Obesity among off-reserve First Nations, Métis, and Inuit peoples in Canada’s provinces: associated factors and secular trends

by

Carmina Ng

A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
Institute of Medical Science
University of Toronto

© Copyright by Carmina Ng 2012
Obesity among off-reserve First Nations, Métis, and Inuit peoples in Canada’s provinces: associated factors and secular trends

Carmina Ng

Doctor of Philosophy

Institute of Medical Science
University of Toronto

2012

Abstract

Aboriginal Canadians (First Nations, Métis, and Inuit) have the highest prevalence of overweight and obesity compared to other ethnic groups in Canada. In order to assess the evolution of the problem over time and to understand potential risk factors, three studies were conducted using nationally-representative survey data. Direct comparisons between Aboriginal and non-Aboriginal Canadians from the same surveys provide important perspectives on the magnitude of health disparities that cannot be obtained by small regional studies that dominate the current available literature. Body mass index (BMI) trajectories from 1994 to 2009 were estimated for Aboriginal and non-Aboriginal Canadians. Aboriginal Canadians experienced higher rates of BMI increase over the 14-year period between 1994 and 2009. Rate of BMI increase was specifically higher for Aboriginal adults born in the 1960s and 1970s when compared with non-Aboriginal adults, and later-born cohorts had consistently higher BMI compared with earlier-born cohorts. The role of potentially modifiable lifestyle factors in obesity among Aboriginal and non-Aboriginal youth was also investigated. Compared to non-Aboriginal youth, consumption of fruits/vegetables and dairy products was lower, and more Aboriginal youth were
"high" TV watchers. Physical activity participation did not differ between "high" and "low" TV watchers for both groups, and was associated with lowered odds for obesity only among Aboriginal youth. The complex relationship between obesity and socioeconomic status for Aboriginal and non-Aboriginal Canadians was explored. Employment status was strongly and negatively associated with obesity among Aboriginal men and women. Aboriginal men of high socioeconomic status (SES) were most likely to be obese, whereas Aboriginal women of high SES were least likely to be obese. Important descriptive and analytical information on an emerging and serious public health issue among Aboriginal people in Canada can inform the design and planning of intervention programs and development of public health strategies targeted at obesity.
Acknowledgments

I thank my supervisor, Prof. Kue Young, and my program advisory committee members Prof. Paul Corey and Prof. Valerie Tarasuk for their mentorship. They provided continuous encouragement and advice even when none was deserved.

I also thank staff and colleagues at the Toronto Region Statistics Canada Research Data Centre.

I gratefully acknowledge funding for this thesis from an Indigenous Health Research Development Program Graduate Scholarship, a Canadian Institutes of Health Research – Institute of Population and Public Health Doctoral Research Award, and a Canadian Diabetes Association Doctoral Student Research Award.
List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACSM</td>
<td>American College of Sports Medicine</td>
</tr>
<tr>
<td>AMPM</td>
<td>Automated Multiple-Pass Method</td>
</tr>
<tr>
<td>BIA</td>
<td>bioelectrical impedance analysis</td>
</tr>
<tr>
<td>BMI</td>
<td>body mass index</td>
</tr>
<tr>
<td>BNS</td>
<td>Bureau of Nutritional Sciences</td>
</tr>
<tr>
<td>CCHS</td>
<td>Canadian Community Health Survey</td>
</tr>
<tr>
<td>CF</td>
<td>cardiorespiratory fitness</td>
</tr>
<tr>
<td>CHMS</td>
<td>Canadian Health Measures Survey</td>
</tr>
<tr>
<td>EE</td>
<td>energy expenditure</td>
</tr>
<tr>
<td>HDL</td>
<td>high-density lipoprotein</td>
</tr>
<tr>
<td>IMR</td>
<td>infant mortality rate</td>
</tr>
<tr>
<td>IOTF</td>
<td>International Obesity Task Force</td>
</tr>
<tr>
<td>KKD</td>
<td>kcal/kg/day</td>
</tr>
<tr>
<td>LFS</td>
<td>Labour Force Survey</td>
</tr>
<tr>
<td>MET</td>
<td>metabolic equivalent</td>
</tr>
<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
</tr>
<tr>
<td>NIH</td>
<td>National Institutes of Health</td>
</tr>
<tr>
<td>NHANES</td>
<td>National Health and Nutrition Examination Survey</td>
</tr>
<tr>
<td>NLSCY</td>
<td>National Longitudinal Survey of Children and Youth</td>
</tr>
<tr>
<td>NSS</td>
<td>Nutrition Survey System</td>
</tr>
<tr>
<td>OLS</td>
<td>ordinary least squares</td>
</tr>
<tr>
<td>PSU</td>
<td>primary sampling unit</td>
</tr>
<tr>
<td>SES</td>
<td>socioeconomic status</td>
</tr>
<tr>
<td>TV</td>
<td>television</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
</tr>
<tr>
<td>WC</td>
<td>waist circumference</td>
</tr>
<tr>
<td>WHR</td>
<td>waist-to-hip ratio</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>YOB</td>
<td>year of birth</td>
</tr>
</tbody>
</table>
List of Figures

Chapter 4
Figure 1. Predicted BMI trajectories by year, Aboriginal identity and birth cohort.
Figure 2. Predicted BMI trajectories 1994-2009 by age, Aboriginal identity and birth cohort.

Chapter 6
Figure 1. Probability for obesity among Aboriginal and non-Aboriginal Canadian adults aged 25-64 years from CCHS 2.2 (2004) by household income and education level
List of Tables

Chapter 4
Table 1. Sample sizes and mean age, follow-up time, and number of observations of each birth cohort, by Aboriginal identity.
Table 2a. Individual growth curve modeling results for respondents with 2 or more BMI observations. Correlations between predicted values from PROC MIXED and actual observed.
Table 2b. Individual growth curve modeling results for respondents with 4 or more BMI observations. Correlations between predicted values from PROC MIXED and actual observed.
Table 3a. Mean individual slopes calculated with PROC SURVEYMEANS for respondents with 2 or more BMI observations. T-test p-value for difference between Aboriginal and non-Aboriginal groups.
Table 3b. Mean individual slopes calculated with PROC SURVEYMEANS for respondents with 4 or more BMI observations. T-test p-value for difference between Aboriginal and non-Aboriginal groups.

Chapter 5
Table 1. Socio-demographic and lifestyle characteristics of Canadian youth aged 12 to 17 years by Aboriginal identity.
Table 2. Logistic regression analysis of the associations between socio-demographic and lifestyle factors and prevalence of obesity among Canadian youth aged 12 to 17 years, odds ratios (OR) and 95% confidence intervals.
Table 3. Mean daily dietary intakes of nutrients and foods by TV watching level – Aboriginal Canadian youth aged 12 to 17 years.
Table 4. Mean daily dietary intakes of nutrients and foods by TV watching level – Non-Aboriginal Canadian youth aged 12 to 17 years.

Chapter 6
Table 1. Descriptive characteristics of sample aged 25 to 64 years, by Aboriginal identity and sex, from CCHS 2.2 (2004).
Table 2. Multivariate logistic regression estimates predicting obesity from sociodemographic, SES, and lifestyle factors by Aboriginal identity and sex.
Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for obesity for age, physical activity level, fruit and vegetable consumption, marital, smoking, and employment status - adjusted for education level and household income level, by Aboriginal identity and sex.
TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION ................................................................................................. 1
  1.1 RATIONALE .............................................................................................................. 1
  1.2 OBJECTIVES .......................................................................................................... 1
  1.3 ORGANIZATION OF THESIS ................................................................................ 2

CHAPTER 2 BACKGROUND ............................................................................................... 3
  2.1 THE HEALTH OF CANADIAN ABORIGINAL PEOPLES ............................................. 3
  2.2 MEASURING OBESITY IN POPULATIONS ............................................................... 6
  2.3 PREVALENCE OF OBESITY IN CANADA .............................................................. 12
  2.4 HEALTH CONSEQUENCES OF OBESITY ............................................................... 18
  2.5 LIFESTYLE DETERMINANTS OF OBESITY .......................................................... 23
  2.6 SOCIAL DETERMINANTS OF OBESITY ................................................................. 35
  2.7 POPULATION INTERVENTIONS FOR OBESITY ..................................................... 40
  2.8 SUMMARY ............................................................................................................. 50

CHAPTER 3 METHODS ...................................................................................................... 53
  3.1 STATISTICS CANADA SURVEY DATASETS ......................................................... 54
  3.2 DEFINITION OF THE ABORIGINAL POPULATION ................................................. 59
  3.3 STATISTICAL ANALYSES ...................................................................................... 63

CHAPTER 4 TRAJECTORIES OF BODY MASS INDEX IN THE ABORIGINAL POPULATION, 1994-2009 ...................................................................................................................... 70

CHAPTER 5 LIFESTYLE FACTORS ASSOCIATED WITH OBESITY IN ABORIGINAL YOUTH ................................................................................................................................. 95

CHAPTER 6 SOCIOECONOMIC CORRELATES OF OBESITY IN THE ABORIGINAL POPULATION .......................................................................................................................... 115

CHAPTER 7 DISCUSSION AND CONCLUSIONS ............................................................. 138
  7.1 SUMMARY AND SYNTHESIS ................................................................................. 139
  7.2 STUDY LIMITATIONS ............................................................................................ 143
  7.3 FUTURE RESEARCH .............................................................................................. 146
  7.4 PUBLIC HEALTH IMPLICATIONS .......................................................................... 148
  7.5 CONCLUSIONS ....................................................................................................... 151

REFERENCES .................................................................................................................... 153
Chapter 1 Introduction

1.1 Rationale

While substantial improvement in the health status of Aboriginal people in Canada has occurred over the past several decades, significant disparities still persist when compared to Canadians nationally. The Aboriginal population is undergoing a health transition characterized by the decline of infectious diseases and the rise of chronic diseases such as diabetes and cardiovascular disease. Of particular concern is the increasing prevalence of obesity among Aboriginal people, far in excess of that among other Canadians nationally. Obesity is recognized as a major risk factor for chronic diseases, and its control can be key to averting an emerging chronic disease pandemic among Aboriginal people. Research into the burden, determinants and control of obesity in the Aboriginal population may provide the evidence needed to design intervention programs and develop public health strategies.

A substantial body of literature already exists on obesity among Aboriginal people, but some gaps still exist. This dissertation comprises three studies which fill some of these gaps and contribute new knowledge.

1.2 Objectives

There are three main objectives of this dissertation, closely aligned with the three studies:
(1) To describe temporal trends and patterns in body weight gain in the Aboriginal population compared to non-Aboriginal Canadians, specifically to identify when peak body weight occurs, the duration of excess body weight, and explore the age, period, and cohort effects on body weight change over a 14-year period;

(2) To determine the association of modifiable lifestyle factors with obesity among Aboriginal and non-Aboriginal youth aged 12-17 years, specifically on diet, physical activity and TV viewing time;

(3) To examine the socioeconomic correlates of obesity among Aboriginal and non-Aboriginal Canadians.

1.3 Organization of Thesis

This thesis consists of three free-standing manuscripts submitted for publication in scientific journals with integrating and linking chapters. Chapter Two provides the literature review relevant to the stated objectives. The literature on Aboriginal health and on the epidemiology and biology of obesity is voluminous, and these will not be comprehensively and exhaustively reviewed. The topics selected for review provide the evidence for why these particular three studies are needed and what gaps in existing knowledge they fill. Chapter Three discusses the methods used in the three studies, which are all secondary analyses of Statistics Canada national health surveys. The complexity of defining the Aboriginal population in Canada is discussed in some detail and the choice of the off-reserve population is explained. Chapters Four to Six are the manuscripts of the three papers. The final chapter provides a synthesis of the three
studies, discussion of their limitations and public health implications, and suggestions for further research.

Chapter 2  

Background

2.1 The Health of Canadian Aboriginal Peoples

The Constitution Act of 1982 defines Aboriginal peoples of Canada as comprising North American Indians or First Nations, Inuit, and Métis people. According to the 2006 Census (Statistics Canada 2006a), over 1.6 million Canadians reported at least some Aboriginal ancestry, accounting for almost 5% of Canada’s total population. Just under three-quarters of the Aboriginal population is of First Nations ancestry, 22% of Métis ancestry, and 4% of Inuit ancestry. It should be recognized that the Aboriginal population is not a homogeneous group, as there is a diversity of cultural, linguistic, and tribal groups. Aboriginal people constitute 15% of the provincial population of Manitoba and Saskatchewan, 35% of Yukon, 50% of the Northwest Territories, and 85% of Nunavut. A slight majority of Aboriginal people (54%) live in urban areas.

The health of Aboriginal Canadians lags behind that of other Canadians. This is reflected in many health indicators, for example, life expectancy, infant mortality rate, and age-standardized mortality rates (Waldram, Herring et al. 2006; Wilkins, Uppal et al. 2008; Tjepkema, Wilkins et al. 2009). Canada’s Aboriginal population appears to be undergoing the final stage of an epidemiological or health transition first proposed by Omran in 1971. As the population exits from periods of “pestilence and famine” and
“receding pandemics” the incidence of “degenerative and man-made diseases” has begun to increase (Omran 1971).

The importance of chronic diseases in the Aboriginal population is evident from self-reported data in health surveys. Among the three most commonly reported chronic conditions, disproportionately high numbers of Aboriginal Canadians suffer from high blood pressure, arthritis, and diabetes compared to their non-Aboriginal counterparts and over 60% suffer from at least one of a long list of chronic conditions (Tjepkema 2002). Such chronic diseases contribute to higher mortality rates and lower life expectancies observed for Aboriginal Canadians. Leading causes of death among Aboriginal adults include diseases of the circulatory system and neoplasms (Trovato 2000). Notably, Aboriginal Canadians are two to three times more likely to die from endocrine system diseases, particularly, diabetes mellitus compared to non-Aboriginal Canadians (Tjepkema, Wilkins et al. 2009).

Much of the health disparities has been attributed to the relative socioeconomic disadvantage of Aboriginal peoples in Canada. To provide some perspective, average income for the population 15 years of age and older reporting some Aboriginal ancestry was $26,251 compared with $35,934 for the non-Aboriginal ancestry population in 2006 (Statistics Canada 2006a). Only 33% of the Aboriginal population (vs. 44% non-Aboriginal) had income of $30,000 or more.
In one study, the income gap between Aboriginal and non-Aboriginal populations in Canada was partly attributed to the lower educational attainment of Aboriginal Canadians (Wilson and Macdonald 2010). Although Aboriginal adults in general earn lower wages than other Canadians with the same levels of education, Aboriginal women who have obtained at least a Bachelor’s degree have higher median incomes than non-Aboriginal Canadian women with equivalent education. Unfortunately, very few pursue post-secondary education. In 2001 (Statistics Canada 2001), only 6% of the population with some Aboriginal ancestry held a university degree compared with 16% of the non-Aboriginal population. Somewhat encouragingly, the proportions for both groups have increased by 2% in the 2006 Census with the difference remaining at 10% (Statistics Canada 2006a). However, the education gap between those who have less than high school graduation level education has widened, from 10% in 2001 (42% among Aboriginal vs. 31% among non-Aboriginal people) to 15% in 2006, with 38% of Aboriginal Canadians not having graduated from high school compared with 23% in the non-Aboriginal population.

