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Original Research

Prevalence of Known Risk Factors for Type 2 Diabetes Mellitus in Multiethnic Urban Youth in Edmonton: Findings From the WHY ACT NOW Project

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Key Messages

- Developing an easy and noninvasive screening tool for identifying children and youth at risk for type 2 diabetes is necessary.
- Modifiable risk factors for type 2 diabetes were common in the sample of urban multiethnic youth (11 to 23 years old) in Edmonton, Alberta, Canada.
- The distribution of type 2 diabetes risk scores and the number of risk factors varied by sex, ethnicity and household socioeconomic status.

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ABSTRACT

Objectives: The Canadian Diabetes Risk Assessment Questionnaire (CANRISK) is a validated, evidence-based, self-administered tool to assess the risk for type 2 diabetes mellitus in multiethnic Canadian adults. Identifying individuals at high risk for type 2 diabetes allows early intervention that improves modifiable risk factors. This study examined the risk factors for type 2 diabetes in multiethnic urban youth in Edmonton, Alberta.
Methods: An interviewer-administered questionnaire was developed based on CANRISK variables, such as age, gender, ethnicity, family history of diabetes, medical history of high blood sugar or high blood pressure, anthropometric measurements, physical activity and dietary intake. Between October 2013 and March 2014, data were collected from a convenience sample of 557 (328 girls and 229 boys) multiethnic youth 11 to 23 years of age in 12 institutions in Edmonton, such as public schools, after-school programs and colleges.
Results: Participating youth (N=529) with self-identified ethnicity were included in the analyses: 109 Indigenous (20.6%); 96 African and Middle Eastern (18.1%); 129 Asian (24.4%); and 195 European (36.9%). More than 70% of the youth had 2 or more risk factors for type 2 diabetes. The participants were classified as low risk (75.6%; n=400); moderate risk (21.2%; n=112); or high risk (3.2%; n=17), with the highest proportion of moderate- and high-CANRISK score categories (52.7%) found in the Asian youth. Boys ($p<0.0001$) and Indigenous participants ($p<0.001$) were more likely to have a greater number of risk factors for type 2 diabetes compared to girls and non-Indigenous youth, respectively. Of the participants, 26.7% (n=141) were overweight or obese, more than 45% of the participants (n=245) were physically inactive, and 17.8% of the participants (n=94) did not consume sufficient amounts of fruits and vegetables to meet daily recommendations.
Conclusions: Almost 25% of the participating multiethnic youth 11 to 23 years of age scored in the moderate or high category of CANRISK. The most prevalent risk factors were ethnicity, followed by physical inactivity, overweight or obesity and low fruit and vegetable consumption. A validated type 2 diabetes screening tool for youth as well as culturally appropriate, evidence-based and multidisciplinary diet and lifestyle interventions aiming to improve modifiable type 2 diabetes risk factors in multiethnic youth, particularly targeting socioeconomically disadvantaged and immigrant children and youth, should be developed, implemented and evaluated.

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RÉSUMÉ

Objectifs : Le questionnaire CANRISK (Canadian Diabetes Risk Questionnaire) est un outil auto-administré, validé et fondé sur des preuves qui permet d'évaluer le risque de diabète sucré de type 2 chez les adultes canadiens de multiples origines ethniques. Le repérage des individus exposés à un risque élevé de diabète de type 2 permet une intervention précoce qui améliore les facteurs de risque modifiables. La présente étude examinait les facteurs de risque de diabète de type 2 chez les jeunes urbains de multiples origines ethniques d'Edmonton, en Alberta.

Méthodes : Un questionnaire administré par un intervieweur a été mis au point en tenant compte des variables CANRISK telles que l'âge, le sexe, l'ethnicité, les antécédents familiaux de diabète, les antécédents médicaux de glycémie élevée ou de pression artérielle élevée, des mesures anthropométriques, de l'activité physique et de l'apport alimentaire. Entre octobre 2013 et mars 2014, l'échantillonnage de commodité a servi à recruter 557 (328 filles et 229 garçons) jeunes de multiples origines ethniques qui étaient âgés de 11 à 23 ans et qui provenaient de 12 établissements d'Edmonton tels que les écoles publiques, les programmes parascolaires et les collèges.

