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Prevalence of overweight and obesity among indigenous populations in Canada: A systematic review and meta-analysis

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ABSTRACT

Previous studies on overweight and obesity among indigenous peoples in Canada have been inconclusive. A systematic review was conducted on the prevalence of overweight and obesity among Canadian indigenous populations. Major bibliographic databases were searched for relevant studies published between January 1990 and June 2013. We reviewed 594 abstracts and included 41 studies in the meta-analyses. Using the heterogeneity test (Cochrane Q) results, the overall prevalence was estimated using fixed- or random-effects model. Nonadults (<18 years) had a pooled prevalence of overweight and obesity at 29.8% (95% CI: 25.2–34.4) and 26.5% (95% CI: 21.8–31.3), respectively. The pooled prevalence of overweight and obesity among adults were 29.7% (95% CI: 28.2–31.2) and 36.6% (95% CI: 32.9–40.2), respectively. Adult males had higher overweight prevalence than females (34.6% vs. 26.6%), but lower obesity prevalence (31.6% vs. 40.6%). Nonadult girls had higher prevalence than boys [overweight: 27.6%; 95% CI: 22.6–32.7 vs. 24.7%; 95% CI: 19.0–30.5; obesity: 28.6%; 95% CI: 20.3–36.9 vs. 25.1%; 95% CI: 13.8–36.4]. Nonadult Inuit had the highest overweight and lowest obesity prevalence. Although Inuit adult had the lowest prevalence of overweight (28.7%; 95% CI: 27.3–30.2) and obesity (32.3%; 95% CI: 25.5–39.1), it was relatively high. This study highlights the need for nutritional intervention programs for obesity prevention among indigenous populations in Canada.

KEYWORDS

Canadian indigenous; overweight; obesity prevalence; overweight prevalence

Introduction

The prevalence of obesity in Canada has almost doubled in the past 25 years (Public Health Agency of Canada, 2011). According to current statistics, an estimated 70% of Canadian adults aged 40 years and older will be overweight or obese by 2040 (Childhood Obesity Foundation, 2011). In 2008, the Canadian government spent an estimated 4.6 billion dollars on obesity-related costs (Childhood Obesity Foundation, 2011; Public Health Agency of Canada, 2011). Besides the negative economic impact, obesity adversely affects quality of life through disability (Armour et al., 2012), suffering, and major limitations in daily living (World Health Organization, 2013). An estimated 18% of Canadian adults were obese (Statistics Canada, 2013a), compared to 25.7% of indigenous adults (Public Health Agency of Canada, 2011). Canadian indigenous peoples are at greater risk of developing obesity and central fat distribution compared with non-indigenous Canadians (Katzmarzyk and Malina, 1998; Liu et al., 2006a; Shields, 2006; Conroy et al., 2007; Kmetc et al., 2008; Downs et al., 2009; Wahi et al., 2009; Anderson et al., 2010; Ng et al., 2010; First Nations Regional Health Survey, 2011).

Indigenous peoples in Canada (First Nations, Inuit, and Métis) make up 4.3% of the Canadian population and are one of the fastest growing populations in Canada (Statistics Canada, 2013b). According to the 2011 census, the Indigenous

population totals 1,400,685, with 851,560 identified as First Nations, 451,795 Métis, and 59,445 Inuit (Statistics Canada, 2013b). The life expectancy of the general indigenous population, though varying among different indigenous ethnic groups, was estimated at 70.4 years for males and 75.5 years for females, compared to 76.5 and 82.1 years for the non-indigenous male and female population, respectively (Health Council of Canada, 2005). Consolidated federal, provincial, territorial, and local government expenditure per person for the period of 1999–2000 indicated that the health expenditure for indigenous populations in Canada was 65% greater than the expenditure for non-indigenous Canadians (\$3,003 and \$1,824, respectively) (Fiscal Realities Economist, 2010). Therefore, the health status of indigenous populations greatly affects the health care system.

Traditionally, indigenous peoples relied on hunting, fishing, gathering, and food sharing as a way of life and cultural identity (Kuhnlein et al., 2004; Sharma, 2010). Historically, high levels of physical activity were required to acquire nutrient-dense traditional foods such as caribou, moose, and deer, all of which contributed greatly to the indigenous diet and survival in the harsh Northern climate (Takano, 2005; Sharma, 2010). Over the past few decades, indigenous populations have been experiencing a nutritional and lifestyle transition characterized by declining consumption of traditional foods, increased consumption of nonnutrient-dense foods high in fat and sugar,

and reduced levels of physical activity for food acquisition and transportation (Bjerregaard et al., 2004; Deering et al., 2009; Sharma et al., 2009; Erber et al., 2010b).

Previous research studies focused mainly on certain regional indigenous groups and reported inconsistent obesity prevalence values. Therefore, this paper aims to systematically review current evidence on obesity among indigenous populations in Canada and to provide suggestions for further discussions in this area. The questions addressed in this review are: (1) what is the prevalence of obesity among indigenous populations in Canada?, (2) what is the prevalence of obesity among indigenous men versus women in Canada?, and (3) what is the prevalence of obesity among different indigenous identity groups in Canada? We also statistically assessed (4) the degree of heterogeneity among the studies, and (5) explored the potential sources of heterogeneity by conducting subgroup analyses by obesity definition, study year, age, and gender.

Methods

Search strategy

A search of Pub Med/Medline, EMBASE, CINAHL, COCHRANE, the ISI Web of Knowledge, and Scopus from January 1990 to June 2013 was carried out to identify original English language studies that contained data on the prevalence of obesity and/or overweight among indigenous populations in Canada. We used the following medical subject heading (MeSH) terms and/or text words for the search: “Aboriginal,” “Indigenous,” “First Nation,” “Métis,” “Inuit,” “obesity,” “overweight,” and “Canada.” The literature was searched for the following criteria: (i) the population (adult, children, and adolescents) with the related MeSH terms; (ii) the results (body mass index [BMI], prevalence of overweight, and obesity); (iii) methodology (descriptive analysis, prevalence indicators, percentages, and survey data); and (iv) location of study. In addition, the reference lists and bibliographies of all included studies and related reviews were screened for further studies.

Selection criteria and obesity classification

To determine the eligibility of each study, two reviewers (FK and BS) independently evaluated the studies following predefined criteria and discussed any discrepancies. The first steps comprised of screening the title and abstracts for relevancy and excluding those that did not meet the criteria. Finally, the full texts of potentially relevant papers were read and studies consistent with the review criteria were selected. The papers were only eligible if the study participants were healthy individuals.