In summary, the Aboriginal population constitutes a sizable minority in Canada. It is undergoing a health transition characterized by the decline of infectious diseases and the rise of chronic diseases such as diabetes and cardiovascular disease. Relative socioeconomic disadvantage of Aboriginal people exacerbates the observed health disparities compared to the Canadian population nationally.


2.2 Measuring Obesity in Populations

Obesity is the excess of body fat or adipose tissue. Since body composition cannot be directly measured, several techniques have been developed to estimate relative percentages of body weight that is body fat and fat-free mass. The general standard for assessing body composition is hydrostatic or underwater weighing (American College of Sports Medicine 2000). However, this method requires a trained technician and costly equipment; therefore, it is impractical for assessing body composition in large populations. Consequently, many researchers employ anthropometric methods that are technically simple to use, inexpensive, and largely reproducible. These include height and weight, waist and hip circumferences, and skinfold measurements. Most anthropometric indices are validated against laboratory standards set by hydrostatic weighing. Since weight and height measurements are available in almost all population-based health-related data, the body mass index (BMI = weight in kg divided by height in m$^2$) has been adopted as the anthropometric classification system of choice.

The World Health Organization (WHO) and the International Obesity Task Force (IOTF) have adopted a six category classification system in which overweight and obesity are defined as BMI values $\geq 25$ kg/m$^2$ and $\geq 30$ kg/m$^2$, respectively (WHO 2000). Obese I, II, III categories delineate cut-points indicating severity of obesity. Prior to these standardized criteria, some studies conducted in 1999 or earlier defined obesity as a BMI of 27 kg/m$^2$ or higher, while others adopted the cutoff value of 29 kg/m$^2$ or greater. In Canada, guidelines for healthy weights have been updated to correspond with the WHO BMI-based cutoffs (Health Canada 2003) from those used in 1988 (Health and Welfare
Canada 1988) which adopted four categories for BMI: BMI < 20 = “may be associated with health problems for some people”; BMI 20-25 = “good weight for most people”; BMI 25-27 = “may lead to health problems in some people”; and BMI > 27 = “increasing risk of developing health problems” and one cutoff each for waist-to-hip ratio (WHR) for men and women: WHR > 1.0 for men and WHR > 0.8 for women = “may be associated with increasing health risks”.

Since the WHO published its obesity definition, most international researchers have adopted these standards for adults, but there is increasing support towards evaluating waist circumference or WHR measurements along with BMI in screening for health risks associated with overweight and obesity (Janssen, Katzmarzyk et al. 2002). In the United States, the National Institutes of Health (NIH) have published guidelines using both the six category BMI system and a sex-specific, two category waist circumference (WC) classification in which men with a WC > 102 cm and women with a WC > 88 cm are considered to be at increased health risk (National Institutes of Health 1998). However, since WC and WHR have not been routinely and consistently measured in national health surveys conducted in Canada, population trends of obesity can only be estimated using BMI-based standards.

Several limitations should be considered when using BMI as an indicator of fatness. BMI classifications have been criticized as being arbitrary as obesity is a matter of degree and dichotomizing this condition into categories fails to capture the full range of variability (Marshall, Hazlett et al. 1991). As with many health measures, the point at
which body fat becomes definitively clinically hazardous is unknown and may vary between individuals and populations. Although height and weight can be measured very accurately, muscular persons with low percentages of body fat may be misclassified as overweight or obese. While it is unlikely that a very large proportion of the general population is highly muscular, the simplicity of the BMI method can be potentially misleading.

A universal BMI classification system cannot account for ethnic differences in body fat distribution. Ethnic differences in stature and fat distribution between Aboriginal and non-Aboriginal Canadians have been reported. Comparisons between a sample of Aboriginal adults and youth from Bear Island First Nation in Northern Ontario with a neighbouring population of predominantly European ancestry show that the Aboriginal group had greater subcutaneous adiposity and centralized distribution of body fat (Katzmarzyk and Malina 1998; Katzmarzyk and Malina 1999). Fat accumulation in the trunk area was also observed to be higher among a sample of urban First Nations women compared with their non-Aboriginal counterparts (Leslie, Weiler et al. 2007) and among a sample of Cree children aged 9 to 12 from two rural and remote communities in northern Québec (Ng, Marshall et al. 2006; Downs, Marshall et al. 2008). Summary results from the 1972 Nutrition Canada Survey (Nutrition Canada 1975; Nutrition Canada 1975) also support differential patterns of fat distribution between Aboriginal and non-Aboriginal Canadians, as indicated by differences in skinfold thicknesses and other anthropometric measurements. Despite efforts for standardization, it is important to
recognize that BMI-based obesity definitions are unable to distinguish body fat
distribution within or between populations.

It is possible that health risks attributable to overweight and obesity can be incorrectly
estimated depending on the cutoffs applied (Willows, Johnson et al. 2007). In addition,
prevalence figures can vary substantially between estimates made from different cutoffs
(Shields and Tremblay 2010). At least one study supports the use of BMI along with WC
thresholds currently available as proxy measures of percent body fat and central adiposity
(Lear, Humphries et al. 2007). No differential associations between the two
anthropometric measures and cardiovascular risk factors have been observed between
Aboriginal and non-Aboriginal groups, suggesting that Aboriginal-specific thresholds for
health risk are likely not necessary. Regardless of its limitations, BMI is a convenient,
non-intrusive measurement of obesity for large population studies. It is a ubiquitous
measure that readily allows for comparisons across populations.

In children, unlike adults, weight and height both increase as they grow; hence, there are
no fixed cutoff points for obesity and overweight. The IOTF has determined the
overweight and obese BMI percentiles for children that correspond to the adult BMI
cutoffs of 25 kg/m² and 30 kg/m² using data from Brazil, Great Britain, Hong Kong, the
Netherlands, Singapore, and the United States (Cole, Bellizzi et al. 2000). Each set of
data contained information for over 10,000 subjects, with ages ranging from 6 to 18
years. These definitions have since been adopted to provide internationally comparable
obesity prevalences. Although WC standards are available even for children (McCarthy,
Jarrett et al. 2001; Katzmarzyk 2004), many researchers continue to rely on BMI alone for categorization.

The use of anthropometric indicators to identify overweight and obesity in children has been criticized, but BMI has been found to be a valid and efficient screening tool since it appears to have high specificity, that is, it will identify few non-obese children as obese (Malina and Katzmarzyk 1999; Reilly, Dorosty et al. 2000). However, BMI may have low sensitivity and fail to identify some obese children leading to underestimates. In one study that reported the agreement among the most commonly used anthropometric indicators of obesity, BMI was found to be the least accurate method for youth aged 12 to 18 years when compared with WC, bioelectrical impedance analysis (BIA), and skinfold measurements (Himes 1999). BMI appeared to be in high agreement with percent body fat only in the upper quintiles, and all indicators yielded inconsistent patterns. This is considered to be a serious problem for epidemiological studies and clinical practice since obesity prevalence will be underestimated and individuals who may require treatment will not receive it.

The BMI-fatness relationship has also been examined in 12-week-old infants and children aged 8 to 12 years (Wells 2000). In infants, the correlation between BMI and percent body fat was 0.79 for males and 0.77 for females, significantly lower than the values of 0.94 and 0.95 reported previously in adult males and females, respectively. In children, the correlations for males and females were 0.89 and 0.76, respectively, also significantly lower than those reported among adults.
Ideally, the cutoffs chosen are derived by determining the thresholds for health risks. The BMI thresholds at which health risks begin to significantly increase is not known for children, thus those for adults are used. However, it is even more difficult to determine risk-related criteria in children and youth as they are less likely to exhibit as many risk factors as adults (Troiano and Flegal 1999). In addition, children and youth have less disease related to overweight and obesity than adults (Cole, Bellizzi et al. 2000). Therefore, most researchers attempt to validate the BMI cutoffs by comparing the specificity and sensitivity of BMI with other measures of adiposity such as hydrostatic weighing and BIA. For example, the optimum combination of sensitivity and specificity was at the 92\textsuperscript{nd} percentile among a cohort of children from the United Kingdom, although the one definition of obesity in children, BMI at or above the 95\textsuperscript{th} percentile, was found to have moderately high sensitivity and high specificity (Reilly, Dorosty et al. 2000).

Not surprisingly, there is high variability between populations (Cole, Bellizzi et al. 2000). For instance, a BMI of 25 kg/m\textsuperscript{2} corresponds to the 88th percentile for Hong Kong males while it corresponds to the 95\textsuperscript{th} percentile for Brazilian males. Similarly, a BMI of 25 kg/m\textsuperscript{2} corresponds to the 83\textsuperscript{rd} percentile for females from the United States while it corresponds to the 94\textsuperscript{th} percentile for Dutch females. Data corresponding to a BMI of 30 kg/m\textsuperscript{2} was no more consistent and in all analyses, data from Singapore was found to stand out with no obvious explanation. In addition, data from six other countries were excluded due to atypical data or small sample sizes. The results of this study highlight the need for further research into the development of more appropriate definitions that take gender as well as ethnicity into consideration.
In summary, despite some limitations, the BMI remains the most widely available indicator of obesity trends and patterns in populations. As it is available in Statistics Canada national health surveys, BMI will be used as a marker of obesity in all three papers of this thesis.

2.3 Prevalence of Obesity in Canada

Obesity in the Canadian Population

In Canada, the prevalence of overweight and obesity has been rising dramatically in recent decades among individuals of all ages. (Note that in the prevalence figures cited, “overweight” includes “obese”). Based on data from several Canadian national surveys covering the period between 1981 and 1996 (Tremblay, Katzmarzyk et al. 2002), the prevalence of overweight increased from 48 to 57% among men and from 30 to 35% among women, while the prevalence of obesity increased from 9 to 14% in men and from 8 to 12% in women. Using the 1981 Canada Fitness Survey, the 1988 Campbell's Survey on the Well-being of Canadians and the 1996 National Longitudinal Survey of Children and Youth to describe overweight patterns among children aged 7 to 13 years (Tremblay and Willms 2000), the prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996, and among girls from 15 to 23.6%. The prevalence of obesity in children more than doubled over that period, from 5 to 13.5% for boys and 11.8% for girls. Revising the estimates using the current standardized definitions for overweight and obesity in children and youth (Cole, Bellizzi et al. 2000) with the same data, more marked increases in overweight were observed for children, from 11 and 13% in 1981 among boys and girls, respectively, to 33% (boys) and 27% (girls) in 1996. Obesity
among children has increased five-fold, from 2% to approximately 10% in both boys and girls (Tremblay, Katzmarzyk et al. 2002).

Measured height and weight data from the Nutrition Canada Survey (1970 – 1972), the Canada Health Survey (1978 – 1979), and the Canadian Heart Health Surveys (1986 – 1992) provide further evidence that prevalence of overweight and obesity among Canadians has increased steadily from 1970 to 1992. Among women, there was a substantial increase in the proportion of overweight and obese between the periods 1970 – 1972 and 1978 – 1979, then an increase in the proportion of obese, but not overweight, was observed between 1978 – 1979 and 1986 – 1992 (Torrance, Hooper et al. 2002). Although the prevalence of obesity increased in all education levels, the subgroups with the greatest relative increase were men in the primary education category, and women in the secondary and post-secondary categories between 1970 – 1972 and 1986 – 1992. An increase in the prevalence of obesity was greatest among current smokers and, to a lesser extent, among former smokers. More recently, measured height and weight data from the 2004 Canadian Community Health Survey (CCHS) cycle 2.2 with a focus on nutrition reveal that 23% of adults aged 18 years and over were obese (Tjepkema 2006), substantially higher than 14% of the population in the period 1978 – 1979. Among young Canadians aged 12 to 17 years, the prevalence of obesity has tripled over 25 years from 3% in 1979 to 9% in 2004, while prevalence of overweight has doubled from 14% to 29% over the same time period (Shields 2006).
According to the 1981 Canada Fitness Survey and the 1996 National Longitudinal Survey of Children and Youth, the prevalence of overweight and obesity among boys and girls aged 7 to 13 years has nearly tripled, from 11.4% in 1981 to 29.3% in 1996 (Willms, Tremblay et al. 2003). Regionally, in Manitoba, the prevalence of overweight was 18.2% in 1981 and increased to 24.6% in 1996. The odds of a child being overweight in 1996 was 1.47 times that in 1981 in Manitoba (lowest in the country), compared with 6.37 times for children living in British Columbia. Prince Edward Island and Newfoundland and Labrador have the highest prevalence of overweight children, at approximately 36%. Children living in the Atlantic provinces have a greater likelihood of becoming overweight compared with children living in the Prairies.

The pattern of weight change over time can be examined using longitudinal data from the National Population Health Survey (NPHS). Between 1996 and 2005, Canadian adults gained an average of 0.5 to 1 kg over each two-year interval (Orpana, Tremblay et al. 2007). Trends in weight gain were a dynamic process where some individuals lose weight during one interval but may then gain weight during the next. Longitudinal data from other studies suggest that adults tend to gain weight into middle age and then body weight begins to decline, but trends differ by race (Burke, Bild et al. 1996), gender (Chiriboga, Ma et al. 2008), and socioeconomic status (Ball, Crawford et al. 2005).

**Obesity in the Aboriginal Population**

Aboriginal Canadians have high prevalence of obesity. In regional studies conducted in the 1980s and 90s, patterns of obesity have been reported among the Mohawk population.
of Kahnawake in Québec (Montour, Macaulay et al. 1989), where obesity steadily increased up to age 65 for both men and women, with over 85% of men and almost all women being obese, before declining at older ages. The prevalence of obesity was 74% among residents with no diabetes, and even higher at 86% among those with diabetes. In the Sioux Lookout Zone located in northwestern Ontario (McIntyre and Shah 1986), where obesity was defined as BMI > 27 in males and BMI > 25 in females, over 70% of women aged 35 to 64 and 50% of males aged 35 to 44 were classified as obese. Among Cree and Ojibwa Indians in northwestern Ontario and northeastern Manitoba (Young and Sevenhuysen 1989), at ages 35 to 54, close to 90% of women had BMI > 26. Among men, obesity was highest among those aged 45 to 54 where over two-thirds had BMI > 26. In Sandy Lake, Ontario (Gittelsohn, Harris et al. 1996), approximately 80% of females had BMI > 27. Fewer males were considered obese, but still a high proportion at almost 70% for men in their 40s. After age 50, obesity prevalence declined, but not much decrease was observed at older ages for women. Among a sample of the population living in the Keewatin region in the Northwest Territories which was over 90% Inuit (Young, Moffatt et al. 1993), prevalence of obesity relative to the non-Aboriginal southern population in Manitoba was generally similar, except among females aged 45 to 64 among whom 69% were classified as BMI > 27 and 50% BMI > 30, twice the prevalence of Manitoban women. Comparing Inuit with Cree Indians of northern Québec aged 15 years and over (Ekoe, Thouez et al. 1990), the Cree population had higher average BMI and Cree females had higher BMI than Cree males, but no sex difference was apparent among Inuit (using an obesity definition of BMI > 25 in women
and BMI > 27 in men). Thus, it is evident that patterns of obesity can differ between Aboriginal groups and vary geographically.

