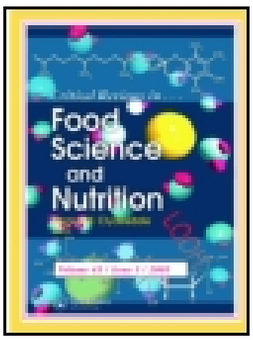

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Prevalence of overweight and obesity among Aboriginal populations in Canada: a systematic review and meta-analysis

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Abstract

Previous studies on overweight and obesity among Aboriginal peoples in Canada have been inconclusive. A systematic review was conducted on the prevalence of overweight and obesity among Canadian Aboriginal 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. Non-adults (<18 yr) 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%). Non-adult 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]. Non-adult Inuit had the highest overweight and lowest obesity prevalence. Although adult 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), it was relatively high. This study highlights the need for nutritional intervention programs for obesity prevention among Aboriginal populations in Canada.

Key Words

Canadian Aboriginal, 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 2013), compared to 25.7% of Aboriginal adults (Public Health Agency of Canada 2011). Canadian Aboriginal peoples are at greater risk of developing obesity and central fat distribution compared with non-Aboriginal Canadians (Anderson et al. 2010;Conroy et al. 2007;Downs et al. 2009;First Nations Regional Health Survey 2011;Katzmarzyk & Malina 1998;Kmetic, Reading & Estey 2008;Liu et al. 2006a;Ng, Young & Corey 2010;Shields 2006;Wahi et al. 2009).

Aboriginal peoples in Canada (First Nations, Inuit and Métis) make up 3.8% of the Canadian population and are one of the fastest growing populations in Canada (Statistics Canada 2010). According to the 2006 census, the Indigenous population totals 1,172,785, with 698,025 identified as First Nations, 389,780 Métis and 50,480 Inuit (Statistics Canada 2010). The life expectancy of the general Aboriginal population, though varying among different Aboriginal 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-Aboriginal 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 Aboriginal populations in Canada was 65% greater than the expenditure for non-Aboriginal Canadians ($3,003 and $1,824, respectively) (Fiscal Realities Economist 2010). Therefore, the health status of Aboriginal populations greatly affects the health care system.

Traditionally, Aboriginal 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 Aboriginal diet and survival in the harsh northern climate (Sharma 2010;Takano 2005). Over the past few decades, Aboriginal populations have been experiencing a nutritional and lifestyle transition characterized by declining consumption of traditional foods, increased consumption of non-nutrient-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;Erber et al. 2010b;Sharma et al. 2009).

Previous research studies focused mainly on certain regional Aboriginal groups and reported inconsistent obesity prevalence values. Therefore, this paper aims to systematically review current evidence on obesity among Aboriginal 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 Aboriginal populations in Canada? 2) what is the prevalence of obesity among Aboriginal men versus women in Canada? and 3) what is the prevalence of obesity among different Aboriginal 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 Aboriginal 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 (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. Lastly, 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 body mass index (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 25-30 kg/m^2 was classified as overweight and a BMI $\geq$ 30kg/m^2 were considered obese. For children and adolescents (non-adults; defined as younger than 18 years old), overweight was classified as 85th $\leq$ BMI $\leq$ 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 non-adults 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 aboriginals, (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(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(Bryan & Walsh 2004;Chateau-Degat et al. 2010a;Chateau-Degat et al. 2010b;Downs et