Only studies that used BMI to measure the prevalence of obesity/overweight among healthy adults (18 years of age and older) and/or children and adolescents were included. Among adults, a BMI within 25–29.9 kg/m² was classified as overweight and a BMI \geq 30 kg/m² were considered obese. For children and adolescents (nonadults; defined as younger than 18 years old), overweight was classified as 85th \leq BMI < 95th percentile and obese was classified as BMI \geq 95th percentile according to growth charts from the Centers for Disease Control (CDC) (CDC/National Centre for Health Statistics, 2010), cut-offs

from the National Health and Nutrition Examination Survey (NHANES) III (CDC/National Centre for Health Statistics, 2013), and criteria from the International Obesity Task Force (IOTF) (Cole et al., 2000). Most studies on nonadults included in this review made use of one classification, if not, we only used IOTF classification for pooled analysis of the results.

Literature was excluded if it: (i) grouped the prevalence of overweight and obesity into a single reported value, (ii) grouped the prevalence of obesity among adults and children, (iii) did not report the prevalence of overweight or obesity on Canadian indigenous peoples, (iv) studied individuals not representative of the general population (e.g., diabetics, athletes, sedentary elderly, etc.), or (v) contained duplicated data from another study. The duplicates were determined by examining the studies for similarities in study location and year, rural/urban area, age, and sex of the participants. For duplicate studies, the one with the largest sample size or the most recent one was considered. If the samples were the same, the one with more detailed results was used.

Data extraction and quality appraisal

Two investigators independently evaluated the selected studies to extract the following data: (i) general study information (author’s name, publication and data collection year, and location), (ii) study population details (sample size, age, ethnicity, and sex), (iii) obesity and overweight classification and BMI, and (iv) obesity and overweight prevalence. The total prevalence was extracted from the paper, or categorized according to age, gender, and age–gender combined.

Using Boyle (1998), we created the guidelines used to assess the quality of each relevant paper. Each paper was assigned a score out of eight, based on sampling, data collection, and analysis methods (data not reported).

Statistical analysis

Meta-analysis was performed for all selected studies. In each study, variance of the prevalence of obesity was calculated using binomial distribution. Heterogeneity was determined using the Q statistic with a significance of 0.1, while I^2 was used to analyze the degree of heterogeneity. The random effects model was applied to estimate the overall prevalence of obesity after heterogeneity was tested and the fixed model if no heterogeneity was observed.

The pooled total, age, sex, and age–sex prevalence of obesity and overweight were estimated using separate meta-analyses. Three categories for data collection period were used to stratify the prevalence trends. Forest plots illustrate the total prevalence. Meta-regression was used to assess the relationship between the prevalence of obesity and the participant’s age, sex, and year of data collection. Stata version 11.0 was used for all statistical analyses.

Results

Our initial search yielded 594 potentially relevant publications. Of these, 537 were considered irrelevant after reviewing the titles and/or abstracts, and 57 underwent full review. Sixteen of these

studies were excluded because they were secondary reports from a study that was already included (Young, 1996; Bryan and Walsh, 2004; Razak et al., 2005; Downs et al., 2008; Lix et al., 2009; Willows et al., 2009; Chateau-Degat et al., 2010a, 2010b; Galloway et al., 2010; Foulds et al., 2012b, 2012c), reported the obesity prevalence among participants with diabetes (Sellers et al., 2007; Oster et al., 2010; Patapas et al., 2012), or reported the prevalence in non-Canadian indigenous peoples (Rode and Shephard, 1995; Quon et al., 2012). The characteristics of the remaining 41 studies and the prevalence data are summarized in Tables 1 and 2 for adults (>18 years old) and nonadults (<18 years old), respectively. A total of 16 studies for prevalence of overweight (Hanley et al., 2000; Young et al., 2000; Kuperberg and Evers, 2006; Ng et al., 2006; Willows et al., 2007; Katzmarzyk, 2008; Downs et al., 2009; Wahi et al., 2009; Zorzi et al., 2009; Khalil et al., 2010; Mendelson et al., 2011; Foulds et al., 2012a; Galloway et al., 2012; Tomlin et al., 2012) and obesity (Bernard et al., 1995; Katzmarzyk and Malina, 1998; Young et al., 2000; Ng et al., 2006; Willows et al., 2007; Katzmarzyk, 2008; Downs et al., 2009; Wahi et al., 2009; Zorzi et al., 2009; Mendelson et al., 2011; Foulds et al., 2012a; Galloway et al., 2012; Tomlin et al., 2012) among nonadults and 25 studies for prevalence of overweight (Thouez et al., 1990; Young et al., 2000; Tremblay et al., 2005; Garriguet, 2008; Ho et al., 2008; Oster and Toth, 2009; Bruce et al., 2010; Hopping et al., 2010a; Liu et al., 2010; Sarkar et al., 2010; Chateau-Degat et al., 2011; Egeland et al., 2011; Elias et al., 2011; Foulds et al., 2011; Galloway et al., 2011; Ng et al., 2011; Zienczuk and Egeland, 2012) and obesity (Thouez et al., 1990; Gittelsohn et al., 1996; Katzmarzyk and Malina, 1998; Anand et al., 2001;

Kuhnlein et al., 2004; Tremblay et al., 2005; Liu et al., 2006a, 2010; Charbonneau-Roberts et al., 2007; Young et al., 2000, 2007; Garriguet, 2008; Ho et al., 2008; Oster and Toth, 2009; Bruce et al., 2010; Hopping et al., 2010a; McDonald and Trenholm, 2010; Sarkar et al., 2010; Chateau-Degat et al., 2011; Egeland et al., 2011; Elias et al., 2011; Foulds et al., 2011; Galloway et al., 2011; Ng et al., 2011; Zienczuk and Egeland, 2012) among adults were included in the meta-analyses.

Of the 16 studies with nonadult participants, 14 had First Nations participants (Bernard et al., 1995; Katzmarzyk and Malina, 1998; Hanley et al., 2000; Young et al., 2000; Kuperberg and Evers, 2006; Ng et al., 2006; Willows et al., 2007; Downs et al., 2009; Wahi et al., 2009; Zorzi et al., 2009; Khalil et al., 2010; Mendelson et al., 2011; Foulds et al., 2012a; Tomlin et al., 2012), one had Inuit participants (Galloway et al., 2012), and one did not subgroup their data and considered their participants to be indigenous (Katzmarzyk, 2008). There were no studies with nonadult Métis participants. Among studies with adult participants, 12 studies had First Nations participants (Thouez et al., 1990; Gittelsohn et al., 1996; Katzmarzyk and Malina, 1998; Young et al., 2000; Kuhnlein et al., 2004; Liu et al., 2006a; Ho et al., 2008; Oster and Toth, 2009; Bruce et al., 2010; Hopping et al., 2010a; McDonald and Trenholm, 2010; Elias et al., 2011; Foulds et al., 2011), 11 had Inuit participants (Thouez et al., 1990; Kuhnlein et al., 2004; Liu et al., 2006a; Charbonneau-Roberts et al., 2007; Young et al., 2007; McDonald and Trenholm, 2010; Chateau-Degat et al., 2011; Egeland et al., 2011; Galloway et al., 2011; Zienczuk and Egeland, 2012), two had Métis participants (Oster and Toth, 2009; McDonald and Trenholm, 2010), and six studies had indigenous participants (unspecified)

Table 1. General characteristics of the studies included in the pooled estimates of the prevalence of overweight and obesity among indigenous children and adolescents in Canada.