Substantial differences in obesity rates may also exist between Aboriginal communities belonging to the same cultural group and located in close proximity. In a study of residents aged 30 to 64 from two large Algonquin communities in Québec located just 250 km apart (Delisle, Rivard et al. 1995), the larger community of River Desert, located adjacent to an urban centre, reported lower obesity and diabetes prevalence rates (29% and 16%, respectively) compared to the smaller, more remote community of Lac Simon, which experienced higher rates of obesity (52%) and diabetes (49%).

Direct comparison with a non-Aboriginal population in the same geographic region is available from a study of Bear Island First Nation in northern Ontario and a sample of individuals of European ancestry from nearby Temagami (Katzmarzyk and Malina 1998). Obesity, defined in adults as BMI >= 27.8 in males and BMI >= 27.3 in females, corresponding to 85th percentile of the National Health and Nutrition Examination Survey (NHANES) data from the United States, was present in 60% of Bear Island women, almost two times the prevalence of the Temagami sample. Half of men were obese, but this was not significantly different from those of European descent (38%).

In general, prevalence of obesity is slightly lower among youth compared to adults. Among children and adolescents aged 5 to 19 years from the same Bear Island population, one-third were obese in 1996 using the cutoff based on the 85th percentile of
the NHANES II data (Katzmarzyk and Malina 1998). Similar estimates were observed among children aged 6 to 11 years from a Mohawk community located near Montreal, Québec, where approximately 40% of girls and 30% of boys aged 6 to 11 years were obese in 1994 (Potvin, Desrosiers et al. 1999) and among children and adolescents aged 2 to 19 years from Sandy Lake where 34% of girls and 28% of boys had BMI exceeding the 85th percentile of NHANES III data (Hanley, Harris et al. 2000).

Prevalence of obesity determined using the IOTF cutoffs for youth is available for two Cree communities in northern Québec where 44% of children aged 9 to 12 years were obese in 2004 – 2005 (Downs, Marshall et al. 2008). In comparison with non-Aboriginal youth, the national prevalence of obesity among off-reserve Aboriginal youth aged 2 to 17 living in the ten provinces was estimated to be over two times higher (Aboriginal 20% vs. non-Aboriginal 8%) in 2004 (Shields 2006). Although different definitions of overweight and obesity have been used across studies over time, overweight and obesity is also clearly emerging as a significant problem among Aboriginal children and adolescents.

As one of the first major national health surveys in Canada, data from the Nutrition Canada Survey of 1972 allowed direct comparisons to be made between Aboriginal and non-Aboriginal populations. This survey specifically included 29 First Nations across the country and four Inuit communities in the then Northwest Territories. According to published tabulations of the survey (Nutrition Canada 1975), the overall sample of First Nations individuals of all age and sex groups were more overweight and obese compared
to other Canadians, based on the ponderal index then in use which is calculated as body weight in kg divided by height in metres cubed (kg/m$^3$). The prevalence of “high” or “moderate” risk based on the ponderal index was consistently higher among Canadian First Nations women compared to other Canadian women nationally. There is thus some evidence that marked disparities in obesity has been ongoing for at least 35 years.

According to CCHS Cycle 1.1 conducted in 2000 – 2001 using self-reported height and weight information, 25% of the off-reserve Aboriginal population were obese compared with 14% of the non-Aboriginal sample (Tjepkema 2002). In 2004, while prevalence of obesity in both groups increased, the difference between groups appears to have increased as well, with 38% of Aboriginal adults being obese compared to 23% among non-Aboriginal adults (Tjepkema 2006).

In summary, a vast amount of survey data has been accumulated to indicate that obesity has become an increasingly significant national public health issue in Canada. Of particular concern is the even worse situation among Aboriginal people, with prevalence far in excess of Canadians nationally. To examine patterns over time, it is important to track longitudinally changes in BMI change to supplement available cross-sectional observations that prevalence of obesity has been increasing over the past few decades.

2.4 Health Consequences of Obesity

Obesity is intricately linked to the development of diabetes. Obesity has been estimated to account for about 80 to 90% of all type 2 diabetes, leading to the suggestion that type 2 diabetes should be renamed “diabesity” or “obesity dependent diabetes mellitus” (Astrup
and Finer 2000). It is well established that obesity is also associated with hypertension, hyperlipidemia, cardiovascular disease (CVD), as well as increased risk of other morbidities and mortality (Pi-Sunyer 1993). In addition, multiple metabolic disorders often cluster within the same individual and the number of morbidities is positively related to the degree of overweight or obesity (Must, Spadano et al. 1999). Obesity reduces life expectancy and quality of life markedly (Fontaine and Barofsky 2001) and increased all-cause mortality and specifically from ischaemic heart disease, stroke, diabetes, some cancers, respiratory, kidney, and liver disease (Teucher, Rohrmann et al. 2010). Obesity can also cause hormonal abnormalities that can lead to decreased fertility and disrupt metabolic processes (Bjorntorp 1997; Haffner et al. 1993; Kahn et al. 2006). Along with physical illness, overweight and obese persons may experience psychological distress (Friedman, Reichmann et al. 2002) and suffer from low self-esteem or even depression (Hill and Williams 1998).

Excessive obesity among Aboriginal Canadians has emerged as a significant health problem and its role as an important risk factor in the development of type 2 diabetes is also well established (Thouez, Ekoe et al. 1990; Young, Dean et al. 2000). Aboriginal Canadians are at particularly high risk for type 2 diabetes and high rates have been observed among many different groups, although substantial geographical variation exists (Young, Schraer et al. 1992; Young and Harris 1994; Maberley, King et al. 2000; Oster, Johnson et al. 2011). The lowering of the age of onset of type 2 diabetes among some Aboriginal groups is particularly worrisome (Harris, Perkins et al. 1996; Dean 1998; Young, Martens et al. 2002). Type 2 diabetes, characterized by insulin resistance and a
relative decrease in insulin secretion, is traditionally a disease of adults, but is being increasingly diagnosed in children and adolescents between the ages of 10 and 18 (American Diabetes Association 2000). The onset of type 2 diabetes during childhood or adolescence increases the number of years during which complications such as cardiovascular disease, renal disorders, visual problems, and amputations can develop (Amschler 2002). In children, the primary correlate of insulin sensitivity is percent body fat, and adiposity accounts for approximately 55% of the variability in insulin sensitivity in children (Arslanian and Suprasongsin 1996). Impaired glucose tolerance can be seen in obese children and adolescents, and is noted particularly in obese children with a family history of diabetes (Valente, Strong et al. 2001).

As in adults, obese children manifest insulin resistance and hyperinsulinemia. It is therefore not surprising that the dramatic rise in the prevalence and incidence of childhood onset type 2 diabetes (Kaufman 2003) is coincident with the epidemic of overweight and obesity among children and adolescents in various regions around the world (Gill, Antipatis et al. 1999). Adiposity in childhood is a strong predictor of obesity into young adulthood (Steinberger, Moran et al. 2001). Thus, even if overweight children do not develop type 2 diabetes during childhood or adolescence, their risk for developing the condition later in life will remain high without intervention. As many children with type 2 diabetes are asymptomatic, they remain undiagnosed until complications occur.

Another major risk factor identified among the Aboriginal population is maternal diabetes (Ball, Brown et al. 2002). This is of particular concern because both gestational
and type 2 diabetes are common among Aboriginal women (Harris, Caulfield et al. 1997; Godwin, Muirhead et al. 1999; Rodrigues, Robinson et al. 1999). In addition, high and low birth weight, defined as greater than 4,000 grams and less than 2,500 grams, respectively, were also identified as factors that increase risk for developing type 2 diabetes in childhood. Unfortunately, high birth weight is also common among Aboriginal Canadian populations (Rodrigues, Robinson et al. 2000).

While excess body fat is recognized as the common denominator for type 2 diabetes (Pinhas-Hamiel and Zeitler 2000), equally or perhaps of greater importance is how the fat is distributed. Individuals with upper body or abdominal obesity show the greatest degree of insulin resistance and hyperinsulinemia, independent of total body fat, and it is the amount of visceral or intra-abdominal fat that is most directly correlated with insulin resistance and hyperinsulinemia (Kissebah and Peiris 1989). In adults, there is a well-documented relationship between glucose tolerance, intra-abdominal visceral fat, and the ratio of visceral fat to peripheral fat (Slyper 1998). The relationship in children is not as clear, but in obese adolescent girls, insulin resistance correlates strongly with the amount of visceral fat, while there is no correlation with subcutaneous fat (Caprio, Hyman et al. 1995). In addition, childhood obesity leads to increased concentrations of triglycerides and decreased high density lipoprotein (HDL) cholesterol, and these abnormalities are most marked in children with a central distribution of body fat (Freedman, Srinivasan et al. 1989; Zwiauer, Pakosta et al. 1992).
One potential mechanism through which visceral fat may affect fasting insulin is through an effect on hepatic insulin extraction (Lonnqvist, Thome et al. 1995). Exposure of the liver to free fatty acids may decrease hepatic insulin clearance, leading to elevated fasting insulin. This fat depot has direct access to the liver through the portal system. The release of excess free fatty acids into the portal circulation may have a number of negative effects on the liver, such as glucose intolerance, impaired metabolism and action of insulin. The resulting insulin resistance may, in turn, contribute to the development of type 2 diabetes (Lonnqvist, Thome et al. 1995). As a result, prevention and treatment programs that aim to reduce visceral fat accumulation may be most effective.

Abdominal obesity is also the most common component of the cluster of metabolic abnormalities that make up the metabolic syndrome (Despres and Lemieux 2006). The metabolic syndrome, which comprises abdominal obesity, high blood pressure, dyslipidemia, and hyperglycemia (Zimmet, Alberti et al. 2005), has been observed to be predictive of or strongly associated with the development of type 2 diabetes among some Aboriginal populations (Kaler, Ralph-Campbell et al. 2006). Prevalence varies between Aboriginal ethnic groups, with high rates observed in the Oji-Cree Indians from northern Ontario and Manitoba and lower among Inuit from the Northwest Territories (Liu, Hanley et al. 2006). At least in the Oji-Cree population, genetic factors have been identified (Pollex, Hanley et al. 2006), but lifestyle factors, namely physical activity level, was also an important correlate.
In summary, the health consequences of obesity are well documented in both the Aboriginal and non-Aboriginal populations in Canada and elsewhere. The close link between obesity and diabetes, and the high burden of both conditions in the Aboriginal population, particularly among youth, suggests that controlling obesity is key to the prevention of diabetes.

2.5 Lifestyle Determinants of Obesity

In the previous sections, the extent and consequences of the obesity problem among Aboriginal Canadians were discussed. Rapid changes in lifestyles of Aboriginal Canadians have been frequently cited as one factor for increasing obesity in this population. In the following sections, ways in which physical activity and dietary factors may affect obesity development are outlined. Lifestyle modifications are cornerstones in obesity management strategies and it is important to consider the current lifestyles of Aboriginal Canadians to better understand the evolution of the obesity problem among this population.

Physical Activity

The benefits of regular physical activity and cardiorespiratory fitness (CF) for health are undisputed (Blair and Morris 2009). Physical activity contributes to lower mortality risk and overall health by reducing risk for various chronic conditions including obesity, cardiovascular disease, diabetes, cancer, hypertension, depression and joint diseases such as osteoporosis and osteoarthritis (Warburton, Nicol et al. 2006). At least some of the benefits from physical activity can be attributed to resultant fat loss (Shephard 1994). Physically active and physically fit persons are less likely to be obese (Poirier and
Despres 2001), but the use of physical activity as a means to weight loss is more likely to be achievable in the short term (Jakicic, Otto et al. 2010) than in the long term (Curioni and Lourenco 2005).

Even without weight loss, the ability of exercise to improve CF attenuates much of the health risk attributed to obesity (Blair, Cheng et al. 2001). For instance, physically fit obese men have been found to have a lower risk of mortality than unfit, lean men (Agren, Narbro et al. 2002). Men and women with moderate-to-high CF levels have substantially lower levels of total and abdominal adiposity (Ross and Katzmarzyk 2003). Exercise training is associated with reduction in abdominal fat, independent of the amount of weight loss (Ross, Dagnone et al. 2000). Obese individuals, young or old, will benefit from more physical activity, preferably of moderate to high intensity, to improve CF. Such individuals will increase their capacity to engage in exercise (i.e., they do not tire as easily) and perhaps become more physically active in general. In one clinical trial that combined dietary changes with an exercise program initiated at different time points (Goodpaster, Delany et al. 2010), the introduction of physical activity clearly promoted greater weight loss and significant reductions in waist circumference and abdominal fat among severely obese adults.

For adults, the current recommendation (Donnelly, Blair et al. 2009) for overweight and obese adults to improve health is physical activity participation for a minimum of 150 minutes per week of moderate-intensity exercise. The American College of Sports Medicine (ACSM) suggests that engaging in moderate intensity physical activity between
150 and 250 per minutes is effective to prevent weight gain, but would provide only modest weight loss. In this range of participation, weight loss is enhanced when accompanied with moderate dietary restriction. However, there is a dose-response relationship and more physical activity may be necessary to prevent weight regain after weight loss. Increasing duration to 200 to 300 minutes per week is deemed effective for long-term weight loss. Amounts of physical activity greater than 250 minutes per week are associated with clinically significant weight loss and effective weight maintenance.

With respect to body composition, the optimal quantity and intensity of physical exercise which influences fat distribution positively is not known. A report from Japan (Yamashita, Nakamura et al. 1996) highlights the benefits of regular physical training to body composition. Sumo wrestlers consume up to 7,000 kcal per day to gain body weight. At the same time, they perform intense physical exercise every day. When young sumo wrestlers underwent laboratory testing for body fat distribution, they showed an accumulation of fat only in the subcutaneous area and demonstrated a markedly developed musculature. Intra-abdominal visceral fat accumulation in sumo wrestlers was relatively low compared with other obese males with a similar BMI. Surprisingly, most of the sumo wrestlers maintained normal glucose and triglyceride levels and had unexpectedly low cholesterol levels despite obesity. These findings suggest that the amount of visceral fat accumulation plays a role in blood glucose and lipid metabolism. In addition, these data also suggest that intense physical exercise may prevent visceral fat accumulation and improve plasma glucose and lipid profile.
Changes in BMI are particularly difficult to assess in children as normal physiological growth and maturation are important processes that can be disrupted. By focusing on reductions in visceral and abdominal fat specifically, researchers avoid discouraging overall growth in BMI that is part of healthy development. In one program (Gutin, Barbeau et al. 2002), obese children were either required to train at a moderate intensity (55-60% of peak oxygen uptake) or high intensity (75-80% of peak oxygen uptake) for four or five days per week, with energy expenditure of each child controlled to 250 kcal per session. No clear effect of exercise intensity was found with respect to reducing visceral or total body fatness. However, the high-intensity group showed greater improvements in CF.

