and minerals, and that adherence to dietary recommendations varies by both sex and ethnicity. Soft drinks and sweetened juices as the top contributors to sugar intake across all groups reveals an important area for education and intervention. There is clearly a need to address these concerns regarding dietary habits and nutrient intake among youth. The evidence gathered in this study can be used to understand the current status of health and wellbeing of urban multiethnic youth and to improve and develop appropriate strategies to reduce the burden of poor diet, as well as to inform policy and program development aiming at a better nutrition status of youth.

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