Author	Year of study	Location	Obesity criteria	Age (y)	Sample size			Overweight (%)			Obesity (%)		
					Total	Male	Female	Total	Male	Female	Total	Male	Female
indigenous ^a													
Katzmarzyk (2008)	2004	10 provinces ^b	CDC	2–17	371	187	184	19.6	17.8	21.4	15.8	13.4	18.3
First Nations													
Katzmarzyk and Malina (1998)	1996	ON	NHANES ^c	5–19	38	21	17	—	—	—	28.9	28.6	29.4
Hanley et al. (2000)	1993–1995	ON	NHANES ^c	2–19	445	202	243	30.9	27.7	33.7	—	—	—
Kuperberg and Evers (2006)	2003–2004	ON	CDC	18–48	102	52	50	27.8	—	—	—	—	—
Zorzi et al. (2009)	2006	BC	CDC	6–18	192	97	95	19.3	17.5	21.1	26.0	23.7	28.4
Wahi et al. (2009)	2006	BC	CDC	6–18	30	14	16	16.7	6.7	10.0	33.3	13.3	20.0
Mendelson et al. (2011)	2003–2004	MB	CDC	≥7	60	—	—	46.7	—	—	20.0	—	—
Tomlin et al. (2012)	2007–2008	Rural BC	CDC	8.7–18.5	133	70	63	20.0	—	—	30.0	—	—
Foulds et al. (2012a)	2007–2011	BC	BMI = 30	>16	882	219	663	30.9	35.2	26.8	48.9	47.5	50.2
Inuit													
Galloway et al. (2012)	2007–2008	QC	CDC IOTF	3–5	463	199	177	28.5 42.6	20.9 —	32.7 —	41.3 24.2	57.1 —	45.2 —
Cree ^d													
Bernard et al. (1995)	1992	QC	CDC	9–18	144	—	—	—	—	—	17.0	—	—
Young et al. (2000)	1996–1997	MB	NHANES ^c	4–19	719	365	354	25.3	26.3	24.3	36.4	33.4	39.6
Ng et al. (2006)	2004	QC	IOTF	9–12	82	—	—	33.0	—	—	38.0	—	—
Willows et al. (2007)	2002	QC	IOTF	2–5	1,044	521	523	31.6	28.2	35.0	21.3	20.9	21.6
			CDC					27.5	23.8	31.2	37.4	40.5	34.2
Downs et al. (2009)	2004–2005	QC	IOTF	9–12	203	—	—	29.9	—	—	34.3	—	—
Khalil et al. (2010)	2005–2007	QC	CDC	9–18	125	61	64	47.2	54.7	39.3	—	—	—

CDC = Centers for Disease Control, IOTF = International Obesity Task Force, NHANES = National Health and Nutrition Examination Survey, BC = British Columbia, MB = Manitoba, ON = Ontario, QC = Quebec.

^aIndigenous encompasses First Nations, Métis, and Inuit.

^b10 provinces refers to Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec and Saskatchewan.

^cNHANES III was used.

^dCree participants were grouped with First Nations participants for analyses.

Table 2. General characteristics of the studies included in the pooled estimates of the prevalence of overweight and obesity among adult indigenous peoples in Canada.

Author	Year of study	Location	Age (y)	Sample size			Overweight (%)			Obesity (%)		
				Total	Male	Female	Total	Male	Female	Total	Male	Female
Indigenous^a												
Anand et al. (2001)	1996–2000	ON	>20	301	123	178	—	—	—	58.5	62.0	56.0
Tremblay et al. (2005)	2000–2001;2003	Canada ^b	20–64	4,720	—	—	35.0	39.0	30.0	28.0	26.0	29.0
Garriguet (2008)	2004	ON, MB, SK, AB, BC ^b	19–50	561	216	345	29.0	38.0	23.0	38.0	33.0	41.0
Sarkar et al. (2010)	2000–2001	YT, NT, NU	>20	866	—	—	28.6	—	—	20.2	—	—
	2005–2006	YT, NT, NU	>20	810	—	—	26.2	—	—	25.4	—	—
Liu et al. (2010)	2000, 2003, 2005	NU, NT, NL, SK, MB, QC ^c	>18	13,048	5,778	7,270	27.7	40.0	26.0	24.1	—	—
Ng et al. (2011)	2004	10 provinces ^{b,c}	25–64	334	114	220	30.9	36.5	28.0	41.6	35.3	44.5
First Nations												
Katzmarzyk and Malina (1998)	1996	ON	20–75	80	35	45	—	—	—	46.8	43.7	49.2
Kuhnlein et al. (2004)	1994–1998	YT	>20	375	177	198	—	—	—	13.6	9.7	17.0
Ho et al. (2008)	2003–2004	QC	>18	133	—	—	32.6	—	—	47.7	—	—
Oster and Toth (2009a)	2003–2007	AB	>18	1,790	—	—	29.4	—	—	55.0	—	—
Bruce et al. (2010)	2003	MB	>18	483	230	253	27.4	—	—	56.4	50.0	65.0
McDonald and Trenholm (2010)	2001	NU, NT, NL, SK, MB, QC	>18	5797	—	—	—	—	—	41.1	—	—
Elias et al. (2011)	2002–03	MB	>20	2931	1158	1773	36.7	41.6	31.6	37.5	33.5	41.7
Foulds et al. (2011)	2007–10	BC	18–77	759	182	577	29.4	33.0	28.4	48.6	48.4	48.7
Inuit												
Thouez et al. (1990)	1982–4	QC	15–64	1082	497	585	26.3	25.9	26.5	10.6	8.3	12.7
Kuhnlein et al. (2004)	1994–8	NU, NT, QC, NL	>20	960	496	464	—	—	—	23.8	18.3	29.7
Liu et al. (2006a)	1986–7, 1989–91, 1993–5	MB, ON, NT	>18	238	—	—	—	—	—	28.7	—	—
Charbonneau-Roberts et al. (2007)	2005	NU	19–77	45	10	35	—	—	—	58.4	25.0	68.0
Young et al. (2007)	1990–2001	NU, QC	>18	780	319	461	—	—	—	21.5	32.5	25.5
Hopping et al. (2010a)	2008	NU	19–89	218	38	180	28.2	31.6	27.4	43.7	34.2	45.7
McDonald and Trenholm (2010)	2001	NU, NT, NL, SK, MB, QC	>18	3776	—	—	—	—	—	41.8	—	—
Egeland et al. (2011)	2007–8	NT, NU, YT, NL	>18	2160	834	1326	28.3	32.5	24.2	35.1	28.6	41.6
Galloway et al. (2011)	2007–08	NU, NL, QC	18–90	2168	837	1331	28.3	33.9	24.8	35.3	25.7	41.3
Chateau-Degat et al. (2011)	2004	QC	18–74	867	392	475	29.4	—	—	28.5	25.1	31.3
Zienczuk and Egeland (2012)	2007–08	NT, NU, NL, YT	>18	2592	998	1597	28.0	40.0	34.0	36.0	27.0	42.0
Métis												
Oster and Toth (2009a)	2003–7	AB	>18	867	—	—	33.2	—	—	49.3	—	—
McDonald and Trenholm (2010)	2001	NU, NT, NL, SK, MB, QC	>18	4719	—	—	—	—	—	34.3	—	—
Cree^e												
Thouez et al. (1990)	1982–4	QC	15–64	913	430	483	28.7	29.5	27.9	33.2	22.8	42.4
Gittelsohn et al. (1996)	1993–5	ON	>20	485	210	275	—	—	—	36.3	30.4	40.9
Young et al. (2000) ^d	1996–7	MB	4–19	719	365	354	25.3	26.3	24.3	36.4	33.4	39.6
Liu et al. (2006a)	1986–7, 1989–91, 1993–5	MB, ON, NT	>18	1180	—	—	—	—	—	36.3	—	—