al. 2008;Foulds, Bredin & Warburton 2012b;Foulds, Bredin & Warburton 2012c;Galloway, Young & Egeland 2010;Lix et al. 2009;Razak et al. 2005;Willows et al. 2009;Young 1996), reported the obesity prevalence among diabetic subjects (Oster et al. 2010;Patapas et al. 2012;Sellers, Yung & Dean 2007), or reported the prevalence in non-Canadian Aboriginal peoples (Quon, McGrath & Roy-Gagnon 2012;Rode & Shephard 1995). The characteristics of the remaining 41 studies and the prevalence data are summarized in Tables 1 and 2 for adults (>18 years old) and non-adults (<18 years old), respectively. A total of 15 studies for prevalence of overweight (Downs et al. 2009;Galloway et al. 2012;Hanley et al. 2000;Katzmarzyk 2008;Khalil, Johnson-Down & Egeland 2010;Kuperberg & Evers 2006;Mendelson et al. 2011;Ng, Marshall & Willows 2006;Tomlin et al. 2012;Wahi et al. 2009;Willows, Johnson & Ball 2007;Young et al. 2000;Zorzi et al. 2009) and obesity (Bernard et al. 1995;Downs et al. 2009;Galloway et al. 2012;Katzmarzyk 2008;Mendelson et al. 2011;Ng, Marshall & Willows 2006;Tomlin et al. 2012;Wahi et al. 2009;Willows, Johnson & Ball 2007;Young et al. 2000;Zorzi et al. 2009) among non-adults and 32 studies for prevalence of overweight (Bruce et al. 2010;Chateau-Degat et al. 2011;Egeland, Cao & Young 2011;Elias et al. 2011;Foulds, Bredin & Warburton 2011;Foulds, Bredin & Warburton 2012a;Galloway et al. 2011;Garriguet 2008;Ho et al. 2008;Hopping et al. 2010a;Katzmarzyk & Malina 1998;Liu et al. 2010;Ng, Corey & Young 2011;Oster & Toth 2009a;Sarkar et al. 2010;Thouez et al. 1990;Tremblay et al. 2005;Young et al. 2007;Zienczuk & Egeland 2012) and obesity (Anand et al. 2001;Bruce et al. 2010;Charbonneau-Roberts, Young & Egeland 2007;Chateau-Degat et al. 2011;Egeland, Cao & Young 2011;Elias et al. 2011;Foulds, Bredin & Warburton 2011;Foulds, Bredin & Warburton 2012a;Galloway et al. 2011;Garriguet 2008;Gittelsohn et al. 1996;Ho et al. 2008;Hopping et al.

2010a;Katzmarzyk & Malina 1998;Kuhnlein et al. 2004;Liu et al. 2006a;Liu et al. 2010;McDonald & Trenholm 2010;Ng, Corey & Young 2011;Oster & Toth 2009a;Sarkar et al. 2010;Thouez et al. 1990;Tremblay et al. 2005;Young et al. 2007;Zienczuk & Egeland 2012) among adults were included in the meta-analyses. Of the 15 studies with non-adult participants, 13 had First Nations participants(Bernard et al. 1995;Downs et al. 2009;Hanley et al. 2000;Katzmarzyk & Malina 1998;Khalil, Johnson-Down & Egeland 2010;Kuperberg & Evers 2006;Mendelson et al. 2011;Ng, Marshall & Willows 2006;Tomlin et al. 2012;Wahi et al. 2009;Willows, Johnson & Ball 2007;Young et al. 2000;Zorzi et al. 2009), one had Inuit participants (Galloway et al. 2012), and one did not subgroup their data and considered their participants to be Aboriginal (Katzmarzyk 2008). There were no studies with non-adult Métis participants. Amongst studies with adult participants, 11 studies had First Nations participants (Bruce et al. 2010;Elias et al. 2011;Foulds, Bredin & Warburton 2011;Gittelsohn et al. 1996;Ho et al. 2008;Katzmarzyk & Malina 1998;Kuhnlein et al. 2004;Liu et al. 2006a;McDonald & Trenholm 2010;Oster & Toth 2009a;Thouez et al. 1990), 11 had Inuit participants (Charbonneau-Roberts, Young & Egeland 2007;Chateau-Degat et al. 2011;Egeland, Cao & Young 2011;Galloway et al. 2011;Kuhnlein et al. 2004;Liu et al. 2006a;McDonald & Trenholm 2010;Thouez et al. 1990;Young et al. 2007;Zienczuk & Egeland 2012), two had Métis participants (McDonald & Trenholm 2010;Oster & Toth 2009a), and eight studies had Aboriginal participants (unspecified) (Anand et al. 2001;Foulds, Bredin & Warburton 2012a;Galloway et al. 2011;Liu et al. 2010;Ng, Corey & Young 2011;Sarkar et al. 2010;Tremblay et al. 2005). Studies were also sub-grouped by data collection period. Before 2000, there were four studies with non-adult participants (Bernard et al. 1995;Hanley et al.