Résultats : Les jeunes participants (N = 529) qui avaient auto-déclaré leur origine ethnique ont fait partie des analyses: 109 autochtones (20,6 %); 96 Africains et Moyen-Orientaux (18,1 %); 129 Asiatiques (24,4 %); 195 Européens (36,9 %). Plus de 70 % des jeunes avaient 2 facteurs de risque ou plus de diabète de type 2. Les participants ont été classifiés comme suit: faible risque (75,6 %; n = 400); risque modéré (21,2 %; n = 112); risque élevé (3,2 %; n = 17). La proportion la plus élevée dans les catégories de scores modérés et élevés de CANRISK (52,7 %) a été observée chez les jeunes Asiatiques. Les garçons ($p < 0,0001$) et les autochtones ($p < 0,001$) étaient plus susceptibles que les filles et les jeunes non autochtones de compter un plus grand nombre de facteurs de risque de diabète de type 2, et ce respectivement. Parmi les participants, 26,7 % (n = 141) étaient en surcharge pondérale ou obèses, plus de 45 % des participants (n = 245) étaient inactifs physiquement et 17,8 % des participants (n = 94) ne consommaient pas assez de fruits et de légumes selon les quantités quotidiennes recommandées.

Conclusions : Presque 25 % des jeunes participants de multiples origines ethniques de 11 à 23 ans ont obtenu un score dans la catégorie modérée ou élevée de CANRISK. Après l'ethnicité, les facteurs de risque les plus fréquents étaient l'inactivité physique, la surcharge pondérale ou l'obésité, et la faible consommation de fruits et de légumes. Un outil de dépistage validé du diabète de type 2 pour les jeunes et des interventions multidisciplinaires sur le régime alimentaire et le mode de vie adaptées aux réalités culturelles et fondées sur des preuves, qui visent la réduction des facteurs de risque modifiables du diabète de type 2 chez les jeunes de multiples origines ethniques, notamment les enfants et les jeunes immigrants défavorisés sur le plan socio-économique, devrait être élaboré, mis en place et évalué.

Introduction

The prevalence of type 2 diabetes mellitus has increased in North American youth in the past 2 decades (1,2), especially among Indigenous populations (3,4). In 2016, the total number of Canadians with diabetes was estimated to be approximately 3.5 million, an increase of 72% compared to the diabetes prevalence in 2006 (5), and about 1% of the Canadian population (≥6 years old) had undiagnosed diabetes (6). The cost of diabetes is on the rise, along with diabetes rates, and a Canadian diabetes cost model estimated the total cost of types 1 and 2 diabetes in Canada for 2010 to be CAD $12.2 billion, with a rise of $4.7 billion by 2020 (7).

A previous prospective study used a network of physicians and Canadian census population data to identify 1.54 new cases of type 2 diabetes in 100,000 children under the age of 18 years during 2006 to 2008 (8). Nonmodifiable risk factors for type 2 diabetes include gender, ethnicity/race and a family history of diabetes (9–11). Males are more likely to develop type 2 diabetes and its complications than females (10), and previous studies have shown that ethnic groups, such as Indigenous Americans, Africans and South Asians, experience the burden of type 2 diabetes and associated risk factors disproportionately, compared to people of European descent (9,12,13). Obesity, poor diet, physical inactivity and sedentary behaviour are modifiable risk factors for type 2 diabetes in both youth and adults (14–16) and are common lifestyle factors, which may have increased the prevalence of prediabetes in youth. There are already a few tools that we know can be useful and inexpensive ways to screen people for their risk for developing type 2 diabetes. High body mass index (BMI) is considered an independent risk factor for type 2 diabetes (17), and waist circumference (WC), a proxy for abdominal obesity, is a known predictor of type 2 diabetes (18). The limitation common to all of these measures is that they focus on only 1 facet of a multifaceted issue. Furthermore, these measures can be unreliable when dealing with children. Alternatively, there is a high correlation between waist-to-height ratio (WHtR) and fat stored in visceral deposits; therefore, this could be a useful measurement for screening children and youth for risk for type 2 diabetes (14,19). WHtR is suggested as an indicator for obesity and cardiometabolic risk for children and adolescents (20,21).

Several studies have assessed risk for type 2 diabetes in the adult Canadian population (22–26); however, little is known about the status of these risk factors for type 2 diabetes in Canadian youth. Edmonton, Alberta, has become increasingly diverse, with about 30% of its population made up of foreign-born immigrants and 6% made up of Indigenous Canadians (First Nations, Métis or Inuit) (27).