AB = Alberta, BC = British Columbia, NL = Newfoundland & Labrador, NT = Northwest Territories, NU = Nunavut, MB = Manitoba, ON = Ontario, QC = Quebec, SK = Saskatchewan, YT = Yukon.

^aIndigenous encompasses First Nations, Métis, and Inuit.

^bOff-reserve.

^c10 provinces refers to Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan.

^dThis is the only study that used the NHANES (National Health and Nutrition Examination Survey) III definition for obesity categories.

^eCree participants were grouped with First Nations participants for analyses.

^fExcept Nunavik & Jamésie regions of Quebec.

(Anand et al., 2001; Tremblay et al., 2005; Garriguet, 2008; Liu et al., 2010; Sarkar et al., 2010; Ng et al., 2011). Studies were also subgrouped by data collection period. Before 2000, there were four studies with nonadult participants (Bernard et al., 1995; Katzmarzyk and Malina, 1998; Hanley et al., 2000; Young et al., 2000) and seven studies with adult participants (Thouez et al., 1990; Gittelsohn et al., 1996; Katzmarzyk and Malina, 1998; Anand et al., 2001; Kuhnlein et al., 2004; Liu et al., 2006a; Young et al., 2000; 2007). From 2000 to 2005, there were six studies with nonadult participants (Kuperberg and Evers, 2006; Ng et al., 2006; Willows et al., 2007; Katzmarzyk, 2008; Downs et al., 2009; Mendelson et al., 2011) and 12 studies with adult participants (Tremblay et al., 2005; Charbonneau-Roberts et al., 2007; Garriguet, 2008; Ho et al., 2008; Oster and Toth, 2009a; Bruce et al., 2010; Liu et al., 2010; McDonald and Trenholm, 2010; Sarkar et al., 2010; Chateau-Degat et al., 2011; Elias et al., 2011; Ng et al., 2011). After 2005, there were six studies with nonadult participants (Wahi et al., 2009; Zorzi et al., 2009; Khalil et al.,

2010; Foulds et al., 2012a; Galloway et al., 2012; Tomlin et al., 2012) and seven studies with adult participants (Oster and Toth, 2009; Hopping et al., 2010a; Sarkar et al., 2010; Egeland et al., 2011; Foulds et al., 2011; Galloway et al., 2011; Zienczuk and Egeland, 2012). The total sample size in the studies ranged from 45 to 13,048 individuals.

Overweight and obesity among nonadults

Among individuals less than 18 years old, the overweight and obesity prevalence ranged from 16.67 to 42.20% and 15.83 to 47.30%, respectively. The pooled prevalence estimate of overweight was 29.8% (95% CI: 25.2–34.4) and obesity was 26.5% (95% CI: 21.8–31.3) (Fig. 1). In subgroup analyses by gender, girls had a higher prevalence of overweight (27.6%; 95% CI: 22.6–32.7) and obesity (28.6%; 95% CI: 20.3–36.9) than boys [overweight (24.7%; 95% CI: 19.0–30.5) and obesity (25.1%; 95% CI: 13.8–36.4)] (Table 3).

Table 3. Pooled results of the point estimates (95% confidence intervals) of the overweight and obesity prevalence among indigenous children and adolescent populations in Canada.

	Pooled estimate	<i>P</i> for heterogeneity (<i>I</i> ²)	No. of participants (No. of studies)	Pooled mean BMI (95% CI)	No. of participants (No. of studies)
Overweight					
Overall	29.8 (25.2–34.4)	<0.001 (89.2)	3,967 (13)	21.1 (19.4–22.9)	1,798 (7)
By gender					
Boys	24.7 (19.0–30.5)	<0.001 (92.2)	1,646 (8)	—	—
Girls	27.6 (22.6–32.7)	<0.001 (88.4)	1,656 (8)	—	—
By overweight definition					
CDC	28.7 (23.2–34.2)	<0.001 (84.0)	2,293 (8)	18.4 (18.2–18.6) ^a	463 (1)
IOTF	31.2 (23.3–39.2)	<0.001 (92.9)	2,395 (5)	21.4 (19.0–23.9)	1,315 (5)
NHANES	28.0 (22.4–33.5) ^a	—	1,164 (2)	20.5 (19.4–21.5) ^a	483 (2)
By ethnic group^b					
Indigenous	19.6 (15.5–23.6) ^a	—	371 (1)	21.0 (19.0–22.9) ^a	569 (2)
First Nations	29.4 (25.2–33.6)	<0.001 (81.9)	3,135 (11)	21.9 (20.3–23.5)	768 (4)
Inuit	42.6 (38.1–47.1) ^a	—	463 (1)	18.4 (18.2–18.6) ^a	463 (1)
Métis	—	—	—	—	—
By study year					
Before 2000	28.0 (22.4–33.5)	—	1,164 (2)	20.5 (19.4–21.5) ^a	483 (2)
2000–2005	30.2 (24.0–36.4)	<0.001 (84.5)	1,860 (6)	22.3 (20.1–24.5)	656 (3)
After 2005	29.5 (16.7–42.2)	<0.001 (93.8)	943 (5)	20.2 (16.7–23.6)	661 (2)
Obesity					
Overall	26.5 (21.8–31.3)	<0.001 (88.7)	3,477 (12)	21.1 (19.4–22.9)	1,798 (7)
By gender					
Boys	25.1 (13.8–36.4)	<0.001 (97.6)	1,476 (8)	—	—
Girls	28.6 (20.3–36.9)	<0.001 (94.6)	1,438 (8)	—	—
By obesity definition					
CDC	30.4 (21.9–38.8)	<0.001 (92.7)	2,066 (7)	18.4 (18.2–18.6) ^a	463 (1)
IOTF	25.4 (19.3–31.2)	<0.001 (88.5)	2,161 (5)	21.4 (19.0–23.9)	1,315 (5)
NHANES	36.0 (32.6–39.4) ^a	—	757 (2)	20.5 (19.4–21.5) ^a	483 (2)
By ethnic group^b					
Indigenous	15.8 (12.1–19.5) ^a	—	371 (1)	21.0 (19.0–22.9) ^a	569 (2)
First Nations	28.2 (22.6–33.7)	<0.001 (87.4)	2,645 (10)	21.9 (20.3–23.5)	768 (4)
Inuit	24.2 (20.3–37.7) ^a	—	463 (1)	18.4 (18.2–18.6) ^a	463 (1)
Métis	—	—	—	—	—
By study year					
Before 2000	27.5 (12.8–42.2)	<0.001 (93.1)	901 (3)	20.5 (19.4–21.5) ^a	483 (2)
2000–2005	25.0 (18.3–31.8)	<0.001 (88.0)	1,758 (5)	22.3 (20.1–24.5)	656 (3)
After 2005	25.8 (22.8–28.8)	0.45 (0)	818 (4)	20.2 (16.7–23.6)	661 (2)