One study (Owens, Gutin et al. 1999) employed magnetic resonance imaging (MRI) to measure central body fatness and examined the impact of a four-month exercise training program without dietary intervention on body composition and abdominal fat distribution in obese children. Compared with the control group, percent body fat declined significantly for those in the training group (-4.9% vs. no change, respectively). Subcutaneous abdominal fat mass decreased slightly (-1.0%) in the training group, while the control group experienced an increase of 2.3%. Although visceral fat increased by 0.5% in the training group, children in the control group had an average increase of 8.1%. An increase in visceral fat storage was expected among children of this age group. Although the physical training group increased slightly in visceral fat, the increase was significantly less than in the control group. Thus, it appeared that physical exercise attenuated the possibly age-related increase in visceral fat. The results of this study
suggest that increasing the physical activity of obese children, even without dietary intervention, can improve aspects of body composition that are linked with risk factors for both cardiovascular disease and type 2 diabetes. In addition, it is also evident that obese children were able to sustain high levels of activity for a long period of time. Obese children, regardless of ethnicity, have large absolute amounts of overall fat compared with non-obese children, so the proportion of visceral fat may be relatively small. Thus, in obese children, it may be more difficult to demonstrate the negative effect of visceral fat on glucose regulation (Tershakovec, Kuppler et al. 2003).

Researchers should take into consideration relative amounts of visceral abdominal fat in future studies and attempt to compare ratios of visceral versus subcutaneous abdominal fat in obese and non-obese children rather than absolute amounts. This may help clarify whether visceral fat plays a discrete role in influencing blood glucose control in children in general and also children of various ethnic groups.

Another major factor is pubertal status. In prepubertal children, visceral fat is related to concentrations of both triglycerides and fasting insulin, independent of total fat and subcutaneous abdominal adipose tissue (Gower, Nagy et al. 1999). However, contrary to findings from adult (Chan, Rimm et al. 1994) and adolescent (Caprio, Hyman et al. 1995) studies, no such relationship exists between visceral fat and insulin sensitivity in prepubertal children (Gower, Nagy et al. 1999). Despite having associations with both triglycerides and fasting insulin, visceral fat does not appear to be independently associated with insulin sensitivity. These observations suggest that obesity and visceral fat confer different health risks in prepubertal children. One reason may be that adults
and adolescents have been exposed to the disease or risk factors for a longer period of
time than in prepubertal children. Another possibility is that these associations develop
with age, maturation, or establishment of disease (Goran and Gower 1999).

While many lifestyle intervention programs fail to result in successful weight loss, both
diet and exercise successfully decrease high insulin levels in children, with or without
reducing body weight (Hardin, Hebert et al. 1997). However, exercise alone appears to
lower fasting insulin levels more than diet modifications alone. In addition, physical
activity has been found to correlate with lower fasting insulin and greater insulin
sensitivity even in non-diabetes, non-overweight children (Schmitz, Jacobs et al. 2002).
Although the mechanisms involved were not clear, one possible mechanism is that
physical exercise improves fat distribution. Another possibility is that regular physical
activity increases fat-free mass, increasing the volume of muscle through which glucose
can be transported (Ivy, Zderic et al. 1999). Repeated bouts of exercise may result in
physiological and cellular adaptations that favour sustained improvement in blood
glucose regulation.

One study (Ferguson, Gutin et al. 1999) demonstrated the importance of maintaining
exercise. Using a modified cross-over design dividing 70 obese children were divided
into two training groups, so that the effects of training cessation could be explored as
well. Group 1 engaged in exercise training for the first four-month period and then
ceased formal exercise training for the next four months, while Group 2 did not engage in
exercise training for the first four months and then engaged in exercise training for the
next four months. In both groups, during periods of exercise training, plasma insulin concentrations decreased significantly and increased during the other four months of no formal exercise training, with no change in plasma glucose concentration. A reduction in plasma insulin concentration without change in plasma glucose concentration indicates improved insulin sensitivity. This study design showed that the withdrawal of exercise training induced a rebound of plasma insulin concentration levels in obese children, illustrating that insulin sensitivity will deteriorate if exercise training is not maintained. Equally important, during the initial four-month period, Group 2 showed an increase in blood insulin levels with no change in plasma glucose levels, indicating that without exercise intervention, obese children will experience a steady reduction in insulin sensitivity.

Similar results have been observed in an exercise intervention study involving adults with well-controlled type 2 diabetes (Mourier, Gautier et al. 1997). Patients in the exercise training groups were asked to engage in physical training for two months consisting of two kinds of exercise: (1) a supervised 45-minute cycling exercise at 75% of their peak oxygen uptake, two times per week, and (2) an intermittent exercise program one time per week. Patients in the exercise program demonstrated a mean increase of 41% in cardiorespiratory fitness and insulin sensitivity by 46%. Body weight was not significantly affected, but training significantly decreased abdominal fat accumulation, with a greater loss of visceral fat (48%) in comparison with the loss of subcutaneous fat (18%). The inclusion of an intermittent exercise group is interesting since this type of
exercise can be less time consuming, and the authors speculated that this would make the exercise program less monotonous.

**Diet and Nutrition**

While the relationships between obesity and various nutrients and foods have been very much studied, few consistent relationships have emerged. There is great difficulty in accurately measuring dietary factors and assessing the impact of foods and nutrients on many health outcomes, including obesity (Willett 1998). Despite numerous studies, the contribution of individual nutrients such as carbohydrate, protein, or fat to weight gain remains unclear. A major methodological issue hindering such studies being that current dietary assessment methods are prone to residual and unmeasured confounding (Hu 2008). The complexity of establishing knowledge of nutrient-obesity relationships is evident from the results of a recent clinical trial that attempted to explore outcomes of a low-fat versus low-carbohydrate dietary intervention that also included a comprehensive lifestyle modification program for obesity (Foster, Wyatt et al. 2010). The low-carbohydrate diet consisted of low carbohydrate intake (20 grams per day for 3 months, and increased 5 grams per day per week thereafter) in the form of low-glycemic index vegetables with unrestricted consumption of fat and protein. The low-fat diet consisted of limited energy intake (1,200 to 1,800 kcal per day or 30% or less total calories from fat). While both groups lost weight at the end of the two years of the study, the low-carbohydrate diet group also exhibited favourable changes in cardiovascular disease risk factors such as increased high-density lipoprotein cholesterol levels. However, attrition
and adverse symptoms were high and suggests that compliance with intensive lifestyle changes is difficult.

Traditional nutritional epidemiological studies use single nutrient approaches to determine how dietary factors affect risk of developing diseases such as cancer, heart disease, and type 2 diabetes. However, the study of overall dietary patterns has emerged as a valuable complementary approach to study the interactions between diet and disease as it takes into account the complex synergistic effects of nutrients and recognizes that individuals consume meals that contain a variety of nutrients in various combinations (Hu 2002). In such studies, the general patterns reveal that individuals consuming a dietary pattern that resembles the “Western” diet characterized by high quantities of red meat, processed meat, butter, potatoes, refined grains, and high-fat dairy foods are more likely to be overweight, and more likely to have reported having at least one chronic condition compared with individuals consuming a dietary pattern that resembles the “prudent” diet, characterized by vegetables, fruits, legumes, fish/seafood, and whole grains.

There is little controversy in encouraging increases in intake of “healthy” foods such as fruits and vegetables and lowering intakes of “junk” foods such as candy and fried salty snacks. High intakes of energy-dense, micronutrient-poor foods such as “junk” foods, and sugar-sweetened soft drinks have been linked to the development of obesity (Swinburn, Caterson et al. 2004). Whether or not fruits and vegetables actually causes weight loss through some properties of the nutrients they contain or does so by replacing foods that lead to weight gain is uncertain.
Data from comprehensive dietary interviews in the form of 24-hour dietary recall or food frequency questionnaire of Aboriginals Canadians is available for select First Nations or Inuit communities across Canada. Two studies from the late 1940s on the nutrition of northern Manitoba Indians (Moore, Kruse et al. 1946) and James Bay Indians (Vivian, McMillan et al. 1948) showed that 85% of total calories were supplied by white flour, lard, sugar and jam, food items which were “either devoid of or extremely low in vitamins and minerals” (Moore, Kruse et al. 1946 p.228).

The Nutrition Canada Survey (Nutrition Canada 1975) showed that First Nations people consumed less milk and fruits and vegetables, but more meat, fish, poultry, cereal products than other Canadians. They were also found to have calcium, folate, and iron intakes that were below recommendations for some age-sex groups. Results from 350 individuals in four Inuit communities (Nutrition Canada 1975) showed that they reported lower overall caloric intakes compared with other Canadians, and calcium, vitamin A, folate, and vitamin C intakes lower than recommended levels.

The James Bay Cree have become one of the more intensely studied Aboriginal populations in Canada. More than five decades have passed and general issues identified in the 1940s persist with similar recommendations being put forward in more contemporary studies. In the 1980s, vitamin A and C deficiencies were still apparent in the population (Hoffer, Ruedy et al. 1981). However, changing patterns of food use have been noted (Berkes and Farkas 1978). Whereas nutritional deficiencies were the primary focus of investigation, current nutrition concerns centre around contaminants
(Dumont, Wilkins et al. 1988; Kosatsky and Dumont 1991; Girard, Noel et al. 1996; Dumont, Girard et al. 1998) and preventing risk for chronic diseases such as diabetes. High prevalences of type 2 diabetes have been documented in the population (Brassard, Robinson et al. 1993; Brassard, Robinson et al. 1993; Brassard and Robinson 1995), and lifestyle risk factors (Lavallee and Robinson 1991) are increasingly being investigated. In relation to dietary factors, nutritional status of infants (Willows, Morel et al. 2000), fish intake (Dewailly, Blanchet et al. 2002; Dewailly, Blanchet et al. 2003), and eating habits of schoolchildren (Downs, Marshall et al. 2008) have been reported.

The Sandy Lake Health and Diabetes Project (Hanley, Harris et al. 1995) that began in 1992 in response to the high prevalence of diabetes in this community (Harris, Gittelsohn et al. 1997) examined existing food patterns and their associations with health risk. Through the use of food frequency questionnaires that incorporated both traditional and store-bought foods, protective effects of vegetables, breakfast, and hot meals were observed while consumption of junk foods and bread and butter groups had negative effects on diabetes risk (Gittelsohn, Wolever et al. 1998). Similarly, low dietary fibre and high protein intakes were implicated in increased prevalence of newly diagnosed diabetes (Wolever, Hamad et al. 1997).

Within the past decades, reviews related to diet of Aboriginal Canadians reflect the shift of attention away from nutrition deficiencies (Moffatt 1995) to more emphasis on developing strategies for healthy eating (Willows 2005). Evidence that unique aspects of the northern diet may be protective of disease has led to increasing interest in the nutrient
composition of traditional country foods. Arctic indigenous population subsist on diets high in quantities of various sea mammals and fish (Hoppner, McLaughlin et al. 1978). Such foods contain high levels of n-3 fatty acids which may be protective for various diseases including hypertension (Popeski, Ebbeling et al. 1991) and cardiovascular diseases (Dewailly, Blanchet et al. 2003).

Beyond specific foods or nutrients, the broad eating pattern of a population has also been shown to promote obesity. Changes from eating patterns based on traditional or “country foods” to those dependent on store-bought or market foods has generally been labelled as ‘westernization’ or ‘modernization’. The health effects of such dietary transition have been demonstrated in many indigenous populations, in Canada and elsewhere (O'Dea 1991; Szathmary, Ritenbaugh et al. 1987; Kuhnlein, Receveur et al. 2004)

For Aboriginal youth specifically, various cross-sectional studies (Macaulay, Paradis et al. 1997; Hanley, Harris et al. 2000; Nakano, Fediu et al. 2005; Kaler, Ralph-Campbell et al. 2006; Receveur, Morou et al. 2008) and one longitudinal study (Horn, Jacobs-Whyte et al. 2007) based on specific regions and communities in Canada have shown that lifestyle factors, primarily poor dietary habits and highly sedentary behaviours are important determinants of obesity.

In summary, individual behaviours such as physical activity and diet play an important role in the development of obesity, either singly or in combination. Evidence from both
the Aboriginal and non-Aboriginal populations suggests that any intervention must take such behaviours into consideration.

2.6 Social Determinants of Obesity

Health behaviours and lifestyle are very much influenced by one’s social conditions. This is of special relevance to Aboriginal Canadians since much of the health disparities compared to non-Aboriginal Canadians has been attributed to the relative socioeconomic disadvantage of Aboriginal peoples in Canada and a persistent income and education level gap exists between the two populations. Lifestyle behaviours and socioeconomic factors have been explored simultaneously in their relationships with health among Aboriginal Canadians. Using data from the CCHS 1.1 conducted in 2000-2001 (Tjepkema 2002), Aboriginal Canadians were reported to have twice the odds for fair or poor self-perceived health, presence of one or more chronic conditions, long-term activity restriction, and experience of major depressive episode during the year previous to the survey compared to non-Aboriginal Canadians after adjustment for age and sex.

However, with further adjustment for socio-demographic factors such as geographic region, marital status, education, income, and work status, all odds ratios were lower than the previous age- and sex-adjusted models, indicating that at least part of the difference in health status between Aboriginal and non-Aboriginal populations could be attributed to the addition of socio-demographic variables in the models.

In relation to obesity, social factors consistently exert independent influence on obesity in studies of national-level Canadian data. In an analysis of the CCHS 3.1 conducted in 2005 with self-reported height and weight data (Slater, Green et al. 2009), low education
and income levels were found to be associated with obesity among women, with high income levels being positively associated with obesity among men. The relationship between education and obesity among men was not significant. Similar findings have been reported using measured height and weight data from the CCHS 2.2 conducted in 2004 with men and women exhibiting opposite SES-obesity relationships, whereby higher SES men were more likely to be obese than low SES men and lower SES women were more likely to be obese than high SES women (Tjepkema 2006).

The same negative SES-obesity relationship has been observed among Canadian children (Shields 2006). In other countries, SES appears to have little effect on the weight status of older adolescents, perhaps because adolescents may be more independent in their decision-making about food choices and activity behaviours (Haas, Lee et al. 2003). Similarly, no significant SES-obesity relationship was observed among a sample of 3- to 5-year-old Belgian children (De Spiegelaere, Dramaix et al. 1998). However, during early adolescence between the ages of 12 and 15 years, the relationship between social status and the prevalence of obesity has been found to be inverse (De Spiegelaere, Dramaix et al. 1998).

In the Canadian Aboriginal population from the CCHS 2.2 data (Garriguet 2008), lower education level was associated with reduced odds for overweight among Aboriginal adults. In contrast, attainment of less than secondary graduation doubled the odds for obesity among non-Aboriginal adults. No associations between overweight and obesity with household income categories were significant. However, it should be noted that
household income was categorized into just two categories (low and middle/high) using total household income and the number of people living in the household. It is plausible that this classification may have been insufficiently sensitive to detect differential associations between groups.

Also using the CCHS 2.2 data, two studies have attempted to describe the relationships through which SES may influence health behaviours that may impact obesity development. Results from a path analysis revealed that low education and income may be indirectly influencing obesity through lower fruit and vegetable intake and leisure time physical activity levels among women (Ward, Tarasuk et al. 2007). In another study, lower education and income groups were found to more likely report low levels of physical activity and low fruit and vegetable intakes (Kuhle and Veugelers 2008). However, because these were cross-sectional data, the direction of these relationships remain unclear.