We conducted a cross-sectional study titled Wellness and Health in Youth—All Communities in Transition NOW (WHY ACT NOW) to examine the health and wellness of multiethnic youth in Edmonton. This study provided a unique opportunity to examine the current state of risk for type 2 diabetes in a multiethnic youth population, a study guided by the Canadian Diabetes Risk Assessment Questionnaire (CANRISK). The CANRISK (a modified version of the Finnish Diabetes Risk Score) was developed by the Public Health Agency of Canada (28,29) and guided the authors to examine the associations of CANRISK score categories with the number of risk factors in several demographic, familial and

socioeconomic variables in the study sample as part of the WHY ACT NOW project. CANRISK is a validated, inexpensive and evidence-based tool that assesses risk for type 2 diabetes in Canadian adults between 40 and 74 years of age (30). It is a self-administered tool that evaluates an individual's risk for type 2 diabetes by examining known risk factors, such as age, gender, ethnicity, personal medical history of high blood sugar or high blood pressure, family history of diabetes, physical inactivity, low vegetable and fruit consumption and, for women only, a history of gestational diabetes or a history of giving birth to a baby who weighed more than 4.1 kg (28,31,32). Even though CANRISK is designed for adults between 40 and 74 years of age, we consulted with this low-cost, noninvasive screening tool to assess the risk for type 2 diabetes in multiethnic youth 11 to 23 years of age to highlight the need for an intervention targeting this population.

Methods

In the WHY ACT NOW study, 12 schools and institutions with large numbers of Indigenous and/or new Canadian students, including public schools, an after-school program and a college, were selected. Between October 2013 and March 2014, convenience sampling was used to recruit 557 youth between the ages of 11 and 23 years. Youth who were pregnant or breastfeeding were excluded from the study. Research Ethics Board approval was obtained from the Health Research Ethics Board at the University of Alberta. The project was approved to work within Edmonton Public Schools by the Cooperative Activities Program with the University of Alberta, Faculty of Education, and the Research Proposal Review Committee of the Edmonton public schools. Written informed consent was provided by all participants before the interviews began, and all participation was voluntary. Parental consent was given for all participants below the age of 18 years. Trained staff conducted interviewer-administered questionnaires with the participating youth and obtained anthropometric measurements.

Anthropometric measures

A stadiometer (SECA 213, SECA, Hamburg, Germany) and a scale (5738BL 06.08, Taylor Precision Products, Oak Brook, Illinois, United States) were used to measure height and weight to the nearest one-tenth of cm and kg, respectively. If the first and second attempts were more than 0.5 cm (for height) or 0.5 kg (for weight) apart, measurements were taken a third time. The measurements were then averaged. Self-reported measurements were recorded if participants refused measurement. For participants 11 to 19 years old, the World Health Organization growth reference for 5- to 19-year-olds was used to determine age- and sex-appropriate BMI z-scores (33). Participants were categorized as underweight, overweight or obese if their BMI-for-age/sex was less than 2 standard deviations (SDs), more than 1 SD or more than 2 SDs from the mean, respectively. The BMI cut-offs were used to classify participants older than 19 years of age as follows: <18.5 kg/m^2 for people who were underweight, 18.5 to 24.9 kg/m^2 for normal weight, 25 to 29.9 kg/m^2 for overweight and ≥ 30 kg/m^2 for people with obesity (34). WC was obtained from the narrowest region between the lowest rib and the iliac crest by using a measuring tape (SECA 201, SECA). Again, if the first 2 measurements were more than 0.5 cm apart, a third measurement was obtained; all measurements taken were averaged. For participants 18 years of age or younger, the WHtR was computed by dividing WC by height and was classified as low (≤ 0.5) or high (>0.5), according to a single cut-off point of 0.5 (19). Participants 19 years of age or older were categorized into the following WC categories, as indicated in CANRISK: less than 94 cm, between 94 and 102 cm and over 102 cm for boys and less than 80 cm, between 80 and 88 cm and over 88 cm for girls.

Questionnaire

A questionnaire was designed to examine various elements of the wellness and health of the multiethnic youth sample in consultation with key stakeholders whose interests varied. The questionnaire included questions regarding the CANRISK variables (29): demographics, diet, physical activity, material style of life (35), possession scores, ethnicity, duration of living in Canada and family environment. It was completed with each participant. For the purpose of this study, risk factors presented in the CANRISK and socioeconomic factors were analyzed. Dietary assessment was performed by utilizing a food-frequency questionnaire that asked participants for their usual weekly food intake; later, the responses were calculated per day. The youth were asked the types and duration of physical activity they typically do each day. The material style of life tool estimates socioeconomic status based on a family's possessions, including cell phone, video game console, digital camera, DVD player, deep freezer, boat, satellite dish/cable, car/truck, motorbike, washing machine, bicycle and computer in working condition in the past 30 days. The total number of items was grouped into categories of low (1 to 5 items), medium (6 to 9 items) or high (10 or 12 items) possession scores. Different ethnicities were scored according to CANRISK: 11 points for South Asian, 10 for East Asian, 5 for black, 3 each for Indigenous and other nonwhite (e.g. Latin American, Arab, West Asian) and 0 for white. Participants were given an opportunity to identify their ethnicity by selecting First Nations, Métis, Inuit, European or Other, specify, and also to provide their country of birth to get a better sense of ethnicity. Self-reported family histories of diabetes (first-degree relative) and personal medical histories of high blood sugar and high blood pressure were recorded per CANRISK. The question regarding education attainment was omitted because all participants were current students in schools below complete college level; the maximum risk points of 5 for people with less than high school education were, therefore, subtracted from the CANRISK score categories. The participants received a 0 score for the questions related to age (all participants were younger than 40 years of age) and to history of giving birth to a baby weighing more than 9 pounds. We asked about the history of diagnosis of high blood sugar regardless of circumstances at diagnosis (e.g. illness or pregnancy). Moreover, as described, we utilized age-appropriate definitions and cut-offs for BMI and WC or WHtR.