BMI = body mass index, CDC = Centers for Disease Control, CI = confidence interval, IOTF = International Obesity Task Force, NHANES = National Health and Nutrition Examination Survey.

^aIn cases with one study in a category, meta-analysis was not performed; weighted pooled analysis was performed when only two studies were available in a category.

^bCree participants were grouped with First Nations participants for analyses.

Overall, an increasing trend for the prevalence of overweight was seen over time. Studies before 2000 had the lowest overweight (28.0%; 95% CI: 22.4–33.5), followed by studies from 2000 to 2005 (30.2%; 95% CI: 24.0–36.4) and studies after 2005 (29.5%; 95% CI: 16.7–42.2). The prevalence of obesity, however, decreased overall. Studies previous to 2000 had an obesity prevalence of 27.5% (95% CI: 12.8–42.2), which decreased from 2000 to 2005 to 25.0%; (95% CI: 18.3–31.8). Further subgroup analyses by the three cultural groups of indigenous peoples revealed that Inuit had the highest prevalence of overweight (42.6%; 95% CI: 38.1–47.1), while First Nations had the lowest prevalence (29.4%; 95% CI: 25.2–33.6). Obesity prevalence among First Nations was the highest prevalence (28.2%; 95% CI: 22.6–33.7), whereas Inuit had the lowest obesity prevalence (24.2%; 95% CI: 20.3–37.7). The prevalence of overweight and obesity among unspecified indigenous individuals were 19.6% (95% CI: 15.5–23.6) and 15.8% (95% CI: 12.1–19.5), respectively (Table 3).

Meta-analysis of the studies that used the NHANES III cut-off (Katzmarzyk and Malina, 1998; Young et al., 2000) had the lowest overweight prevalence (28.0%; 95% CI: 22.4–33.5) and the highest obesity prevalence (36.0%; 95% CI: 32.6–39.4), followed by studies (Wahi et al., 2009; Zorzi et al., 2009; Khalil

et al., 2010; Foulds et al., 2011; Ng et al., 2011; Galloway et al., 2012; Zienczuk and Egeland, 2012) that used the CDC cut-off for overweight (28.7%; 95% CI: 23.2–34.2) and obesity (30.4%; 95% CI: 21.9–38.8). Studies using the IOTF cut-off (Ng et al., 2006; Willows et al., 2007; Katzmarzyk, 2008; Downs et al., 2009; Galloway et al., 2012) had the highest overweight (31.2%; 95% CI: 23.3–39.2) and the lowest obesity prevalence (25.4%; 95% CI: 19.6–31.2) (Table 3).

Among nonadults, the pooled BMI was 21.1 kg/m² (95% CI: 19.4–22.92) and were similar among the different indigenous groups. Inuit had the lowest pooled mean BMI of 18.4 kg/m² (95% CI: 18.2–18.6). First Nations individuals had a pooled mean BMI of 21.9 kg/m² (95% CI: 20.3–23.5). For studies that did not subgroup their analysis and instead used “indigenous,” the pooled mean BMI was 21.0 kg/m² (95% CI: 19.0–22.9) (Table 3).

Overweight and obesity among adults

Among adults, overweight and obesity prevalence ranged from 19.77 to 36.70% and 10.63 to 58.45%, respectively. The pooled prevalence estimates of overweight and obesity among adults were 29.7% (95% CI: 25.2–34.4) and 36.6% (95% CI:

Table 4. Pooled results of the point estimates (95% confidence intervals) of the overweight and obesity prevalence among adult (>18 years) indigenous populations in Canada.

	Pooled estimate	<i>P</i> for heterogeneity (<i>I</i> ²)	No. of participants (No. of studies)	Pooled mean BMI (95% CI)	No. of participants (No. of studies)
Overweight					
Overall	29.7 (28.2–31.2)	<0.001 (88.8)	39,479 (22)	29.0 (28.2–29.9)	12,189 (13)
Male	34.6 (32.2–37.1)	<0.001 (94.3)	13,686 (15)	—	—
Female	26.6 (24.5–28.7)	<0.001 (93.3)	19,980 (15)	—	—
By ethnic group^a					
Indigenous	29.8 (26.7–32.9)	<0.001 (93.3)	21,522 (7)	30.7 (29.8–31.5)	1,517 (3)
First Nations	29.7 (26.0–33.4)	<0.001 (88.8)	7,089 (7)	29.6 (27.7–31.5)	3,809 (4)
Inuit	28.7 (27.3–30.2)	0.022 (59.4)	9,867 (7)	27.8 (27.1–28.6)	6,863 (6)
Métis	33.2 (30.1–36.3) ^b	—	867 (1)	—	—
By study year					
Before 2000	28.2 (23.8–32.6)	0.005 (83.1)	2,855 (4)	28.2 (26.9–29.5)	2,579 (5)
2000–2005	30.8 (27.7–33.9)	<0.001 (94.5)	23,943 (9)	28.5 (26.0–31.1) ^b	1,204 (2)
After 2005	29.0 (27.9–30.1)	0.075 (43.9)	12,681 (9)	29.8 (28.7–31.0)	8,409 (6)
Obesity					
Overall	36.6 (32.9–40.2)	<0.001 (98.8)	56,920 (32)	29.0 (28.2–29.9)	12,189 (13)
Male	31.6 (26.9–36.2)	<0.001 (98.5)	9,467 (21)	—	—
Female	40.6 (35.6–45.7)	<0.001 (98.5)	14,232 (21)	—	—
By ethnic group^a					
Indigenous	35.2 (29.3–41.0)	<0.001 (98.4)	21,522 (8)	30.7 (29.8–31.5)	1,517 (3)
First Nations	40.9 (34.9–46.9)	<0.001 (98.0)	14,926 (11)	29.6 (27.7–31.5)	3,809 (4)
Inuit	32.3 (25.5–39.1)	<0.001 (98.8)	14,886 (11)	27.8 (27.1–28.6)	6,863 (6)
Métis	41.7 (27.0–56.4) ^c	—	5,586 (2)	—	—
By study year					
Before 2000	30.6 (22.4–38.8)	<0.001 (98.4)	6,394 (10)	28.2 (26.9–29.5)	2,579 (5)
2000–2005	37.4 (32.5–42.3)	<0.001 (98.9)	38,280 (13)	28.5 (26.0–31.1) ^b	1,204 (2)
After 2005	41.9 (35.7–48.0)	<0.001 (98.0)	12,246 (9)	29.8 (28.7–31.0)	8,409 (6)