2000;Katzmarzyk & Malina 1998;Young et al. 2000) and 10 studies with adult participants (Anand et al. 2001;Gittelsohn et al. 1996;Katzmarzyk & Malina 1998;Kuhnlein et al. 2004;Liu et al. 2006a;Thouez et al. 1990;Young et al. 2007). From 2000 to 2005, there were six studies with non-adult participants (Downs et al. 2009;Katzmarzyk 2008;Kuperberg & Evers 2006;Mendelson et al. 2011;Ng, Marshall & Willows 2006;Willows, Johnson & Ball 2007) and 13 studies with adult participants (Bruce et al. 2010;Charbonneau-Roberts, Young & Egeland 2007;Chateau-Degat et al. 2011;Elias et al. 2011;Garriguet 2008;Ho et al. 2008;Hopping et al. 2010a;Liu et al. 2010;McDonald & Trenholm 2010;Ng, Corey & Young 2011;Tremblay et al. 2005). After 2005, there were five studies with non-adult participants (Galloway et al. 2012;Khalil, Johnson-Down & Egeland 2010;Tomlin et al. 2012;Wahi et al. 2009;Zorzi et al. 2009) and nine studies with adult participants (Egeland, Cao & Young 2011;Foulds, Bredin & Warburton 2011;Foulds, Bredin & Warburton 2012a;Galloway et al. 2011;Hopping et al. 2010a;Oster & Toth 2009a;Sarkar et al. 2010;Zienczuk & Egeland 2012). The total sample size in the studies ranged from 45 to 13,048 individuals.

Overweight and obesity among non-adults

Among individuals less than eighteen 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). 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).

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 Aboriginal 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 Aboriginal 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 & 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 (Foulds, Bredin & Warburton 2011;Galloway et al. 2012;Khalil, Johnson-Down & Egeland 2010;Ng, Corey & Young 2011;Wahi et al. 2009;Zienczuk & Egeland 2012;Zorzi et al. 2009) 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 (Downs et al. 2009;Galloway et al. 2012;Katzmarzyk 2008;Ng, Marshall & Willows 2006;Willows, Johnson & Ball 2007) 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 non-adults, the pooled BMI was 21.1 kg/m^2 (95% CI: 19.4-22.92) and were similar among the different Aboriginal groups. Inuit peoples had the lowest pooled mean BMI of 18.4 kg/m^2 (95% CI: 18.2-18.6). First Nations individuals had a pooled mean BMI of 21.9 kg/m^2 (95% CI: 20.3-23.5). For studies that did not subgroup their analysis and instead used "Aboriginal," the pooled mean BMI was 21.0 kg/m^2 (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: 32.9-40.2), respectively. 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 "Aboriginal

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/m^2 (95% CI: 28.2-29.9). Among the three Aboriginal groups, BMI values were similar. First Nations individuals had the highest BMI of 29.6 kg/m^2 (95% CI: 27.7-31.5). While, Inuit peoples had the lowest pooled mean BMI of 27.8 kg/m^2 (95% CI: 27.1-28.6). For studies that simply used "Aboriginal people," the pooled mean BMI was 30.7 kg/m^2 (95% CI: 29.8-31.5). Data on BMI was not given for studies that had Métis participants (McDonald & Trenholm 2010;Oster & Toth 2009b) (Table 4).