Scoring the variables and examining risk factors for type 2 diabetes

The data analysis was performed in 2015. Scoring was applied to each section of the questionnaire according to the CANRISK scoring guideline (29). We followed the CANRISK scoring system in every respect, with a few exceptions, as described below. For our study participants, the following conditions listed in CANRISK were considered as risk factors: male sex, overweight or obese BMI, a large WC or a WHtR larger than 0.5, <30 minutes of daily physical activity, not eating vegetables or fruits daily, diagnosis of high blood pressure or high blood sugar, first-degree family member with diabetes and certain ethnicities, particularly South Asian and East Asian. For WHtR, a score of 0 and 6 was given to a WHtR of ≤ 0.5 and >0.5, respectively. The total number of diabetes risk factors for each participant was determined per CANRISK and then grouped into 3 categories of having 0 or 1, 2 to 4 or 5 or more risk factors. The ratings for each section were then totaled, and type 2 diabetes risk scores were calculated for each participant. The scoring cut-offs were modified from the CANRISK due to the 3 questions that

were not applicable to our study population (age, education attainment and having given birth to a baby weighing more than 9 pounds). The question regarding education attainment was omitted, so the maximum score of 5 was subtracted from the CANRISK score categories; in this study, scores lower than 16, from 16 to 27, or 28 and over were categorized as low, moderate or high risk, respectively.

Statistical analyses

We applied the Pearson chi-square and the Fisher exact tests to estimate the associations between risk score categories (low, moderate or high risk) and the number of diabetes risk factor categories (0 to 1, 2 to 4, 5 or more) with gender and ethnicity. The Mantel-Haenszel chi-square test was applied to detect the linear associations of risk score categories and the number of diabetes risk-factor categories with other ordinal variables, i.e. age group, length of time lived in Canada, employment status of the family and material style of life categories; $p<0.05$ was considered significant. Spearman correlation coefficients were computed to measure the strength and direction of association between 2 variables. We assessed the associations of a number of factors (sex, ethnicity, age, duration of living in Canada, employment status and material style of life score) with risk-score categories and number of risk factors.

Results

Table 1 presents the demographic and baseline characteristics of the study's participants. In the final analyses, 529 of 557 participants were included because anthropometric measures were missing or refused by 28 participants. We collected detailed information about ethnicity, although, for a simple presentation of the results, we grouped the participants into 4 ethnicity categories. The participants were grouped into Indigenous (n=109; 20.6%); African and Middle Eastern (n=96; 18.1%); Asian (n=129; 24.4%) or European (n=195; 36.9%) backgrounds. The mean age of participants was 16.6±1.8 years, and 59% (n=312) were girls. Of all participants, 26.7% had overweight or obese BMIs (34.7% of Indigenous, 33.3% of African/Middle Eastern, 22.5% of Asian and 21.5% of European); 70.1% had normal BMIs, and 3.2% had underweight BMIs. Of the youth, 81% had at least 2 family members who were employed. Approximately 70% of the group had material style of life scores of 9 to 12, which indicates high possession scores. The majority of the participants (n=388; 74.3%) were born in Canada, although 25.0% of African/Middle Eastern-born and 29.1% of Asian-born youth had lived in Canada for fewer than 5 years.

Table 2 shows the number of participants in each risk-score category as well as the number with each risk factor for type 2 diabetes. The majority of participants were classified as having low risk (n=400; 75.6%), whereas approximately 25% of youth had moderate or high risk for type 2 diabetes (moderate 21.2%; high 3.2%). Nonmodifiable risk factors for diabetes, such as ethnicity and family history of type 2 diabetes, were present in 347 (65.6%) and 88 (16.6%) participants, respectively. Almost half of the participants (46.3%) were physically inactive daily. Of the participants, 141 (26.7%) had BMIs in the overweight or obese categories, and 17.8% did not eat vegetables or fruits daily. WCs and WHtRs were above cut-offs in 104 (19.7%) participants. History of high blood sugar or high blood pressure was self-reported by 2 and 1 participants, respectively.