BMI = body mass index; CI = confidence interval.

^aCree participants were grouped with First Nations participants for analysis.

^bIn cases with one study in a category, meta-analysis was not performed; weighted pooled analysis was performed when in a category only two studies were available.

^cFixed effects model were used.

32.9–40.2), respectively (Fig. 2). Males had a higher overweight prevalence than females (34.6%; 95% CI: 32.2–37.1 vs. 26.6%; 95% CI: 24.5–28.7), but lower obesity prevalence (31.6%; 95% CI: 26.9–36.2 vs. 40.6%; 95% CI: 35.6–45.7). Studies before 2000 had the lowest overweight prevalence (28.2%; 95% CI: 23.8–32.6), while studies from 2000 to 2005 had the highest prevalence (30.8%; 95% CI: 27.7–33.9). After 2005, the overweight prevalence decreased slightly (29.0%; 95% CI: 27.9–30.1). Obesity prevalence increased with study date. Before 2000, the obesity prevalence was 30.6% (95% CI: 22.4–38.8), and increased to 37.4% (95% CI: 32.5–42.3) between 2000 and 2005 and again to 41.9% (95% CI: 35.7–48.0) after 2005 (Table 4).

In subgroup analyses, Inuit had the lowest prevalence of overweight (28.7%; 95% CI: 27.3–30.2) and obesity (32.3%; 95% CI: 25.5–39.1) followed by First Nations [overweight (29.7%; 95% CI: 26.0–33.4) and obesity (40.9%; 95% CI: 34.9–46.9)] and then Métis [overweight (33.2%; 95% CI: 30.1–36.3) and obesity (41.7%; 95% CI: 27.0–56.4)]. In studies with unspecified “indigenous participants,” the prevalence of overweight and obesity were 29.8% (95% CI: 26.7–32.9) and 35.2% (95% CI: 29.3–41.0), respectively (Table 4).

The pooled BMI was 29.0 kg/m² (95% CI: 28.2–29.9). Among the three indigenous groups, BMI values were similar. First Nations individuals had the highest BMI of 29.6 kg/m² (95% CI: 27.7–31.5). While, Inuit had the lowest pooled mean BMI of 27.8 kg/m² (95% CI: 27.1–28.6). For studies that simply used “indigenous people,” the pooled mean BMI was 30.7 kg/m² (95% CI: 29.8–31.5). Data on BMI were not given for studies that had Métis participants (Oster and Toth, 2009; McDonald and Trenholm, 2010) (Table 4).

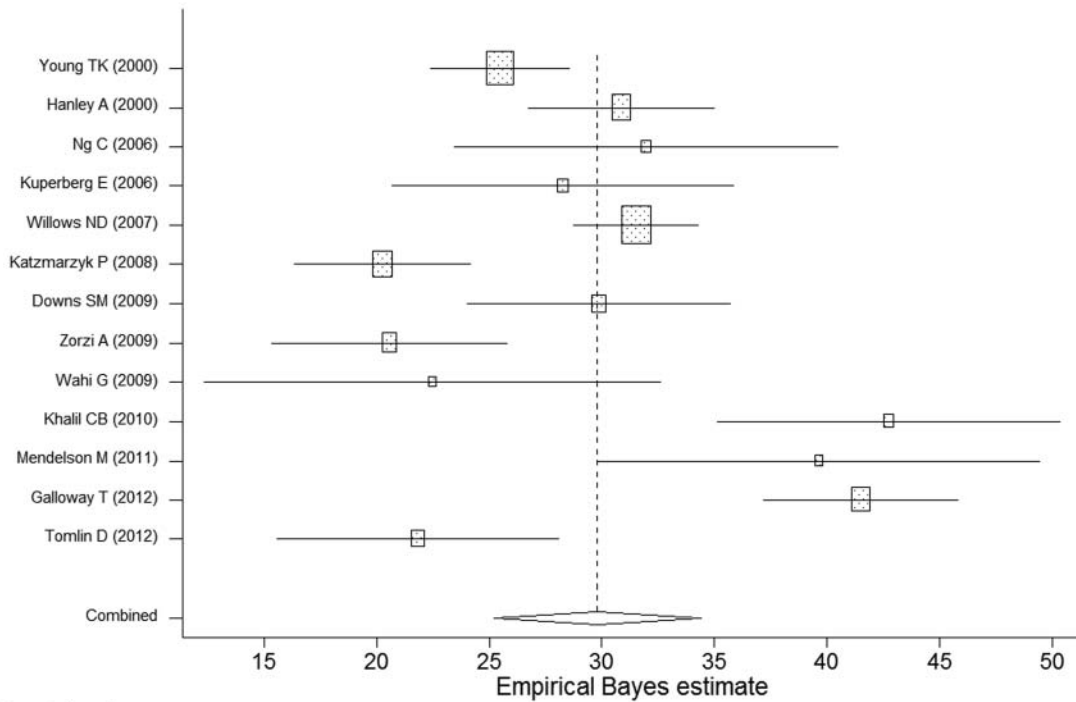
Discussion

This systematic review looked at the prevalence of overweight and obesity among indigenous populations in Canada. Overall, the prevalence of overweight and obesity increased over time among nonadults and adults. Of the three ethnic groups, adult Métis had the highest prevalence of both overweight and obesity. Among nonadults, Inuit participants had the highest prevalence of overweight and lowest obesity prevalence; however, adult Inuit participants had the lowest prevalence of overweight and obesity. The pooled estimates revealed that there was a significant difference between First Nations and Inuit in terms of the prevalence of overweight among nonadults and prevalence of obesity among adults. The data for nonadult Inuit participants were, however, limited to a single study and there were no studies with nonadult Métis participants.