Discussion

This systematic review looked at the prevalence of overweight and obesity among Aboriginal populations in Canada. Overall, the prevalence of overweight and obesity increased over time among non-adults and adults. Of the three ethnic groups, adult Métis had the highest prevalence of both overweight and obesity. Among non-adults, 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 non-adults and prevalence of obesity among adults. The data for non-adult Inuit participants were however, limited to a single study and there were no studies with non-adult Métis participants. Our meta-regression analysis among non-adults 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 & 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 & Specter 2004; Hopping et al. 2010b). Food insecurity has been observed in Aboriginal communities, in the context of obtaining traditional and market foods (Power 2008). Although low socioeconomic status has been positively associated with obesity, Aboriginal peoples of both low and high socioeconomic status experience a high prevalence of obesity (Ng, Corey & Young 2011). A study conducted in an Aboriginal 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 (Che & Chen 2001;El Hayek, Egeland & Weiler 2010;Moffatt 1995).

Though Aboriginal peoples continue to pass down knowledge of traditional lifestyle methods and diet, dietary transitions have resulted in higher consumptions of non-nutrient 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 higher prevalence of chronic disease (Kuhnlein et al. 2004;Young & 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 (Inuit Tapiriit Kanatami 2008;Northwest Territories Health and Social Services 2005), and 58% of the population residing in the Northwest Territories are overweight or obese, compared to 52% of the non-Aboriginal

population (Statistics Canada 2013). In southern Canada, Aboriginal populations had a higher prevalence of certain chronic diseases often seen as complications of obesity, such as diabetes (Bruce et al. 2010;Foulds, Bredin & Warburton 2012b).

Physical activity is a key modifiable factor for preventing obesity. Historically, Aboriginal peoples had higher levels of physical activity than non-Aboriginal peoples (Katzmarzyk 2008;Levesque, Cargo & Salsberg 2004;Liu et al. 2006b;Ng, Young & Corey 2010;Shields 2006). However, physical activity levels are decreasing in Aboriginal communities, especially rural, on-reserve and northern communities (Foulds, Bredin & Warburton 2012a), due to lower engagement in traditional activities, such as hunting (Curtis, Kvernmo & Bjerregaard 2005), and increased television and computer use (Steffen et al. 2009). Lower physical activity levels were found to be more prevalent amongst those living in rural areas, on reserve and in the north, suggesting the importance of emphasizing physical activity promotion in those areas (Foulds, Bredin & Warburton 2012a). In one study, half the Aboriginal children sampled watched greater than 15 hours of television weekly - a sedentary activity linked with obesity. The percentage of Aboriginal children in the study viewing a high amount of television was approximately twice that of non-Aboriginals (Ng, Young & Corey 2010;Steffen et al. 2009).

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 Aboriginal school in British Columbia addressed aspects, such as family and community environment (Naylor et al. 2010). Household-based lifestyle interventions among Aboriginal families were successful at reducing energy intake and increasing physical activity (Anand et al. 2007).

Given the diversity in values and traditional practices among Aboriginal communities, a successful obesity intervention for Aboriginal peoples could use a community-wide approach developed in partnership with elders and community members**.** The diversity of Aboriginal 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 (O'Sullivan 2013;Pigford et al. 2012;Purden 2005). Current health trends and healthcare costs resulting from obesity in Aboriginal 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 non-adult 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 non-adult participants. Overall, BMI has been found to be generally similar between girls and boys up to age 13, however, after that age Aboriginal 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 Aboriginal populations. Current health trends and healthcare costs resulting from obesity in Aboriginal 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 Aboriginal 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 Aboriginal populations.

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Conflicts of Interest

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

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Table 1: General characteristics of the studies included in the pooled estimates of the prevalence of overweight and obesity among Aboriginal 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
Aboriginal[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 et al.1998	1996	ON	NHANES[c]	5-19	38	21	17	-	-	-	28.9	28.6	29.4
Hanley et al. 2000	1993-5	ON	NHANES[c]	2-19	445	202	243	30.9	27.7	33.7	-	-	-
Kuperberg et al. 2006	2003-4	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	2003-4	MB	CDC	≥7	60	-	-	46.7	-	-	20.0	-	-
Tomlin et al. 2012	2007-8	Rural BC	CDC	8.7-18.5	133	70	63	20.0	-	-	30.0	-	-
Foulds et al. 2012a	2007-11	BC	BMI = 30	>16	882	219	663	30.9	35.2	26.8	48.9	47.5	50.2