Obesity can affect one’s SES through lower labour force participation and “wage penalties”. Obese persons have been observed to earn lowered wages for comparable employment, most notably among women (Baum and Ford 2004; Baum and Ruhm 2009). In one analysis, the estimated wage differential between obese and non-obese individuals was equivalent to one and a half year of education (Cawley 2004). Obese persons have also been found to more likely not pursue higher education (Karnehed, Rasmussen et al. 2006) and more likely to move downward in SES (Karnehed, Rasmussen et al. 2008).
On the other hand, a negative SES-obesity relationship may be due to decreased awareness and knowledge of healthy behaviours among those of lower SES. Among Latin American adolescents, SES has been found to be strongly associated with obesity knowledge (McArthur, Pena et al. 2001). Wealthier families may show greater awareness of obesity and demonstrate more competence in topics such as fat and calorie content of foods and beverages, weight loss methods, energy expenditure, food preparation methods, and relationship between obesity and health. Adolescents from higher SES groups tend to have greater access to learning opportunities about obesity in both school and community settings. In addition, classroom instruction about obesity was found to be generally more available to students from higher SES groups.

Another way by which SES influences weight gain patterns is that SES may affect an individual’s perceptions and behaviours toward body weight ideals. Concern about weight has been shown to differ between SES groups in school-age children. Students in 4th and 7th grades belonging to the high SES category selected significantly smaller ideal body size than in the low SES group (Adams, Sargent et al. 2000). Moreover, more females in the high SES category were trying to lose weight, compared to females in the low SES group.

Individuals of low SES may also have decreased access to health care. Among a sample of white and black women, family income showed the strongest positive association with total health care access (Scarinci, Slawson et al. 2001). Women employed full time had increased odds of insurance coverage, whereas employment had no similar effect among
men (Merzel 2000). Children of single parents are more likely to have unmet health care needs (Heck and Parker 2002). Adolescents who lack health insurance are more likely to be overweight (Haas, Lee et al. 2003).

The inverse relationship between SES and obesity status is influenced by non-modifiable factors such as sex, ethnicity, and age, as well as modifiable factors such as physical activity and knowledge. This association may be compounded by the fact that individuals of low SES often have decreased access to health care services and less knowledge on weight management.

Certain aspects of SES can be captured by where one lives. Others have used Statistics Canada data to explore neighbourhood-level determinants of obesity (Oliver and Hayes 2005; Oliver and Hayes 2008). Unfortunately, defining a “neighbourhood” is a complex task. According to one review of the relationship between neighbourhoods and obesity (Black and Macinko 2008), most studies utilize postal codes to create administratively-defined areas such as census tracts or other census-based geographic areas. Other studies have defined neighbourhood in various, non-uniform ways including subjectively by asking respondents their “perceived neighbourhood” as well as objectively by radius around ones residence of some particular fixed distance. Still others have defined a neighbourhood by racial composition and income or other socio-economic measures. Criticisms of neighbourhood-level research centre around the issue of how one defines a neighbourhood (Chaix et al. 2009). In addition, it is not feasible to expect that
individuals necessarily conduct their daily lives within administratively-defined geographic areas.

In the context that many Aboriginal Canadians are experiencing rapid socioeconomic changes, it is important to identify whether obesity is disproportionately affecting certain socioeconomic groups so that appropriate intervention and prevention efforts may be developed. Socioeconomic and health disparities between Aboriginal and non-Aboriginal Canadians exist simultaneously (Tjepkema 2002) and in a complex fashion. The associations between socioeconomic variables and obesity remain unexplored, particular by sex and using more detailed socioeconomic variables.

In summary, SES plays a strong role in determining the distribution of overall health status in general and obesity in particular. The SES-obesity relationship likely differs between populations and contexts. While this relationship is complicated by varying ways SES can be measured, investigating the associations between SES indicators and obesity may be useful to inform both how SES may affect obesity development as well as elucidating socioeconomic consequences of obesity.

2.7 Population Interventions for Obesity

In the previous sections, some evidence on intervention trials on highly selected groups were presented to indicate the role of physical activity and diet in the development or reduction of obesity. On a population-wide basis, several diabetes prevention trials provide clear clinical evidence that obesity prevention through lifestyle change can be effective. Three such trials with obesity as a major endpoint or intermediate outcome
measure include the Da Qing Impaired Glucose Tolerance and Diabetes Study (Pan, Li et al. 1997), the Diabetes Prevention Project (Diabetes Prevention Program Research Group 2000), and the Finnish Diabetes Prevention Study (Uusitupa, Louheranta et al. 2000). These were successful in preventing the incidence of diabetes up to 58% by some combination of diet and/or exercise.

Among interventions that involve indigenous populations specifically in Canada, only school-based interventions were population-wide. The Sandy Lake Health and Diabetes Project (SLHDP) and the Kahnawake Schools Diabetes Prevention Project (KDSPP) were two programs that aimed to prevent diabetes and obesity by improving diet and physical activity behaviours or children, but interventions involved family and other community members.

**The Sandy Lake Health and Diabetes Project**

Sandy Lake is a community of approximately 1,800 Oji-Cree people located approximately 2,000 km northwest of Toronto. The community is isolated and for most of the year is accessible only by air. The SLHDP began in 1992 with one of its major objectives being to develop culturally appropriate data collection instruments and intervention strategies to modify risk factors for diabetes and its complications (Hanley, Harris et al. 1995).

A school-based pilot project (Saksvig, Gittelsohn et al. 2005) was implemented in 1998 targeting multiple aspects of the daily activities and interactions of children in grades
three to five. Cultural adaptations were made to the school curriculum to include foods, physical activities, and cultural traditions. One unique strategy was to use storytelling to introduce the main concepts of the health education lessons. Parents and family members were informed about the healthy eating and physical activity messages their children were learning in school through community radio and letters. Peers were provided opportunities to be role models through a youth radio show and creation of cooking videos. A school-wide policy banning high-fat and high-sugar snack foods in the schools was implemented in conjunction with a school lunch program.

After one school year, children who were exposed to the intervention were significantly associated with more knowledge about foods low in fat, and having higher scores on the dietary self-efficacy and were more likely to meet dietary fibre recommendations. Few other significant outcomes were observed and notably, no reduction in obesity in children was found. Efforts to expand this project to neighbouring communities have led to several strategies that may improve efficacy (Ho, Gittelsohn et al. 2006). These include changing social norms by intervening in multiple institutions and tailoring programs to individual communities, highlighting the need for a flexible approach.

The Kahnawake Schools Diabetes Prevention Project

Kahnawake is a Mohawk community of 7,100 people located approximately 25 km from Montreal (Potvin, Cargo et al. 2003). The KDSPP involved active collaboration between the researchers and a Community Advisory Board consisting of members of the Kahnawake community, which was involved in all stages of the project planning and
execution, ensuring that the interventions were culturally relevant and sustainable. Community concerns about rising rates of diabetes led to the development of the KDSPP in 1994 (Macaulay, Paradis et al. 1997). While the long-term goal of the KDSPP is to decrease the incidence of type 2 diabetes, short-term goals include changing eating habits and physical activity levels among children aged 6 to 12 years by improving knowledge, attitudes, self-efficacy, intention, and skills of both children and parents, while incorporating Mohawk traditions and fostering community empowerment.

The KDSPP intervention included a school health education program that was structured to improve self-esteem and create positive attitudes about healthy lifestyles. Small, incremental, and easily achievable goals were set to promote self-efficacy. Educational activities were often interactive, practical experiences, such as hands-on exercises on food sampling, label reading, and experiments.

Environmental adjustments were made to increase availability of healthy foods and opportunities to be physically active. Kahnawake elementary school canteens offered foods that were low in fat, low in simple sugars, and/or high in fibre. One school added an extra physical education class each week and incentives were provided for teachers who integrated extra physical activities into their classes.

Children’s knowledge and skills in healthy behaviours were reinforced by supportive teachers and family members. Extensive use of the local media helped increase community awareness and encourage participation in KSDPP events and activities. The
project helped organize cooking contests during community fairs, pow-wow dancing, walkathons, and treasure hunts. Ongoing programs include an annual elementary school race attracting over 800 children from other Mohawk communities, a gymnastics club, a volleyball league, as well as a walk and run club.

Despite KSDPP’s success in engaging the Kahnawake community in a variety of school and community interventions aimed at diabetes prevention, no significant improvement in the diabetes profile of this community has been shown (Potvin, Cargo et al. 2003). One critical achievement of this project was the creation of an environment that supported healthy lifestyles in schools and the community in general. Moreover, through the experiences of KSDPP, four principles for implementation of community programs were developed (Potvin, Cargo et al. 2003). These principles were: (1) the integration of community people and researchers as equal partners in every phase of the project; (2) the structural and functional integration of the intervention and evaluation research components; (3) having a flexible agenda responsive to demands from the broader environment; and (4) the creation of a project that represents learning opportunities for all those involved. These principles should be considered when attempting to develop related programs for similar populations.

The SLHDP and the KSDPP were school-based interventions conducted in specific isolated (Sandy Lake) and urban (Kahnawake) Aboriginal communities in Canada. Two larger-scale intervention programs have been implemented in the United States involving
indigenous populations of varying geographic areas and these are discussed here for comparison.

Pathways

The Pathways project was the result of a collaboration among universities and American Indian nations, schools, and families. The intervention was a school-based culturally appropriate obesity primary prevention program targeting American Indian children that promoted healthful eating behaviours and increased physical activity (Davis, Going et al. 1999). Teachers were provided with detailed lesson plans, an instructor’s manual, and all necessary instructional materials. All classroom instructors attended centralized training sessions twice per year each lasting 2 days to ensure accurate implementation of the program. Over 5 years, positive changes in eating and physical activity were reported in some intervention schools (Davis, Clay et al. 2003).

The physical education curriculum emphasized health outcomes and aimed to: (1) develop high levels of physical activity for all children, regardless of skill level; (2) promote health-related fitness through aerobic activities and allow for sports skill development to enhance success and enjoyment of activities; and (3) be practical and easy to implement by both classroom teachers and PE specialists (Davis, Going et al. 1999). The PE component also included a unit of American Indian games derived from the traditional games of each nation. Games were modified so that participation can be maximized.
The goal of the school food service intervention was to lower the amount of fat in school meals to 30% of energy (Snyder, Anliker et al. 1999). Behavioural guidelines were developed to help Pathways food service personnel in the planning, purchasing, and preparation of lower fat foods in school meals. Results from the feasibility phase of the study indicate that while control school lunch menus averaged 34 to 40% of energy from fat, the intervention schools averaged only 31%.

The family intervention involved three primary strategies designed to create an informed home environment supportive of behavioural change: (1) giving the children "family packs" containing worksheets, interactive assignments, healthful snacks, and low-fat tips and recipes to take home to share with their families; (2) implementing family events at the school to provide a fun atmosphere in which health education concepts could be introduced and reinforced; and (3) forming school-based family advisory councils composed of family members and community volunteers who provided feedback on Pathways strategies, helped negotiate barriers, and explored ideas for continued family participation (Teufel, Perry et al. 1999). The Family Celebration was the second family event where children were given an opportunity to share some of the games and knowledge learned through Pathways with their families. Completed lesson materials were displayed in the classrooms and families were awarded certificates of completion recognizing their participation in their child’s Pathways experience throughout the year.

The program produced significant positive changes in fat intake and in food- and health-related knowledge and behaviours. However, similar to the SLHDP and KSDPP, no
significant reductions in adiposity were observed in the intervention populations (Caballero, Clay et al. 2003). The inability of such interventions to elicit clear decreases in obesity may be due to short follow-up times, but modest results suggest that more intense or better targeted intervention strategies may be required. One example of a more intense intervention is the Zuni Diabetes Prevention Project.

**The Zuni Diabetes Prevention Project**

The Zuni Indian reservation in New Mexico is recognized as a community with high rates of type 2 diabetes. The primary purpose of the 4-year Zuni Diabetes Prevention project was to reduce type 2 diabetes risk factors among Zuni high-school-age youths by enhancing knowledge of diabetes, supporting increased physical activity, increasing fruit and vegetable intake, and reducing soft drink consumption (Teufel and Ritenbaugh 1998). Mechanisms and strategies of intervention included integrating diabetes education into the school curriculum, constructing a school-based wellness centre, creating supportive social networks that help organize and deliver the programs, and modifying the food supply available to the youths.

Innovative ways to integrate diabetes related information into common school courses was one strategy to enhance students’ knowledge of diabetes prevention. Diabetes education was successfully incorporated into regular courses such as biology, math, and computers. For example, biology students were given opportunities to participate in exercise testing. Math students were asked to plot, graph, and calculate slopes of plasma
glucose and insulin values in response to food ingestion. Computer exercises involved designing nutritionally accurate advertisements.

The development of a teen wellness centre provided students more opportunities to be physically active. The center sponsored a large variety of activities including hiking, rock climbing, aerobics, biking, swimming, dances, and sports tournaments. Strength training equipment and cardiovascular machines were made available for all students to use and physical education classes had access to the facility. Students were employed as lay health educators working within the center, providing role models for others in the community. Use of the facility steadily increased throughout the study, indicating the center's increasing popularity and that more Zuni youth were engaging in physical activity.

Few modifications to the food supply were possible due to time constraints. The most notable change was the non-availability of soft drinks within the school. At year 3, virtually no sugared soft drinks were available within the school. There was no evidence that students were bringing soft drinks to school. Students consumed more water and diet sodas instead of soft drinks. As the study progressed, it appeared that it became socially acceptable to choose water and diet drinks as beverages of choice.

Results of this program through 3 years (Ritenbaugh, Teufel-Shone et al. 2003) demonstrate steady declines in fasting and 30-minute plasma insulin levels, which were elevated at baseline. BMI significantly decreased in females, but remained unchanged in
males. Growth and maturation or perhaps a favorable change in body composition (i.e., increase in muscle mass) may be contributing factors. However, percent body fat was not measured and no control group was available to compare whether these Zuni males would have significantly increased their BMI without the intervention. Weight maintenance was more favorable than weight gain and a lack of change in BMI over 3 years may in fact be a positive outcome of the intervention.

Interventions such as the SLHDP, KSDPP, Pathways, and Zuni projects which were specific to First Nations and American Indian populations have utilized a variety of interventions to prevent diabetes and/or obesity. While successes in terms of changes in metabolic markers and BMI vary, most resulted in positive behavioural and knowledge changes in diet and physical activity. These programs also demonstrated that individual health education/health promotion should be culturally appropriate, and ideally be accompanied by multi-faceted strategies including environmental change.

One common strategy was the use of a community focal point to implement interventions, namely schools or community centres, with specific components in the programs involving adult members of the communities though training and promotion activities that aimed to reach elders, family members, and peers. The generally modest outcomes of the population-based approaches summarized above suggest that a better understanding of the lifestyle behaviours of Aboriginal populations is warranted so that improved targeting of interventions and more effective intervention tactics may be developed.
2.8 Summary

Aboriginal peoples of Canada have a high burden of obesity compared to other Canadians and consequently suffer from poorer health. As prevalence of obesity increases in this population, a better understanding of current trends and associated risk factors is needed. From various national and regional studies, poor lifestyle habits and adverse health behaviours appear to be prime targets for intervention.