Our meta-regression analysis among nonadults showed that girls had a higher prevalence of overweight and obesity than boys and the rates increased over time. This increasing trend is consistent with previous study that reported between 1981 and 1996, the prevalence of obesity among Canadian children aged 7–13 tripled from 5 to 15% (Tremblay and Willms, 2000).

Eating habits are directly related to the availability of and access to healthy food options, especially in remote communities where healthier foods can be cost-prohibitive (Drewnowski and Specter, 2004; Hopping et al., 2010b). Food insecurity has been observed in indigenous communities, in the context of obtaining traditional and market foods (Power, 2008). Although low socioeconomic status has been positively associated with obesity, indigenous peoples of both

a) Overweight



b) Obesity

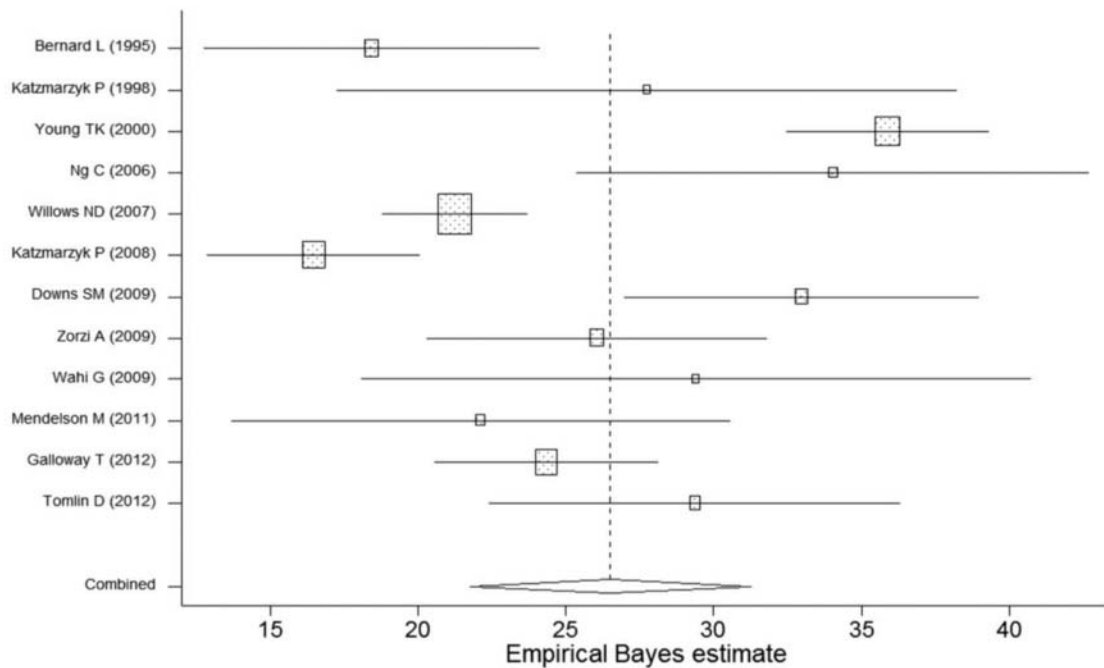


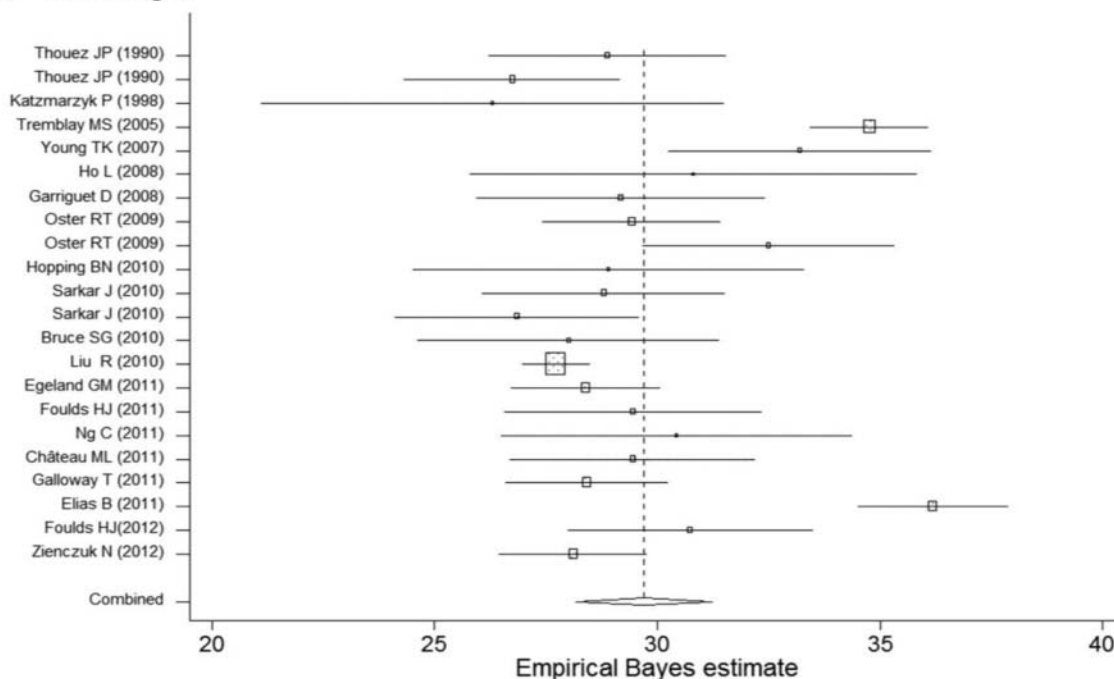
Figure 1. Forest plots of the prevalence of (a) overweight and (b) obesity among nonadult indigenous individuals.

low and high socioeconomic status experience a high prevalence of obesity (Ng et al., 2011). A study conducted in an indigenous community found that the diet consisted of mainly energy dense foods low in nutritional value, such as sweetened beverages and snacks, and were low in foods of high nutrient density, such as fruit and vegetables (Zotor et al., 2012). As a result, many micronutrient inadequacies were observed; many children were at risk of zinc inadequacy, and the mean intakes of calcium and vitamin D were

below the recommended levels (Moffatt, 1995; Che and Chen, 2001; El Hayek et al., 2010).