Inuit															
Gallowa y et al. 2012	2007-8	QC	CDC	3-5	463	199	177		28.5	20.9	32.7		41.3	57.1	45.2
			IOTF						42.6	-	-		24.2	-	-
Cree[d]															
Bernard et al. 1995	1992	QC	CDC	9-18	144	-	-		-	-	-		17.0	-	-
Young et al. 2000	1996-7	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	1044	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	2004-5	QC	IOTF	9-12	203	-	-		29.9	-	-		34.3	-	-
Khalil et al. 2010	2005-7	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

[a]Aboriginal encompasses First Nations, Métis and Inuit.

[b]10 provinces refers to Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan

[c]NHANES III was used

[d]Cree 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 Aboriginal peoples in Canada

Author	Year of Study	Location	Age (y)	Sample Size			Overweight (%)			Obesity (%)		
				Total	Male	Female	Total	Male	Female	Total	Male	Female
Aboriginal[a]												
Anand et al. 2001	1996-2000	ON	>20	301	123	178	-	-	-	58.5	62.0	56.0
Tremblay et al. 2005	2000-1;2003	Canada[b]	20-64	4720	-	-	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	2000-1	YT, NT, NU	>20	866	-	-	28.6	-	-	20.2	-	-
Sarkar et al. 2010	2005-6	YT, NT, NU	>20	810	-	-	26.2	-	-	25.4	-	-
Liu et al. 2010	2000, 2003, 2005	NU, NT, NL, SK, MB, QC[f]	>18	13048	5778	7270	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 et al.1998	1996	ON	20-75	80	35	45	-	-	-	46.8	43.7	49.2
Kuhnlein et al. 2004	1994-8	YT	>20	375	177	198	-	-	-	13.6	9.7	17.0
Ho et al. 2008	2003-4	QC	>18	133	-	-	32.6	-	-	47.7	-	-
Oster et al. 2009a	2003-7	AB	>18	1790	-	-	29.4	-	-	55.0	-	-
Bruce et al. 2010	2003	MB	>18	483	230	253	27.4	-	-	56.4	50.0	65.0
McDonald et al. 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 et al. 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 et al. 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 et al. 2009a	2003-7	AB	>18	867	-	-		33.2	-	-		49.3	-	-
McDonald et al. 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

[a]Aboriginal encompasses First Nations, Métis and Inuit.

[b]Off- reserve

[c]10 provinces refers to Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan

[d]This is the only study that used the NHANES (National Health and Nutrition Examination Survey) III definition for obesity categories

[f]Except Nunavik & Jame'sie

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

	Pooled estimate		P for heterogeneity(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)**		**3967 (13)**		**21.1 (19.4-22.9)**		**1798 (7)**
By gender									
Boys	24.7 (19.0-30.5)		< 0.001 (92.2)		1646 (8)		-		-
Girls	27.6 (22.6-32.7)		< 0.001 (88.4)		1656 (8)		-		-
By overweight definition									
CDC	28.7 (23.2-34.2)		**< 0.001 (84.0)**		2293 (8)		18.4 (18.2-18.6)[a]		463 (1)
IOTF	31.2 (23.3-39.2)		< 0.001 (92.9)		2395 (5)		21.4 (19.0-23.9)		1315 (5)
NHANES	28.0 (22.4-33.5)[a]		-		1164 (2)		20.5 (19.4-21.5)[a]		483 (2)
By ethnic group[b]									
Aboriginal	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)		3135 (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)		-		1164 (2)		20.5 (19.4-21.5)[a]		483 (2)
2000-2005	30.2 (24.0-36.4)		<0.001 (84.5)		1860 (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)**		**3477 (12)**		**21.1 (19.4-22.9)**		**1798 (7)**
By gender									
Boys	25.1 (13.8-36.4)		< 0.001 (97.6)		1476 (8)		-		-
Girls	28.6 (20.3-36.9)		< 0.001 (94.6)		1438 (8)		-		-
By obesity definition									
CDC	30.4 (21.9-38.8)		< 0.001 (92.7)		2066 (7)		18.4 (18.2-18.6)[a]		463 (1)
IOTF	25.4 (19.3-31.2)		< 0.001 (88.5)		2161 (5)		21.4 (19.0-23.9)		1315 (5)
NHANES	36.0 (32.6-39.4)[a]		-		757 (2)		20.5 (19.4-21.5)[a]		483 (2)
By ethnic group[b]									
Aboriginal	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)		2645 (10)		21.9 (20.3-23.5)		768 (4)
Inuit	24.2 (20.3-		-		463 (1)		18.4 (18.2-		463 (1)