The risk-score categories and risk factors by different variables are illustrated in Table 3. The distribution of risk scores and the number of risk factors varied significantly by sex, ethnicity, duration of living in Canada and the socioeconomic status of the household. The majority of girls (87.5%) and boys (58.5%) were categorized as being at low risk according to CANRISK score categories; significantly more boys than girls had moderate or high CANRISK scores ($p<0.0001$) and a greater number of risk factors ($p<0.0001$). Comparing differing ethnicities, we found that Asian youth had a significantly higher proportion of individuals with moderate or high CANRISK scores than any other ethnic group ($p<0.0001$). However, Indigenous youth had the highest proportion of individuals with 5 or more risk factors (n=16; 14.7%). In youth who had lived in Canada for fewer than 5 years, there was a significantly higher proportion having moderate or high risk ($p=0.004$) and 5 or more risk factors ($p=0.0003$). The material style of life category of 0 to 5 had the highest proportion of individuals with 5 or

Table 1
Demographic and baseline characteristics of multiethnic youth (age 11 to 23 years) in Edmonton, Alberta

Variables	Indigenous (n=109; 20.6%)	African & Middle Eastern (n=96; 18.1%)	Asian (n=129; 24.4%)	European (n=195; 36.9%)	Total
Age (years), mean ± SD	16.6±2.3	16.5±2.2	16.3±1.3	16.7±1.6	16.6±1.8
Sex, n (%)					
Female	61 (56.0)	57 (59.4)	73 (56.6)	121 (62.1)	312 (59.0)
Male	48 (44.0)	39 (40.6)	56 (43.4)	74 (38.0)	217 (41.0)
Total	109 (20.6)	96 (18.1)	129 (24.4)	195 (36.9)	529 (100.0)
BMI (kg/m^2)					
Underweight	2 (1.9)	3 (3.1)	10 (7.8)	2 (1.0)	17 (3.2)
Normal	69 (63.3)	61 (63.6)	90 (69.7)	151 (77.4)	371 (70.1)
Overweight	19 (17.4)	27 (28.1)	19 (14.7)	28 (14.4)	93 (17.6)
Obesity	19 (17.4)	5 (5.2)	10 (7.8)	14 (7.2)	48 (9.1)
Employment status					
Unemployed*	9 (8.5)	5 (4.9)	3 (2.2)	3 (1.4)	20 (3.6)
1 family member	32 (30.2)	12 (11.8)	14 (10.3)	27 (13.0)	85 (15.4)
>1 family member	65 (61.3)	85 (83.3)	119 (87.5)	178 (85.6)	447 (81.0)
Material style of life, n (%)					
0–5	5 (4.9)	4 (4.4)	2 (1.6)	2 (1.1)	13 (2.6)
5–9	46 (45.1)	29 (32.2)	32 (25.6)	32 (17.7)	139 (27.9)
9–12	51 (50.0)	57 (63.3)	91 (72.8)	147 (81.2)	346 (69.5)
Duration of living in Canada (years), n (%)					
Fewer than 5	0 (0.0)	23 (25.0)	37 (29.1)	7 (3.6)	67 (12.8)
5 years or more	0 (0.0)	25 (27.2)	22 (17.3)	20 (10.3)	67 (12.8)
Born in Canada	109 (100.0)	44 (47.8)	68 (53.5)	167 (86.1)	388 (74.3)

BMI, body mass index.
* The participant and both parents are unemployed.

Table 2
Number of multiethnic youth (age 11 to 23 years) in Edmonton, Alberta, with risk factors for type 2 diabetes and CANRISK scores

Variables	Total, n (%)
CANRISK score	
Lower than 16 (low risk)	400 (75.6)
16 to 27 (moderate risk)	112 (21.2)
28 and over (high risk)	17 (3.2)
Diabetes risk factor	
Ethnicity: Indigenous, African & Middle Eastern, Asian	347 (65.6)
Daily physical inactivity	245 (46.3)
Overweight or obesity	141 (26.7)
Family history of diabetes	88 (16.6)
Low fruit and vegetable consumption on a daily basis	94 (17.8)
Waist circumference/waist-to-height circumference above cut-off	104 (19.7)
Self-reported medical history of high blood sugar	2 (0.4)
Self-reported medical history of high blood pressure	1 (0.2)

CANRISK, Canadian Diabetes Risk Assessment Questionnaire.

more risk factors ($p<0.0001$). Age group did not have any significant associations with risk score categories or number of risk factors.

Discussion

This study assessed type 2 diabetes risk factors in a sample of multiethnic youth between the ages of 11 and 23 years in Edmonton, Alberta, guided by CANRISK. Although the results do not directly correlate with the likelihood of the youth's developing type 2 diabetes, it is noteworthy that our findings showed that modifiable risk factors for type 2 diabetes, including overweight/obesity, physical inactivity and fruit- and vegetable-deficient diets, were prevalent. If not addressed, these factors may add to the risk for type 2 diabetes in youth whose genetic susceptibility is high.