Though indigenous peoples continue to pass down knowledge of traditional lifestyle methods and diet, dietary transitions have resulted in higher consumptions of nonnutrient dense foods (Elliott et al., 2012). Traditional diets have been shown to contain adequate nutrient content (Elliott et al., 2012), and changing food and physical environments in Northern communities have been linked with

a) Overweight



b) Obesity

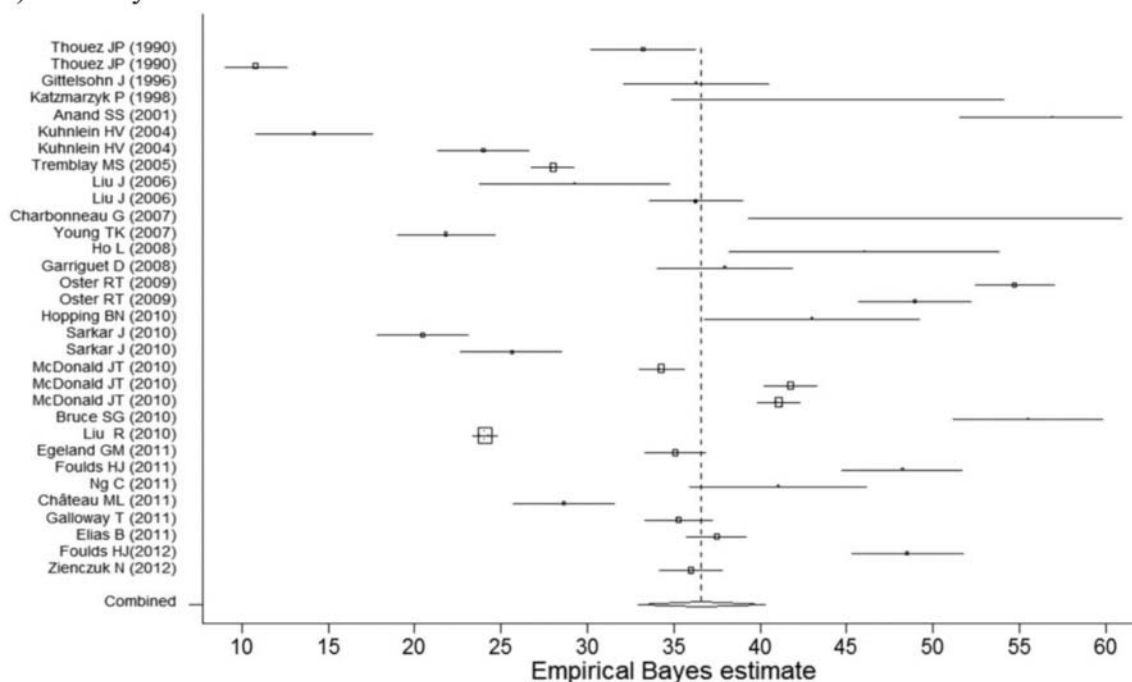


Figure 2. Forest plots of the prevalence estimates of (a) overweight and (b) obesity among adult indigenous participants.

a higher prevalence of chronic disease (Kuhnlein et al., 2004; Young and Katzmarzyk, 2007). People in the Arctic have limited access to fresh and affordable fruit and vegetables (Erber et al., 2010a). In the Inuvialuit region, it is estimated that more than 30% of people have one or more chronic health conditions (Northwest Territories Health and Social Services, 2005; Inuit Tapiriit Kanatami, 2008), and 61% of the population residing in the Northwest Territories are overweight or obese, compared to 52% of the non-indigenous population (Statistics Canada, 2013a). In southern Canada, indigenous populations had a higher

prevalence of certain chronic diseases often seen as complications of obesity, such as diabetes (Bruce et al., 2010; Foulds et al., 2012b).

Physical activity is a key modifiable factor for preventing obesity. Historically, indigenous peoples had higher levels of physical activity than non-indigenous peoples (Levesque et al., 2004; Liu et al., 2006b; Shields, 2006; Katzmarzyk, 2008; Ng et al., 2010). However, physical activity levels are decreasing in indigenous communities, especially rural, on-reserve, and northern communities (Foulds et al., 2012a), due to lower engagement in traditional activities, such as hunting (Curtis et al., 2005), and

increased television and computer use (Steffen et al., 2009). Lower physical activity levels were found to be more prevalent among those living in rural areas, on-reserve, and in the north, suggesting the importance of emphasizing physical activity promotion in those areas (Foulds et al., 2012a). In one study, half the indigenous children sampled watched greater than 15 hours of television weekly—a sedentary activity linked with obesity. The percentage of indigenous children in the study viewing a high amount of television was approximately twice that of non-indigenous (Steffen et al., 2009; Ng et al., 2010).

During the past few decades, most obesity prevention programs focused on behavioral change; however, previous studies have shown that using a community-wide approach was more successful. A review of 55 studies on the effectiveness of obesity prevention programs in children concluded that successful interventions used a broad range of program components (Waters et al., 2011). Some promising policies and strategies identified in this review included changes to the school curriculum to incorporate healthier diets, increasing access to more nutrient dense foods, increasing physical activity sessions, and developing basic movement skills (Waters et al., 2011). A whole school approach, which involved teacher participation, used to promote health nutrition and physical activity within an indigenous school in British Columbia addressed aspects, such as family and community environment (Naylor et al., 2010). Household-based lifestyle interventions among indigenous families were successful at reducing energy intake and increasing physical activity (Anand et al., 2007).

Given the diversity in values and traditional practices among indigenous communities, a successful obesity intervention for indigenous peoples could use a community-wide approach developed in partnership with elders and community members. The diversity of indigenous culture and its influence on lifestyle and food choices suggests the need for more culturally aware health professionals so that obesity prevention and treatment methods are more successful (Purden, 2005; Pigford et al., 2012; O'Sullivan, 2013). Current health trends and healthcare costs resulting from obesity in indigenous communities suggest that interventions modeled on successful community-based programs may have a significant health and economic impact. Limitations included little data on certain ethnic groups, such as Métis and Inuit. The data for nonadult Inuit were limited to a single study and the BMI was not provided for Métis. Therefore, designing and performing studies with the primary objective of investigating anthropometric and nutritional status of Métis population in Canada needs to be prioritized. Sample data may have varied as some studies used different overweight and obesity cut-offs.

We found that compared with the CDC and NHANES criteria, the IOTF definition tends to overestimate the prevalence of overweight and underestimates the prevalence of obesity.

Another limitation of our study is that many studies did not report the mean BMIs; therefore, undernutrition may be a reason for the wide CIs for the BMI pooled mean estimates.

Age is also a factor in variations in overweight and obesity rates as we were not able to perform a subgroup analyses by age among nonadult participants. Overall, BMI has been found to be generally similar between girls and boys up to age 13, however, after that age indigenous girls tend to have a higher BMI than boys (Hanley et al., 2000).

This review highlights the need for nutritional intervention programs aimed at health promotion and obesity prevention among indigenous populations. Current health trends and healthcare costs resulting from obesity in indigenous communities suggest that interventions modeled on successful community-based programs may have a significant health and economic impact. Socioeconomic factors should be considered as food security significantly influences dietary choices of indigenous populations. This review shows that overweight and obesity prevalence increased over time in all age groups and highlights the need for nutritional intervention programs that consider socioeconomic factors and are aimed at health promotion and obesity prevention among indigenous populations.

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Conflicts of interest

The authors declare that they have no potential conflicts of interest.

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