	37.7)[a]						18.6)[a]		
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)		1758 (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

[a]In 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.

[b]Cree participants were grouped with First Nations participants for analyses.

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

	Pooled estimate	P for heterogeneity (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)**	**39479 (22)**	**29.0 (28.2-29.9)**	**12189 (13)**
Male	34.6 (32.2-37.1)	< 0.001 (94.3)	13686 (15)	-	-
Female	26.6 (24.5-28.7)	< 0.001 (93.3)	19980 (15)	-	-
By ethnic group[a]					
Aboriginal	29.8 (26.7-32.9)	< 0.001 (93.3)	21522 (7)	30.7 (29.8-31.5)	1517 (3)
First Nations	29.7 (26.0-33.4)	< 0.001 (88.8)	7089 (7)	29.6 (27.7-31.5)	3809 (4)
Inuit	28.7 (27.3-30.2)	0.022 (59.4)	9867 (7)	27.8 (27.1-28.6)	6863 (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)	2855 (4)	28.2 (26.9-29.5)	2579 (5)
2000-2005	30.8 (27.7-33.9)	< 0.001 (94.5)	23943 (9)	28.5 (26.0-31.1)[b]	1204 (2)
After 2005	29.0 (27.9-30.1)	0.075 (43.9)	12681 (9)	29.8 (28.7-31.0)	8409 (6)
Obesity					
Overall	**36.6 (32.9-40.2)**	**< 0.001 (98.8)**	**56920 (32)**	**29.0 (28.2-29.9)**	**12189 (13)**

Male	31.6 (26.9-36.2)		< 0.001 (98.5)		9467 (21)		-		-
Female	40.6 (35.6-45.7)		< 0.001 (98.5)		14232 (21)		-		-
By ethnic group[a]									
Aboriginal	35.2 (29.3-41.0)		< 0.001 (98.4)		21522 (8)		30.7 (29.8-31.5)		1517 (3)
First Nations	40.9 (34.9-46.9)		< 0.001 (98.0)		14926 (11)		29.6 (27.7-31.5)		3809 (4)
Inuit	32.3 (25.5-39.1)		< 0.001 (98.8)		14886 (11)		27.8 (27.1-28.6)		6863 (6)
Métis	41.7 (27.0-56.4)[c]		-		5586 (2)		-		-
By study year									
Before 2000	30.6 (22.4-38.8)		< 0.001 (98.4)		6394 (10)		28.2 (26.9-29.5)		2579 (5)
2000-2005	37.4 (32.5-42.3)		< 0.001 (98.9)		38280 (13)		28.5 (26.0-31.1)[b]		1204 (2)
After 2005	41.9 (35.7-48.0)		< 0.001 (98.0)		12246 (9)		29.8 (28.7-31.0)		8409 (6)