Since obesity trends in this population have been primarily described using cross-sectional surveys, a longitudinal analysis would provide insight into patterns of weight change in this population. Data from cross-sectional surveys are useful to identify the high rates of obesity that exist within the Aboriginal population. However, it is not possible from cross-sectional data to determine when individuals are gaining weight and whether the rates of change are the same by age and between Aboriginal and non-Aboriginal Canadians.

Obesity intervention may be most effective among youth before lifestyle behaviours are firmly established. Most lifestyle studies of Aboriginal populations have been conducted within Aboriginal communities. At the national-level among the off-reserve Aboriginal population, eating patterns among adults have been described. In addition, the relationship between physical activity and obesity among adults has also been previously reported. However, relatively little is known regarding the lifestyle patterns of Aboriginal youth living off-reserve, particularly their dietary behaviours.
Socioeconomic factors need to be considered as Aboriginal Canadians are a relatively socioeconomically disadvantaged group. SES and health behaviours can mutually influence each other and are undoubtedly intertwined and difficult to disentangle. Despite large socioeconomic disparities that exist between Aboriginal and non-Aboriginal Canadians, the SES-obesity relationship between Aboriginal Canadians remains unclear. Nevertheless, a better understanding of cross-sectional SES-obesity relationships can determine which groups are most obese and provide impetus for exploring both causal factors and consequences of obesity.

While Canadian Aboriginal populations are apparently experiencing an epidemiologic transition, it is unclear to what extent this is happening, particularly among Canadian Aboriginal people not living on reserves who have been underrepresented in health research. An examination of the current obesity trends and lifestyle patterns of this population along with socioeconomic factors may reveal important trends in their health needs and provide insights into how to develop interventions for reducing disease risk.
Research Framework

In this thesis, the following organizing framework is used for exploring trends and factors related to obesity among Aboriginal Canadians:

What is already known: Substantial evidence that high rates of obesity exist in select First Nations communities. Lifestyle behaviours among Aboriginal youth are poor and Aboriginal adults have been persistently socio-economically disadvantaged compared to non-Aboriginal Canadians.

Are these issues limited to First Nations communities or are these also concerns for Aboriginal Canadians (First Nations, Métis, Inuit) who live alongside non-Aboriginal Canadians?

What are the longitudinal trends of obesity?

Objective 1:
Describe longitudinal trends of BMI change among Aboriginal Canadians in comparison with non-Aboriginal Canadians. (Chapter 4)

How are lifestyle behaviours related to obesity?

Objective 2:
Describe associations between obesity and lifestyle behaviours among Aboriginal youth in comparison with non-Aboriginal youth. (Chapter 5)

How are socio-economic disparities related to obesity?

Objective 3:
Describe associations between obesity and socio-economic factors among Aboriginal adults in comparison with non-Aboriginal adults. (Chapter 6)

Improved understanding of risk factors for obesity among Aboriginal Canadians to inform intervention strategies.
Chapter 3   Methods

This dissertation explores obesity in Aboriginal Canadians through secondary analyses of national surveys conducted by Statistics Canada in the ten provinces, which allow for direct comparisons with the non-Aboriginal population. Three studies were devised to take advantage of the data available in two specific datasets.

First, successive cycles of the National Population Health Survey (NPHS) were analyzed to describe obesity trends longitudinally, comparing BMI rates of change between Aboriginal and non-Aboriginal Canadians by birth cohort to explore possible age, period, and cohort effects. The NPHS uniquely provides national-level longitudinal data on over 300 Aboriginal individuals covering 14 years.

Second, two separate analyses of the Canadian Community Health Survey (CCHS) Cycle 2.2 – Nutrition were conducted to describe lifestyle and socioeconomic risk factors for obesity among Aboriginal youth and adults. The CCHS 2.2 provides contemporary national-level measured height and weight data along with detailed nutrition and health information for the first time since 1972. Thus, it was possible to examine the dietary and leisure time activities of Aboriginal youth in relation to obesity. Next, since the CCHS 2.2 is part of a series of health surveys conducted annually by Statistics Canada, core common content included detailed socioeconomic information including income level, education attainment, and employment status. These data were examined to describe the socioeconomic patterning of obesity among Aboriginal Canadians.
3.1 Statistics Canada Survey Datasets

More detailed descriptions of the specific surveys and the relevant variables chosen for analyses are provided in the individual papers in Chapters 4 to 6. A brief overview of the design and contents of the surveys is presented here. Selected aspects of these surveys relating to Aboriginal people have already been published, including average daily nutrient intakes and daily consumption of select foods and food groups (Garriguet 2008) and physical activity and obesity (Katzmarzyk 2008).

*Canadian Community Health Survey Cycle 2.2 – Nutrition (2004)*

The CCHS 2.2 conducted in 2004 presents opportunities for research linking chronic diseases and lifestyle risk factors among a nationally-representative sample of off-reserve Aboriginal Canadians. More than three decades have passed since the Nutrition Canada survey of 1970 – 1972 was conducted. The Nutrition Canada survey was the last comprehensive survey which included First Nations and Inuit participants and provided data on the consumption and serum blood levels of different macro and micronutrients along with anthropometric information.

The main objectives of the CCHS 2.2 were estimating the distributions of usual dietary intakes in terms of foods, food groups, dietary supplements, nutrients and eating patterns among a representative sample of Canadians using the 24-hour dietary recall method. In addition, height and weight were measured along with questions on selected health conditions and socio-economic and demographic characteristics of respondents.
The CCHS uses the area frame designed for the Labour Force Survey (LFS) which utilizes a complex two-stage stratified design. The LFS first selects clusters using a sampling method with a probability proportional to size, and then the final sample is chosen using a systematic sampling of dwellings in the cluster. The CCHS uses the LFS clusters, which it then stratifies by health regions. Lastly, it selects a sample of clusters and dwellings in each health region.

The CCHS 2.2 represents data collected in the fourth year of collection for the CCHS. Data collection occurred between January 2004 and January 2005 in the ten provinces. Note that while other cycles of CCHS have included the three northern territories, where about half of the population is Aboriginal, CCHS 2.2 excluded them. The sample of over 35,107 respondents of all ages was selected from four different frames: the LFS area frame, a list of CCHS cycle 2.1 dwellings, and the Prince Edward Island and Manitoba health insurance plan registries. The use of more than one frame was necessary to ensure the minimum number of 80 individuals required in each domain of interest (provincial health region level by age and sex groups). The overall response rate was 76.5%, but only 63% of respondents had both their body height and weight measured by interviewers. Adjustment for non-response was achieved by weighting households that responded to the survey to compensate for non-responding households. A specific weighting factor used only with the measured body height and weight information was created to adjust for non-response bias in body mass index calculations.
The survey attempted to achieve a representative sample of Aboriginal peoples from all ten provinces in Canada. It oversampled Aboriginal Canadians aged 19 to 50 years to allow for minimum representation by each province and sex and to obtain national-level intake distributions for four age-sex domains of interest (19-30 Male/Female and 31-50 Male/Female).

The CCHS 2.2 is unique from other cycles of the CCHS because it included measured height and weight information and dietary data from 24-hour recalls. While 1,528 individuals of all ages responded "yes" to being an Aboriginal person in the CCHS 2.2, only a portion agreed to have their height and weight measured by the interviewer. One potential option to increase the analytical sample for the studies using the CCHS 2.2 is to combine or pool the data with one or more adjacent cycles of the survey. However, one issue is that the sample of CCHS 2.1 (conducted in 2003) was used as a sampling frame for CCHS 2.2. Therefore, the samples of these two surveys are not independent, making variance estimation for the pooled or combined cycles difficult (Thomas and Wannell 2009).

The next adjacent cycle of CCHS to cycle 2.2 was CCHS 3.1 (conducted in 2005). Combining data from CCHS 2.2 with that from the CCHS 3.1 would be problematic because key measures of interest were measured differently. In addition to having no 24-hour dietary or measured height and weight information for respondents in the main sample, the CCHS 3.1 was a telephone survey while data for the CCHS 2.2 data of interest were collected in-person, introducing "mode effects" into the results (St-Pierre
and Béland 2004). Although there is a CCHS 3.1 sub-sample 2 that included measured height and weight information for 4,735 Canadians from the ten provinces only (Statistics Canada 2007a), a new version of the socio-demographic characteristics module used to identify Aboriginal peoples was incorporated. This new wording results in slightly different proportion of respondents who self-identify as an Aboriginal person. The new ethnic origins module (used since June 2005) was asked of over two-thirds of respondents where 107 out of 3,231 respondents (3.3%) reported being an Aboriginal person. Only 39 out of 1,504 respondents (2.5%) who were asked the same version question as CCHS 2.2 reported being an Aboriginal person. Thus, while there exists data from more Aboriginal respondents from other cycles of the CCHS, it was not a feasible approach to combine these with data from the CCHS 2.2.

Although data were collected in 2004, data for the general and dietary recall components were first made available to the Research Data Centres (where the analyses must be conducted) in late 2006. The microdata files were revised in mid 2008 to correct known errors in the nutrition data and other variables, as well as incorporate vitamin and mineral supplement data and new derived income variables.


The target population of the longitudinal NPHS household component includes household residents in the ten Canadian provinces in 1994/1995 excluding persons living on Indian Reserves and Crown Lands, residents of health institutions, full-time members of the Canadian Forces Bases and some remote areas in Ontario and Québec. The
Household component is conducted every two years. For seasonality reasons, data is collected in four quarters: May, July, September and January. For non-respondents, there is an additional follow-up collection period in April of the second year.

The topics covered in the questionnaire include: disability, diseases and health conditions, education, literacy and skills, health, health care services, lifestyle and social conditions, mental health and well-being, and prevention and detection of disease.

The NPHS longitudinal sample is composed of 17,276 persons, created by first selecting households and then within each household, choosing one member 12 years of age or older to be the longitudinal respondent. The NPHS longitudinal sample consists of all longitudinal respondents who have completed at least the general component of the questionnaire in Cycle 1. It also includes 2,022 children from the first cycle (1994/1995) of the National Longitudinal Survey of Children and Youth (NLSCY) which also began in 1994/1995.

In Cycle 1, 75% of the interviews were conducted in person and the rest by telephone. Since Cycle 2, 95% of the interviews are conducted by telephone. Interviews in person are conducted if the respondent does not have a telephone, upon request by the respondent, or if the respondent lives in a health institution.

Sampling weights provided were computed using an initial weight representing the inverse probability of selection. This weight is then adjusted to take into account
specifics of the survey and to compensate for non-response. The weights were then post-stratified to be consistent with the reference year for the panel, which is the 1996 Census-based population estimates for 1994.

3.2 Definition of the Aboriginal Population

The Aboriginal population that is included in the NPHS and CCHS refers specifically to the off-reserve First Nations, Inuit and Métis population living in the ten provinces. Reserves are legally and constitutionally defined parcels of land set aside by the federal government for First Nations (North American Indian) people. (In Canada they are called “reserves” whereas in the United States they are referred to as “reservations”). Inuit and Métis people do not live in reserves, although they may inhabit communities and settlements where they form the overwhelming majority of the population. As explained below, the on-reserve First Nations population has been “incompletely enumerated” in recent censuses and is thus not sampled by surveys such as the NPHS and CCHS. The Aboriginal population in the NPHS and CCHS therefore is composed of Inuit, Métis, and First Nations people living off-reserve in the ten provinces, and should not be taken as representative of all Aboriginal peoples in Canada.

Statistics Canada’s main source of information on Aboriginal Canadians is from the Census of Canada undertaken every five years. The census ethnic origin questions are included in the long questionnaire which is administered to 20% of all households, while a short questionnaire is administered to the remaining 80% households asking only basic demographic information such as age and sex. In an attempt to capture a more complete picture of the Aboriginal population, the long questionnaire is administered to 100% of
households in northern areas, Indian reserves, Indian settlements, Indian government
districts and “terres réservées” (Statistics Canada 2007b). Such geographic areas in
Canada have high proportions of Aboriginal peoples with lower population density than
other areas in Canada.

Since the 1986 Census, a large number of First Nations reserves have chosen not to
participate in the Census, euphemistically referred by Statistics Canada as “incompletely
enumerated”. Statistics Canada estimated that there were 22 such incompletely
enumerated Indian reserves and Indian settlements in the 2006 Census, failing to capture
information for approximately over 40,000 persons (Statistics Canada 2008a).
Nevertheless, the Census of Canada remains the single largest source of data for
identifying the Aboriginal population, providing the sampling foundation for other
surveys on specific topics of interest to be conducted.

Multiple iterations of the ethnic origin or ancestry questions in the long and short
questionnaires have been attempted since 1871. Aboriginal people were defined by their
tribal descent or their matrilineal descent before 1951, but changed to their patrilineal
descent between 1951 to 1971. Since 1981, descent from either parent could be reported
and multiple origin responses were allowed.

Wording and format changes have also been made, but the basic concept of ethnic origin
remains. The 2006 Census long questionnaire asks respondents: “What were the ethnic
or cultural origins of this person’s ancestors? An ancestor is usually more distant than a
grandparent”. Examples such as “Canadian”, “English”, “French”, “Cree”, “Mi’kmaq (Micmac)”, “Métis”, “Inuit (Eskimo)”, etc, are provided.

Beginning in the 1996 Census, an Aboriginal identity question: “Is this person an Aboriginal person, that is, North American Indian, Métis or Inuit (Eskimo)?” was incorporated into the long questionnaire. This second concept was included to measure a person’s affiliation with one of the three Aboriginal groups in addition to the ancestry questions.

Comparing data based on Aboriginal identity has limitations. Drastic changes in response have been observed among 1996, 2001, and 2006 Censuses, far beyond those deemed possible due to births, deaths, or migration. For socio-political, personal, or other reasons, an increased number of people identified themselves as an Aboriginal person in 2006. A further identification problem independent of the wording of the census identity and ancestry questions is the proportion of individuals who change their reporting between Aboriginal and non-Aboriginal and within Aboriginal groups from one census to another.

Two other categories exist to identify those referred to as registered, status, or Treaty Indians under the Indian Act and those who are members of an Indian Band or First Nation. Like the Aboriginal identity questions, these categorizations should also be used with caution as these definitions are not necessarily reflective of one’s actual ancestral origins. There are indeed small percentages of persons identified as a registered or
Treaty Indian, for example, but do not report any Aboriginal ancestry. Similarly, there are individuals who report being a member of an Indian Band or First Nation who do not report any Aboriginal ancestry. To further complicate matters, some report one of Aboriginal identity or ancestry, but not both.

In most Statistics Canada surveys, including the CCHS and NPHS used in the following chapters, Aboriginal identity is the variable used. Due to intermarriage among different ethnic groups, a large proportion of the Aboriginal population reports multiple ancestries, reducing power to perform analyses on separate Aboriginal ethnicities. A respondent was considered an Aboriginal person if he or she self-identified with one or more Aboriginal groups. This definition includes those who identified with one or more Aboriginal groups and one or more non-Aboriginal groups.

Although it is important to recognize the diversity of Aboriginal people in Canada, insufficient sample sizes did not allow the separate analyses of Inuit, Métis and off-reserve First Nations from the CCHS 2.2 or the longitudinal NPHS. However, despite their diversity there is broad commonality among Aboriginal people relative to non-Aboriginal people in Canada to justify considering them as a group. This is analogous to treating “Canadians” as a group even though Canadians belong to multiple ethnic, linguistic, cultural, and socioeconomic subgroups.