More than 70% of participants had at least 2 risk factors for type 2 diabetes, and almost 25% had moderate or high risk scores in our study, and these rates are much higher than observations in other studies. The presence of 2 or more risk factors for developing type 2 diabetes was 25.3% in Caucasian children and adolescents in rural Illinois (36), 40% in multiethnic children and adolescents in rural regions of Alabama and the southeastern United States (37), 40% in multiethnic children and adolescents in Kentucky (38) and 39% in Brazilian adolescents (39). One possible reason is that the selected schools and institutions in our study have high Indigenous and new Canadian populations, which are considered high-risk ethnicities. In addition, we utilized a more comprehensive list of type 2 diabetes risk factors, per the CANRISK tool, and we examined a larger number of factors than other studies had. The differences in the number of risk factors and the methods used to measure them may explain the inconsistent prevalence of having several risk factors for type 2 diabetes in our study than what was found in other studies. The proportion of participants who were overweight or obese in our study (over 25%) was similar to that of other findings in Canadian youth aged 9 to 19 years (40). However, the proportion of participants with central obesity (about 20%) differed from the national data for 15- to 19-year-old Canadian youth (28%) (41), possibly because of the different age ranges that were included in the studies. The large proportion of physically inactive youth is an

Table 3
Distribution of participants according to modified CANRISK and number of diabetes risk-factor categories and demographic and socioeconomic factors among multiethnic youth (age 11 to 23 years) in Edmonton, Alberta

Variables	CANRISK score, n (%)			p for trend*	Number of risk factors,‡ n (%)			p for trend*
	Low risk (score <16)	Moderate risk (score 16–27)	High risk (score >27)		0–1	2–4	≥5	
Sex								
Female	273 (87.5)	39 (12.5)	0 (0.0)	<0.0001	119 (38.1)	180 (57.7)	13 (4.2)	<0.0001
Male	127 (58.5)	73 (33.7)	17 (7.8)		24 (11.1)	171 (78.8)	22 (10.1)	
Ethnicity								
Indigenous	83 (76.1)	20 (18.4)	6 (5.5)	<0.0001	9 (8.2)	84 (77.1)	16 (14.7)	<0.0001
African & Middle Eastern	81 (84.4)	14 (14.6)	1 (1.0)		7 (7.3)	83 (86.5)	6 (6.2)	
Asian	61 (47.3)	58 (45.0)	10 (7.7)		20 (15.5)	100 (77.5)	9 (7.0)	
European	175 (89.7)	20 (10.3)	0 (0)		107 (54.9)	84 (43.1)	4 (2.0)	
Age group (years)								
11–15	124 (78.0)	31 (19.5)	4 (2.5)	0.36	44 (27.7)	104 (65.4)	11 (6.9)	0.073
16–17	155 (74.2)	49 (23.4)	5 (2.4)		69 (33.0)	130 (62.2)	10 (4.8)	
18–23	121 (75.1)	32 (19.9)	8 (5.0)		30 (18.6)	117 (72.7)	14 (8.7)	
Duration of living in Canada (years)								
Less than 5	40 (59.7)	24 (35.8)	3 (4.5)	0.004‡	7 (10.5)	53 (79.0)	7 (10.5)	0.0003¶
5 or more	50 (74.6)	15 (22.4)	2 (3.0)		12 (17.9)	53 (79.1)	2 (3.0)	
Born in Canada	306 (78.9)	70 (18.0)	12 (3.1)		124 (32.0)	238 (61.3)	26 (6.7)	
Employment status								
Unemployed†	14 (73.7)	5 (26.3)	0 (0)	0.86	1 (5.2)	15 (79.0)	3 (15.8)	0.012‖
1 family member	58 (72.5)	20 (25.0)	2 (2.5)		21 (26.2)	51 (63.8)	8 (10.0)	
>1 family member	323 (76.0)	87 (20.5)	15 (3.5)		121 (28.5)	281 (66.1)	23 (5.4)	
Material style of life∞								
0–5	10 (76.9)	2 (15.4)	1 (7.7)	0.048§	1 (7.7)	10 (76.9)	2 (15.4)	<0.0001#
5–9	93 (66.9)	41 (29.5)	5 (3.6)		19 (13.7)	105 (75.5)	15 (10.8)	
9–12	271 (78.3)	64 (18.5)	11 (3.2)		114 (33.0)	216 (62.4)	16 (4.6)	