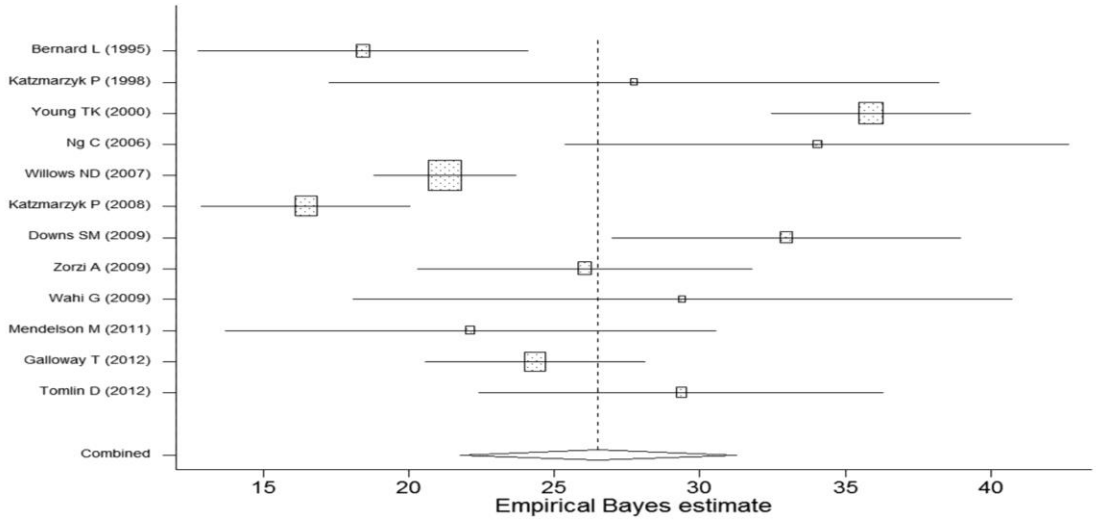
BMI, body mass index; CI, confidence interval

[a]Cree participants were grouped with First Nations participants for analysis

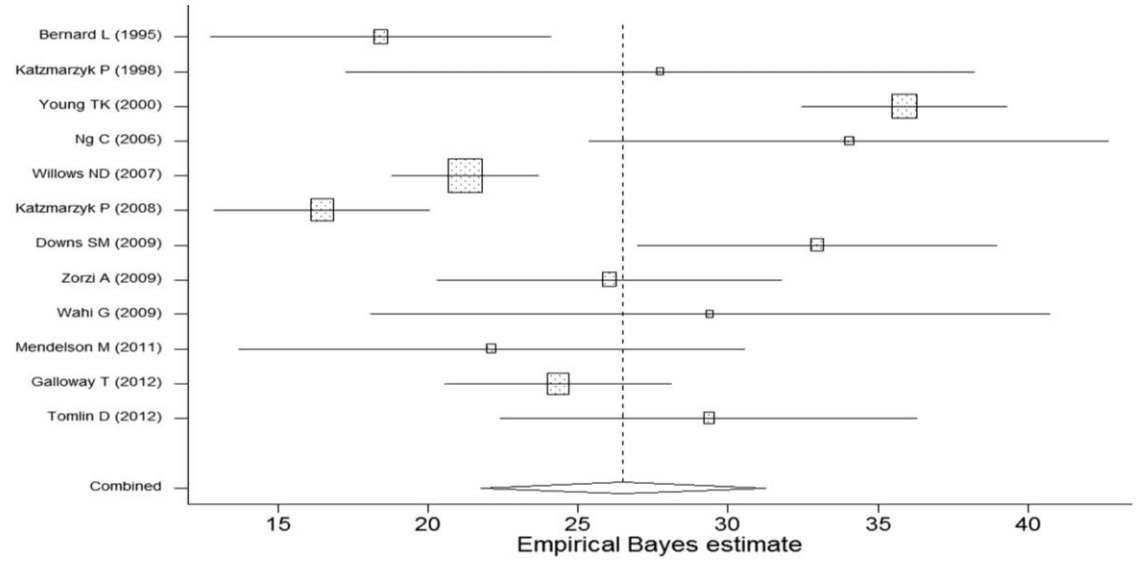
[b]In cases with one study in a category, meta-analysis was not performed; weighted pooled analysis was performed when in a category only two studies were available.