The limit of the three studies of this thesis to the off-reserve Aboriginal population covered by CCHS and NPHS is actually not a drawback. This group has been shown to
exhibit poorer health than other Canadians (Tjepkema 2002). Furthermore, much of the published literature on “Aboriginal” health in Canada has been based predominately on studies among on-reserve First Nations people (Young 2002). Relatively little is known about the off-reserve population, and this thesis thus fills an important gap.

### 3.3 Statistical Analyses

Details on the specific data management and statistical procedures used are discussed separately in each of the three papers. The key statistical models used are described below.

**Individual Growth Curve Models**

In Chapter 4, individual growth curve models were used to determine whether the rate of change in BMI differed by Aboriginal identity. The two-level growth curve model can be expressed as follows:

**Level 1: Within Individual**

\[ \text{BMI}_{ij} = \pi_{0i} + \pi_{1i} (\text{YEAR}_{ij}) + \varepsilon_{ij} \]

**Level 2: Between Individual**

\[ \pi_{0i} = \gamma_{00} + \gamma_{01} \text{ABORIGINAL}_i + \gamma_{02} \text{MALE}_i + \zeta_{0i} \]

\[ \pi_{1i} = \gamma_{10} + \gamma_{11} \text{ABORIGINAL}_i + \zeta_{1i} \]

where \( \varepsilon_{ij}, \zeta_{0i}, \zeta_{1i} \) are error terms and \( i = \) individual respondent and \( j = \) measurement occasion.

Substituting Level 2 equations into Level 1 equation, the combined model can be expressed as the following:
\[ \text{BMI}_{ij} = \left[ \gamma_{00} + \gamma_{10} \times \text{YEAR}_{ij} + \gamma_{01} \text{ABORIGINAL}_i + \gamma_{02} \text{MALE}_i + \gamma_{11} \text{ABORIGINAL}_i \times \text{YEAR}_{ij} \right] + \left[ \zeta_0 + \zeta_{1i} \times \text{YEAR}_{ij} + \epsilon_{ij} \right] \]

where

\[ \left[ \gamma_{00} + \gamma_{10} \times \text{YEAR}_{ij} + \gamma_{01} \text{ABORIGINAL}_i + \gamma_{02} \text{MALE}_i + \gamma_{11} \text{ABORIGINAL}_i \times \text{YEAR}_{ij} \right] \]

is the fixed effects component and

\[ \left[ \zeta_0 + \zeta_{1i} \times \text{YEAR}_{ij} + \epsilon_{ij} \right] \]

is the random effects component.

Variables were defined as:

BMI is a continuous variable

ABORIGINAL = 1 if Aboriginal respondent, and = 0 if non-Aboriginal respondent

YEAR = years from baseline with values: 0 (cycle 1), 2, 4, 6, 8, 10, 12, 14 (cycle 8)

MALE = 1 if male, and = 0 if female

Estimates can be interpreted as the following:

\( \gamma_{01} \) = average difference in BMI between Aboriginal and non-Aboriginal respondents

\( \gamma_{02} \) = average difference in BMI between male and female respondents

\( \gamma_{10} \) = average rate of change in BMI (slope) for non-Aboriginal respondents

\( \gamma_{11} \) = average difference in rate of change in BMI (slope) between non-Aboriginal and Aboriginal respondents

**Logistic Regression Models**

For Chapters 5 and 6, logistic regression was used to assess the relationships between obesity status and social, economic, and lifestyle risk factors. The logistic regression model can be expressed as:

64
\[ \ln(\text{odds}(Y)) = b_0 + b_1X_1 + b_2X_2 + \ldots + b_kX_k \]

where:

- \( Y \) is the dependent variable of interest
- \( b_0 \) is the constant
- and there are \( k \) independent (\( X \)) variables where:
  - \( b_k \) terms are the logistic regression coefficients and \( \text{Exp}(b_k) = \text{the odds ratio for an independent variable } k \).

### Variance Estimation

Both the NPHS and the CCHS 2.2 sampling were complex, multistage designs where households were selected from different sampling frames in a clustered fashion. In this way, individuals had unequal probabilities of selection and respondents may not be independent of each other. There are two general classes of approaches for variance estimation when survey samples were not derived from simple random sampling: a Taylor linearization approach (Rao 2006) or a re-sampling approach such as the jackknife, balanced repeated replication, and bootstrap procedures (Rust and Rao 1996).

For both the NPHS and the CCHS 2.2, Statistics Canada provided sampling weight variables and a set of 500 bootstrap weight variables. Each bootstrap weight corresponds to a bootstrap sample of the primary sampling units (PSUs). Both the bootstrap and Taylor linearization approach assume that the design of the survey was approximately stratified multistage, and that there was with-replacement sampling of PSUs at the first stage. While Taylor linearization requires simplifying assumptions that ignore weight adjustments due to non-response and post-stratification (Demnati and Rao 2004), an
advantage of the bootstrap approach is that these adjustments can be incorporated (Roberts et al. 2003).

The Statistics Canada bootstrap approach to variance estimation involves several steps as described by Roberts et al. (2003):

1. Use the full sample to get estimate of $\hat{\theta}$ of $\theta$
2. Form the $b^{th}$ replicate by sampling $n_{h}-1$ PSUs independently with replacement from the $n_{h}$ sampled PSUs in the stratum
3. Create the $b^{th}$ replicate weight variable by adjusting the original weight variable on each unit, to account for the results of the replicate sampling, nonresponse, post-stratification, etc.
4. Calculate the estimate $\tilde{\theta}_{b}$ using the $b^{th}$ replicate weight variable, in the same way as $\theta$ was calculated
5. Repeat steps (1) to (4) $B$ times (for both CCHS and NPHS, $B = 500$)
6. Calculate the bootstrap estimate of the covariance matrix of $\tilde{\theta}$ as:

$$
\tilde{v}_{xz} = \frac{\sum_{b=1}^{B} (\tilde{\theta}_{b} - \hat{\theta})(\tilde{\theta}_{b} - \hat{\theta})'}{B}
$$

One potential issue arises with using Statistics Canada’s bootstrap approach for variance estimation when the planned analyses involve small subsamples. In the case of iterative model-fitting such as in a logistic regression, fitting problems may occur from some of the 500 replicate samples in domains containing relatively small samples from a subpopulation. This may cause non-convergence of the iterative algorithm and possibly
unacceptable coefficient estimates being used in the bootstrap variance calculations (Roberts et al. 2003).

Initial logistic regression analyses using the CCHS 2.2 for studying associated risk factors for obesity among Aboriginal Canadians revealed that this may be the case as the Aboriginal sample is relatively small. Thus, for the studies using the CCHS 2.2 data, the Statistics Canada supplied bootstrap weights were not used. Since PSU and stratum details were provided with the CCHS 2.2 (Statistics Canada 2008c), the Taylor linearization approach using these design details was used to estimate variance. While it is suggested that a domain analysis be used for subpopulation analyses whereby the subpopulation is treated as a random variable (Heeringa et al. 2010), this was not employed in the studies using the CCHS 2.2 for several reasons. First, the Aboriginal population sampled in the CCHS 2.2 was itself an additional sampling frame as all respondents who reported being an Aboriginal person living in the ten provinces in the CCHS 2.1 were asked to participate in CCHS 2.2 (Statistics Canada 2008b). This additional sampling frame was included in an attempt to achieve a large enough Aboriginal sample for analyses of dietary intakes. The sampling fraction for Aboriginal Canadians was deliberately made larger than the average fraction in order to increase this domain’s sample size. This oversampling may increase the precision of estimates from this domain and possibly allowing direct estimation of this domain (Rao 2003). Thus, considering the Aboriginal domain as a random effect may be unreasonable. Further, under the subpopulation distribution types described by Heeringa et al. (2010), the Aboriginal subsample may resemble the “design domain” type where the distributional
pattern of Aboriginal respondents are concentrated in certain subsets of strata and PSUs (specifically targeted in the Aboriginal sampling frame). However, since the Aboriginal population is also a relatively “rare” subclass of the total sampled population and Aboriginal respondents are likely to be sparsely distributed across strata and PSUs—resembling the “mixed class” distributional pattern—it is recognized that the sampling errors are based on fewer degrees of freedom than estimates for the full sample and the variance estimates obtained by Taylor linearization may indeed overestimate the precision of estimates.

It is nearly an impossible task to account for every sampling feature and weight adjustment in design-based statistical analyses. Because it may be unreasonable to assume that all respondents in this Aboriginal subpopulation could belong to any PSUs, in analyses of the CCHS 2.2 data, the subclass sample size was not captured as a random variable in the variance calculation. A compromise was made by incorporating the clusters and strata design information into variance estimation by Taylor linearization so that the potential dependence of respondents within the same cluster is accounted for. In the analyses with the CCHS 2.2 data, the potential effect of weight adjustments was necessarily assumed to be negligible as Taylor linearization cannot accommodate these adjustments (Rao 2006).

For the analyses with the NPHS data, the Statistics Canada bootstrap approach was not used for variance estimation of the individual growth curve models since current software available cannot readily incorporate this approach. The bootstrap method was, however,
applied to variance estimation of the mean rate of change in BMI obtained by ordinary least squares regression.

How well an estimate is truly representative of the actual off-reserve First Nations, Métis, and Inuit population in the ten provinces is uniquely difficult to ascertain compared to other ethnic groups because the Aboriginal population is known to be incompletely enumerated in the Census of Canada (Statistics Canada 2008a). Without “gold standard” population counts, the true target population is itself unclear. This limitation that the results of all analyses contained in this thesis may not represent the true off-reserve First Nations, Métis, and Inuit population living in the ten provinces is acknowledged throughout this thesis.
Abstract

Objective: Aboriginal Canadians have a high burden of obesity and obesity-related chronic conditions. Body mass index (BMI) trajectories from 1994 to 2009 were estimated for Aboriginal and non-Aboriginal Canadians using self-reported height and weight data from the National Population Health Survey to explore age, period, and cohort effects of BMI change.

Methods: Linear growth curve models were estimated for 311 Aboriginal and 10,967 non-Aboriginal respondents divided into five birth cohorts born in the 1940s, 50s, 60s, 70s, and 80s.

Results: Overall, Aboriginal Canadians experienced higher rates of BMI increase over the 14-year period. Rate of BMI increase was specifically higher for Aboriginal adults born in the 1960s and 1970s when compared with non-Aboriginal adults. At ages 25, 35, and 45, recent-born cohorts had consistently higher BMIs compared with earlier-born cohorts with magnitudes of differences typically larger in the Aboriginal population. Recent-born cohorts also exhibited steeper BMI trajectories.

Conclusion: Cohort effects may be responsible for the divergent BMI trajectories between Aboriginal and non-Aboriginal Canadians born in the 1960s and 1970s. Aboriginal Canadians, particularly of more recent-born cohorts, experienced faster increases in BMI from 1994 to 2009 than non-Aboriginal Canadians, suggesting that prevalence of obesity will continue to rise in this population without intervention.
Introduction

Aboriginal Canadians have the highest prevalence of overweight and obesity compared to other Canadians. Using the most recently available measured height and weight data from the Canadian Community Health Survey Cycle 2.2 (CCHS 2.2) to derive body mass index (BMI, kg/m$^2$), estimates of the off-reserve First Nations, Métis, and Inuit population in the ten provinces revealed that the prevalence of obesity among Aboriginal Canadians was over two times higher than non-Aboriginal Canadians. Twenty percent of Aboriginal youth aged 12 to 17 years (Shields 2006) and 38% of Aboriginal adults aged 18 years and over (Tjepkema 2006) were obese in 2004.

Over the past few decades, prevalence of obesity among the general Canadian population has been on the rise (Luo et al. 2007; Torrance et al. 2002; Tremblay et al. 2002). Although the trends observed were based on various nationally-representative cross-sectional surveys conducted between 1970 and 2004, there is sufficient evidence to suggest that period effects are quite relevant when exploring changing patterns of obesity in the Canadian population. Data from cross-sectional surveys such as the CCHS 2.2 are useful for identifying the high rates of obesity that exist within the Canadian Aboriginal population. From these data, obesity prevalence is known to be higher among Aboriginal adults compared to youth, suggesting that obesity development is also very much age-related. At the same time, age and period effects cannot be examined without consideration of potential cohort effects.
Exploring cohort effects of obesity prevalence are particularly interesting as rapid lifestyle changes among at least some Aboriginal Canadian populations (Hanley et al. 1995; Szathmary et al. 1987; Young 1988) have been proposed as one reason for high prevalences of obesity-related chronic conditions among this population, particularly type 2 diabetes (West 1974). In addition, Aboriginal Canadians born between certain time periods in recent history underwent significant social and cultural stresses such as forced acculturation and relocation (Bartlett 2003), as well as environmental dispossession and loss of land (Richmond and Ross, 2009). Such experiences have been previously postulated to negatively influence the health status of some Aboriginal Canadians (Berry 1990).

Others have attempted to disentangle age-period-cohort effects of obesity, but few studies have been based on longitudinal data. For instance, Reither et al. (2009), Komlos and Brabec (2010), and Keyes et al. (2010) pooled cross-sectional cycles of the NHANES. One advantage of these studies combining multiple cycles from different years is that a long period of time can be covered, because individual respondents are not followed for long periods of time. However, by pooling multiple waves of cross-sectional data, it is assumed that the population does not change over time. In the United States and Canada, immigration and emigration are quite common and the population is evolving. While one study restricted the analytic sample to United States-born respondents only (Keyes et al. 2010), out-migration of citizens still cannot be fully accounted for. It is plausible that citizens who choose to emigrate to other countries are doing so for employment reasons.
and thus bias can be introduced if such workers are likely to be healthier and possibly less likely to be obese (Gates et al. 2008).

Given the dramatically higher rates of obesity observed among Aboriginal Canadians, longitudinal trends in BMI change among this population deserve attention. This information will help to describe trajectories of BMI among Aboriginal Canadians in relation to non-Aboriginal Canadians as well as allow for the identification of when peak BMI growth occurs in the development of obesity.

The objectives of this study were to explore age, period, and cohort effects by analyzing the BMI growth trajectories and rates of BMI change over a 14-year period among Aboriginal Canadians and compare these with non-Aboriginal Canadians using nationally-representative longitudinal health survey data.

Methods

Data source

Data from the longitudinal National Population Health Survey (NPHS) conducted by Statistics Canada, nationally representative of the ten provinces of Canada, were used in this study (Statistics Canada 2006c). The NPHS was designed to collect longitudinal data on the health of the Canadian population and related socio-demographic information. The first cycle of data collection took place in 1994/1995. Thereafter, the survey collected data every second year and has completed eight cycles from 1994/1995 to 2008/2009. The target population of the NPHS included all household residents living in
the ten provinces in 1994/1995 excluding persons living on Indian Reserves and Crown Lands, residents of health institutions, full-time members of the Canadian Forces Bases and some remote areas in Ontario and Québec. The longitudinal sample consists of 17,276 respondents. Overall response rate at cycle 1 was 86.0%. Longitudinal response rates at subsequent cycles were 93.6%, 88.9%, 84.9%, 80.8%, 77.6%, 77.0%, and 70.7% for cycles 2 to 8, respectively. A respondent was considered “responded” if they provided complete or partial responses to the interview, were deceased, or institutionalized. At cycle 8, 9,680 respondents completed the survey, while 2,373 of the original panel of 17,276 members were deceased, and 163 were institutionalized.