CANRISK, Canadian Diabetes Risk Assessment Questionnaire.
* The Pearson chi-square test was performed for sex and ethnicity. The Mantel-Haenszel chi-square test was applied for linear associations of other variables.
† The participant and both parents are unemployed.
‡ Spearman correlation is −0.128 (−0.036, −0.220).
§ Spearman correlation is −0.106 (−0.016, −0.197).
¶ Spearman correlation is −0.159 (−0.084, −0.234).
‖ Spearman correlation is −0.088 (−0.003, −0.174).
Spearman correlation is −0.226 (−0.148, −0.304).
∞ Material style of life, 0-5 is low, 5-9 is medium, and 9-12 denotes a high possession score, which was defined as having a cellphone, video game console, digital camera, DVD player, satellite cable, motorbike, washing machine, bicycle, and computer in working condition at home, in the past 30 days.

alarming concern, given that this is a modifiable factor. Although self-reported medical histories of having high blood sugar was rare in our study, the youth presented risk factors that were both modifiable and nonmodifiable.

The most prevalent type 2 diabetes risk factor was ethnicity in this study; almost two-thirds of the participants had ethnic backgrounds (i.e. Indigenous, African, Middle Eastern or Asian) that may genetically predispose people to type 2 diabetes. Indigenous and Asian youth showed a higher prevalence of having high risk scores or a greater number of risk factors; this finding is presumably because Indigenous and Asian ethnicity is considered a risk factor for type 2 diabetes. For Asian youth, ethnicity was the top contributor to the risk score (10 to 11 points), and this may explain why a larger proportion of Asian youth had moderate or high risk scores when the rate of youth who were overweight or had obesity was low. Moreover, youth who had lived in Canada for fewer than 5 years had higher risk scores and more risk factors compared to Canadian residents living in Canada longer and Canadian-born youth, whereas the pattern of risk-score distribution was similar between ≥5-year residents and Canadian-born youth. In general, immigrants are healthier than nonimmigrants in the host country, known as the "healthy immigrant effect" (42). However, this effect seems to vary depending on life stage; it is more apparent in adult immigrants than in children and adolescents (42). It is, therefore, important and necessary to support healthy settlement and acculturation for children and adolescents in immigrant families, given that the healthy immigrant effect diminishes after settlement in a host country (43). Promoting a healthy acculturation process through improving knowledge about nutrition, learning cooking skills to utilize new healthful foods, and increasing physical activity in a new living environment may mitigate the impact of losing the healthy immigrant effect (43). Our findings, therefore, highlight the need and importance of addressing modifiable risk factors for type 2 diabetes, such as diet and physical activity, despite low risk scores according to CANRISK, thereby preventing overweight/obesity and elevated blood sugar level or blood pressure, which are all heavily weighted risk factors in CANRISK, in order to alleviate genetically predisposed risks in multiethnic youth.

Our findings provide some implications for interventions. This study is based on modifying a screening tool, which is developed for adults 40 to 74 years of age, and on utilizing the modified tool to assess the risk among youth. Developing and validating a type 2 diabetes screening tool for youth may enable more accurate screening of youth at high risk at a younger age and, hence, contribute to early diagnosis and a society-wide promotion of healthier lifestyles and prevention programs targeting youth (30).

Because of the drastic increase of type 2 diabetes, developing and implementing evidence-based interventions to prevent type 2 diabetes at a young age is essential. Type 2 diabetes in youth results from a complex set of interrelated factors with varying degrees of complexity. These challenges are often resistant to traditional top-down preventive approaches (6). Strategies to reduce the risk for type 2 diabetes in youth should be developed to embrace the general population and youth as well as high-risk subgroups (44). The findings of this study highlight the subgroups in our multiethnic youth sample that may require immediate attention: males, Middle Eastern, African, Asian and Indigenous ethnicities, youth who recently moved to Canada from another country, youth without an employed family member, and youth who are socioeconomically disadvantaged. Such strategies must consider youth who may be in a disadvantageous socioeconomic status because we found a significant positive association between low material style of life scores and having a greater number of risk factors. Socioeconomically disadvantaged populations may experience financial or geographic barriers to healthful foods or physical activity facilities; however, studies have shown that people in socioeconomically deprived communities have a tendency to spend most household income on unhealthful foods that provide empty calories (45) and that similar populations have benefited from dietary-intervention programs (46,47). Similarly, a study concluded that a physical activity intervention program effectively improved obesity measures such as WC in people with low socioeconomic status (48). We found that the most prevalent modifiable risk factor for type 2 diabetes was physical inactivity. The trend toward the higher number of risk factors in youth who have more than 1 employed family member suggests that the lifestyle and health of youth may be dependent on the support of family members in preparing healthful meals or helping youth to participate in sports. Including families and a component to improve youth's health literacy in intervention programs may, therefore, be beneficial. Our study also showed an inverse association between duration of living in Canada and presence of diabetes-related risk factors. As discussed earlier, addressing modifiable factors, such as physical activity and diet, may reduce risk for developing type 2 diabetes. It is important to implement accessible and culturally sensitive programs to increase knowledge about type 2 diabetes prevention, to promote healthy lifestyles that encourage daily physical activity and the consumption of fruits and vegetables, and to prevent chronic diseases among Indigenous and newcomer populations in Canada. Working with organizations that serve the above populations, such as schools and cultural communities, may be critical in accessing various populations and implementing interventions to reduce risks for type 2 diabetes. An intervention program developed with youth input may be more sustainable because it utilizes the knowledge, needs and interests of the target population. This approach may encourage ownership of the program and improve sustainability. Previous studies have shown that youth might be facing several barriers to behaviour changes that allow for engagement in healthy lifestyles and, thus, prevent type 2 diabetes (49–52). Additional barriers to early detection and prevention of type 2 diabetes in youth are inadequate knowledge about screening and risk factors and early treatment for type 2 diabetes; inadequate use of health-care services and lack of access to traditional/cultural health practices; language barriers; and limited social support (6,53–56). Continued social and health inequities, if not addressed by culturally appropriate programs, may exacerbate the challenges related to type 2 diabetes that Canadian youth face (6). These risk factors need immediate attention, given the knowledge that diabetes' prevalence in Alberta is predicted to more than double between 2007 and 2035 from 4.5% to 11.1%, and the associated health-care costs are projected to increase by 237% (57).