[c]Fixed effects model were used.

a) Overweight

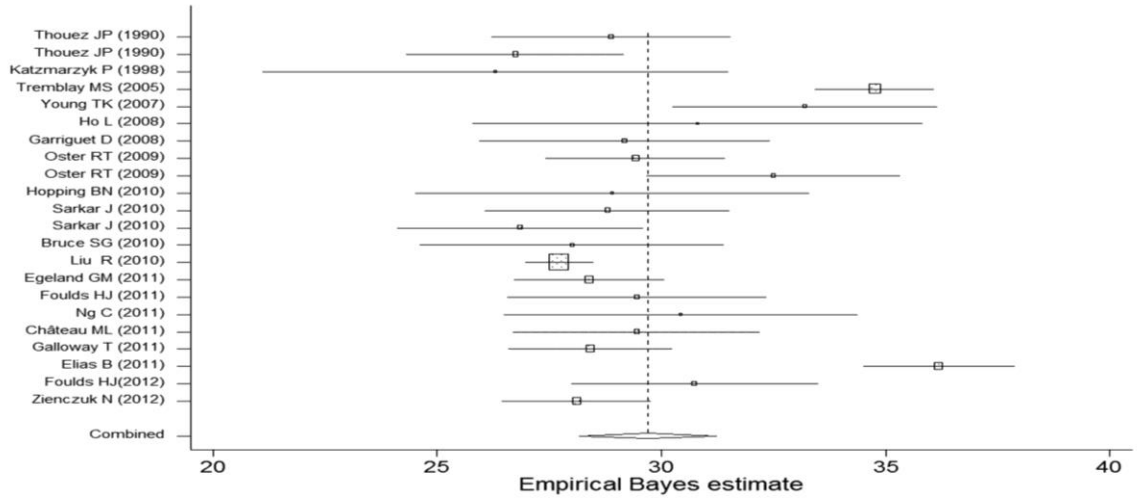


b) Obesity



Fgure 1. Forest plots of the prevalence of (a) overweight and (b) obesity among Aboriginal children and adolescent individuals (First Nations, Inuit and Métis).

a) Overweight



b) Obesity

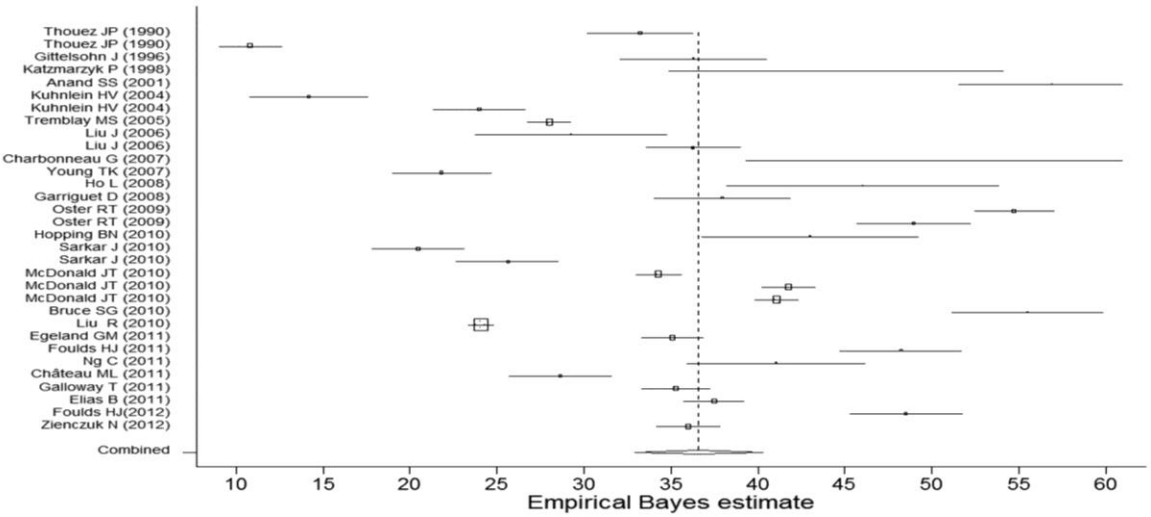


Figure 2. Forest plots of the prevalence estimates of (a) overweight and (b) obesity among adult Aboriginal participants (First Nations, Inuit and Métis).