Limitations

There are some limitations in the study. Schools and institutions were carefully selected to include a large number of Indigenous and/or new Canadian students; therefore, the sample may not be representative of urban Canadian youth, and the findings may not be generalizable to all Canadian youth. Responses, including medical histories, were self-reported by the participants and may include recall bias, particularly given that some participants were too young to provide accurate information about themselves and their parents. Our study did not utilize biomedical parameters to clinically assess the prevalence of and risk for type 2 diabetes. CANRISK is a screening tool for adults older than 40 years of age. To be able to assess risk in youth, we removed some of the questions from the CANRISK questionnaire and modified the risk scores. We found associations between some risk factors and risk scores and a number of risk factors; however, these findings do not imply causality. The present study did not include the risk factors associated with diabetes in children and youth, such as polycystic ovarian syndrome, fatty liver disease, psychotropic medications or

exposure to diabetes in utero. Future studies that consider these risk factors is needed so as to develop and validate a type 2 diabetes screening tool for youth to truly capture the prevalence of youth at increased risk for type 2 diabetes. The questionnaire also had the limitation of assigning a score of 0 to youth who responded "didn't know" to the questions assessing previous diagnoses of high blood pressure, high blood sugar and family history of diabetes. Despite these challenges, it is important to note that self-reported data are much easier and less expensive to collect than are the alternative methods of measuring the risk factors in CANRISK (32). This study has the strengths of a large multiethnic sample and the utilization of measured anthropometrics.

A follow-up education program, WHY ACT NOW, was developed and delivered to participating schools. WHY ACT NOW used evidence-based public health initiatives that support healthy lifestyles, balanced diets and physical activity to reduce the risk factors for type 2 diabetes and obesity in urban multiethnic youth. A website (https://www.whyactnow.ca/why-act-now) providing visual presentations of community findings (viewer-friendly graphs, charts, partner feedback, reports, published papers and interactive outreach components) was developed to inform participants of the study's results and to improve public knowledge of type 2 diabetes prevention.

Conclusions

The majority of youth had at least 2 risk factors for type 2 diabetes. Following ethnicity, which is a nonmodifiable risk factor, the most prevalent risk factors were daily physical inactivity, overweight or obesity, high WC or WHtR and low daily fruit and vegetable consumption, which may be modifiable by practicing a healthy lifestyle. There were significant differences in the distribution of risk scores and the number of risk factors by sex, ethnicity, duration of living in Canada and the socioeconomic status of the household. Our findings support the need for developing and validating a type 2 diabetes screening tool, similar to the CANRISK for adults, that incorporates socioeconomic factors to identify youth who are at increased risk and to develop, implement and evaluate culturally appropriate diet and lifestyle interventions that target urban multiethnic youth so that modifiable risk factors for type 2 diabetes can be addressed.

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Author Disclosures

Conflicts of interest: None.

Author Contributions

FK developed the conception and methodology of the study, oversaw data analyses and interpretation, and drafted the manuscript; FN performed data analyses and interpretation and drafted the manuscript; MD performed data analyses; SLJ performed data interpretation and drafted the manuscript; NJ critically reviewed the manuscript; SS oversaw the project and critically reviewed and finalized the manuscript.

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