Interviews lasting approximately 1 hour were conducted using a computer assisted interview system. In Cycle 1, 75% of the interviews with the longitudinal respondents were conducted in person and the rest by telephone. Since Cycle 2, approximately 95% of the interviews were conducted by telephone. In-person interviews were conducted if the respondent did not have a telephone, upon request by the respondent, or if the respondent lived in a health institution. Interviews for respondents under 12 years old were done by proxy. Proxy reporting was also possible for reasons of illness or incapacity.

All respondents with ethnicity self-ascribed as Native/Aboriginal Peoples of North America comprised the Aboriginal group and all others were non-Aboriginal. Respondents were asked to self-report their height and body weight. These were
subsequently used to calculate BMI by dividing weight in kilograms by height in meters$^2$ (kg/m$^2$).

*Study population*

Five 10-year cohorts were created from year of birth (YOB) in order to explore possible cohort effects over the 14-year period between 1994 and 2009: YOB 1940-1949, YOB 1950-1959, YOB 1960-1969, YOB 1970-1979, and YOB 1980-1989. Ten-year ranges were used to allow for a minimum cell size of 10 and for age overlap between three cohorts over the course of the study (i.e., members from three cohorts be of the same age). To check whether results would be influenced by differential coding of birth cohorts, cohorts were also categorized as 10-year birth year intervals falling in between the decade classifications: YOB 1945-1954, YOB 1955-1964, YOB 1965-1974, YOB 1975-1984, and YOB 1985-1993. Respondents born in years 1994 and 1995 were available, but were excluded because BMI overweight and obesity cutoffs are only available for children aged two years and older (Cole et al. 2000). Since the overall results did not differ from those using the cohorts determined by calendar decade of birth, the decade groupings are reported here for simplicity.

For this study, 311 Aboriginal and 10,967 non-Aboriginal individuals born between 1940 and 1989 with at least two measures of self-reported BMI from any two cycles were available for analyses. BMIs of pregnant women were excluded.
Statistical analyses

All analyses were weighted using the survey sampling weights provided by Statistics Canada. All data manipulation and analyses were completed using SAS (version 9.2). Level of significance was set at $p<0.05$.

Individual growth curve models can measure individual change over time and allow for comparisons of rate of change between groups (Singer and Willett 2003). Initial analyses revealed significant variability in the BMI trajectories of individuals. Thus, models incorporating random components for intercept and linear slope were examined.

Growth curve models for each of the five birth cohorts and the entire sample were fitted using the SAS procedure PROC MIXED to assess whether the linear rate of change in BMI differed between the Aboriginal and non-Aboriginal groups. Terms to determine whether the quadratic rate of change in BMI differed between Aboriginal and non-Aboriginal groups were originally included in the models, but were excluded from the models presented here for two reasons. First, the estimates for quadratic rates of change were very small relative to the linear rates of change within each of the 10-year age ranges. In addition, using PROC MIXED, linear growth curve models are not as affected by missing data compared to non-linear growth curve models (Zhang and Wang 2009). To examine the influence of missing data in this study, analyses were repeated separately among respondents who had four to eight measures of BMI available. Correlations between predicted values (from the fixed effects estimates only) and observed BMI values were calculated.
Because the NPHS used a complex sampling design, Statistics Canada recommends that a weighted bootstrap technique be employed for estimation of variances. However, the bootstrapping procedure cannot be readily incorporated with PROC MIXED. Thus, to supplement the growth curve analyses, linear slopes for BMI were calculated by ordinary least squares (OLS) linear regression using PROC REG to obtain estimated values of BMI change per year for each respondent (Matthews 1993). Mean BMI change for each birth cohort were then calculated and compared between Aboriginal and non-Aboriginal groups. For these comparisons, the bootstrap technique was used to estimate variances using PROC SURVEYMEANS and PROC SURVEYREG with the bootstrap weights specific to the NPHS provided by Statistics Canada to account for the design effect. For these mean OLS results, because many significance tests were made, both 95% confidence intervals and p-values are reported so that the plausible range, direction, and strength of the difference in rate of BMI increase can be interpreted rather than relying solely on the p-value (Sterne and Smith 2001). While it is possible to lower the arbitrary threshold p=0.05 using the Bonferroni method to adjust for multiple comparisons, this was not appropriate in this study (Rothman 1990). In a large health survey such as the NPHS where many associations between variables can be studied by many researchers, it is not possible to account for each significance test (Rothman and Greenland 2008). It is important to note that for this study, significance testing of difference in rates of BMI change between Aboriginal and non-Aboriginal groups within each cohort were planned comparisons to supplement the growth curve analyses. Analyses from both the growth
curve models and the individual linear slopes were used to assess whether rates of BMI change differed between Aboriginal and non-Aboriginal Canadians within birth cohorts.

To further explore potential age, period, and cohort effects, predicted BMI values from the growth curve models were then graphed in the following ways. First, linear trajectories were plotted across the survey years (years 1995 to 2009 as x-axis) for assessment of the general period effect of each birth cohort by Aboriginal identity. Aboriginal and non-Aboriginal BMI trajectories of each cohort were then plotted by age with their adjacent cohorts to display any differences at the overlapping ages of 25 (cohorts 1980s, 1970s, 1960s), 35 (cohorts 1970s, 1960s, 1950s), 45 (cohorts 1960s, 1950s, 1940s), and 55 (1950s, 1940s).

**Results**

Mean follow-up times for the five cohorts for the Aboriginal sample ranged from 10.7-11.8 years and the mean number of BMI measures ranged from 5.6-6.5 (Table 1). For the non-Aboriginal sample, follow-up times for the five cohorts ranged from 11.6-12.0 years and the mean number of BMI measures ranged from 6.2-6.7 (Table 1). Approximately 90% of the non-Aboriginal and 86% of the Aboriginal population had a minimum of four BMI observations.

The estimated rate of change in BMI differed between Aboriginal and non-Aboriginal (linear slope: see Aboriginal*year) cohorts born in the 1960s and 1970s (Table 2a and 2b, for respondents with at least two and four BMI observations, respectively). According to
these modeled data, on average, non-Aboriginal Canadians experienced a BMI increase of 0.25 units per year compared to 0.34 units per year among Aboriginal Canadians for those born in the 1970s. Among those born in the 1960s, non-Aboriginal Canadians experienced an average increase of 0.16 units per year compared to 0.23 units per year among Aboriginal Canadians. These results from growth curve modeling were closely replicated by the individual slope calculated from OLS regression (Table 3a and 3b, for respondents with at least two and four BMI observations, respectively). In these analyses where differences between groups were estimated using the weighted bootstrapping procedure accounting for the complex sampling design, the difference between Aboriginal and non-Aboriginal groups among the 1960s cohort was only significant among those with at least four BMI observations or more.

Linearly predicted BMI trajectories plotted against time (cycle year) for Aboriginal and non-Aboriginal groups are shown in Figure 1. Since data collection for each survey cycle occurred over two years, graph labels use the latter year. Thus, although the labels indicate starting year of 1995, some of the data were actually collected in 1994 and the trajectories cover the period between 1994 and 2009.

As expected, younger Canadians born in the 1980s showed the greatest increases in BMI over the period from 1994 to 2009 as the survey captured their rapid growth during childhood, adolescence, and young adulthood. Based on the growth curve models, on average, these respondents experienced an approximate increase of 0.5 units of BMI per year, but the slopes were parallel between Aboriginal and non-Aboriginal groups.
However, points of divergence were observed among birth cohorts 1960s and 1970s, reflecting the significant differences in rates of BMI change between groups reported in Tables 2 and 3. For cohorts born in the 1940s and 1950s, similar rates of change were evident between groups.

Inferences about age, period, and cohort effects may be speculated from graphical depictions of the estimated BMI growth trajectories of cohorts with overlapping age ranges (Figure 2). For both Aboriginal and non-Aboriginal Canadians, BMI is higher in more recent born cohorts compared to earlier born cohorts, suggesting the existence of a period effect. At the intersecting ages of 25, 35, and 45, the highest BMIs observed were consistently those of the most recent born cohort of each respective graph. The magnitude of differences was much more pronounced among Aboriginal Canadians, however. In Figure 2, comparing the 1980s cohort with the 1960s, based on the modeled BMI trajectories within Aboriginal and non-Aboriginal groups differed by approximately 1 BMI unit at age 25. However, differences between early and recent Aboriginal cohorts were almost 3 units at ages 35 and 45. Compared with their non-Aboriginal counterparts, the steeper slopes of the Aboriginal BMI trajectories translate to an average peak BMI of almost 32 kg/m$^2$ from ages 45 to 55, significantly higher than the peak BMI of just over 28 kg/m$^2$ from ages 55 to 65 among non-Aboriginal adults.

**Discussion**

Longitudinal data are required to disentangle age, period, and cohort effects and to our knowledge, the NPHS is the only source of publicly available data providing up to eight
serial self-reported measures of BMI over a span of 14 years. Since age, period, and cohort are linearly dependent, all three cannot be estimated simultaneously (Menard 2001), graphical depictions of the data can aid in the exploration of such effects. For the purposes of this study, whether rates of change in BMI differed between age groups were of primary interest. Due to the small sample size, single year age effects could not be estimated separately, but were necessarily grouped into birth cohorts by decade.

Nationally-representative cross-sectional studies comparing BMI between Aboriginal and non-Aboriginal adults (Shields 2005; Tjepkema 2006; Tremblay et al. 2005) and children (Shields 2005) have consistently indicated that obesity is more prevalent among Aboriginal Canadians. The results of this study are also consistent with cross-sectional studies of various regional areas in Canada (Gittelsohn et al. 1996; Young et al. 1993; Young and Sevenhuysen 1989), where BMI was observed to steadily increase with age until approximately age 60.

Earlier analyses of six waves of the NPHS data have shown that adults aged 18 to 64 years gained on average 4.01 kg for men and 3.44 kg for women between 1996 to 2005 (Orpana et al. 2007). Trends in weight change were described as a dynamic process where some individuals lose weight during one interval, but may then gain weight during the next or vice versa. Body weight change patterns can also differ by race (Burke et al. 1996), gender (Chiriboga et al. 2008), and socioeconomic status (Ball et al. 2005).
This study adds further detail by describing modeled BMI trajectories in the context of age, period, and cohort effects and focuses on exploring the development of obesity in an ethnic group with the highest rates of obesity in Canada. In addition to higher BMIs for any given age until approximately age 65 where data are sparse, Aboriginal Canadians have a different BMI trajectory compared to non-Aboriginal Canadians. While higher BMI itself is a risk factor for adverse health outcomes, the higher rate of change in BMI over the life course observed among Aboriginal Canadians is also of concern. One advantage of this analysis is that the rate of BMI change within individuals was able to be estimated in addition to between-individual differences in BMI. This study provides evidence for the existence of a point of divergence where the BMI of Aboriginal Canadians increases at a faster pace, resulting in peak BMI that is higher than that of non-Aboriginal Canadians. The duration of obesity is a significant health indicator as it is an important risk factor in the development of type 2 diabetes (Everhart et al. 1992; Pontiroli and Galli 1998; Sakurai 2000) and hypertension among adults (Droyvold et al., 2005; Juhaeri et al. 2002) and children (McGavock et al. 2007; Mirzaei et al. 2007).

Independent of baseline BMI, instability in BMI has been linked to cardiovascular disease and metabolic risk factors among adults (Christen et al. 2007) and rate of increase in adiposity has been linked to poorer blood lipid profiles among children (Srinivasan et al. 2001).

An upsurge in the modeled rate of BMI change compared to non-Aboriginal Canadians occurred most markedly for Aboriginal Canadians born in the 1960s and 1970s who were between 15 and 35 years of age at the beginning of the study. It is unclear whether this
group of individuals is a unique cohort or that the differences were age-related and specific to Aboriginal Canadians. Some of these individuals may be part of a generation who experienced profound cultural and social experiences that have influenced their health negatively. Detailed exploration of characteristics of each cohort would require further investigation of this population using socio-ethnographic research methods.

It is plausible that the steep increase in BMI for this age group over the 14 years of the survey is in fact a biological or genetic characteristic unique to Aboriginal Canadians. Genetic variability in BMI change (Coady et al. 2002) and ethnic differences in growth patterns have also been previously described between black and white Americans (Ambrosius et al. 2001; Sheehan et al. 2003). In one study, the period of adolescence was identified as the point of divergence where the higher rate of BMI increase observed among black adolescents was attributed partly to earlier puberty compared to white youth (Kimm et al. 2001). Unfortunately, accurate pubertal status was not available with the NPHS, but other longitudinal surveys may be useful for this purpose (e.g. National Longitudinal Survey of Children and Youth).

Aboriginal peoples in Canada form a very diverse population encompassing many cultural and linguistic groups. The target population of this study was limited to off-reserve First Nations, Métis, and Inuit people living in the ten provinces. Because a large proportion of the Aboriginal population was not in the sampling frame of the survey used (namely First Nations peoples living on reserves and a large majority of the Inuit population who live in Canada’s three northern territories), the results may not be
representative of all Aboriginal people in Canada. Moreover, because the results of this study were based on a Statistics Canada health survey, individuals who were not captured by Statistics Canada’s methods of identifying Aboriginal Canadians would also not be represented (Statistics Canada 2007b). However, the off-reserve population included here has often been excluded from most previous studies of Aboriginal health in Canada as many researchers have chosen to focus on smaller, geographically circumscribed Aboriginal communities (Young 2003).

BMI is a proxy measure for body fatness with known limitations (Lemieux et al. 2004). While at the individual level, BMI may fail to accurately detect increased health risk, it has been found to be a reliable indicator of increased risk for various chronic diseases at the population level (Rabkin et al. 1997). In adulthood, height is assumed to be constant and absolute weight change measured in units of either kilograms or pounds have been used to assess change in health risk. Weight change does not have a linear impact on health risk among individuals of differing initial body weights. For example, an individual 2 m tall achieving a weight loss of 5 kg from an initial body weight of 120 kg (BMI change from 30.0 to 28.8 kg/m$^2$) may not experience the same magnitude of reduced health risk with a 5 kg weight loss as a person whose initial body weight was just 100 kg (BMI change from 25.0 kg/m$^2$ to 23.8 kg/m$^2$). In addition, this study also included children and youth who may be growing in height. Thus, for this study, BMI was used as the predictor variable instead of absolute weight change.
One major limitation of this study was that BMI was self-reported rather than objectively measured. However, misreporting was not expected to be different between Aboriginal and non-Aboriginal groups. Although it has been suggested that individuals are likely to underestimate their body weight and perhaps overweight individuals being more likely to do so (Connor Gorber et al. 2007), this would have in fact biased the results towards the null hypothesis that there is no difference in rate of change in BMI between Aboriginal and non-Aboriginal groups since higher prevalences of overweight and obesity were present among the Aboriginal Canadians in this study.

Based on evidence from other Canadian data, the impact of potential differences in rates of BMI change between reported and measured BMI may not have led to significantly different findings. In a study using national data collected in 2005 from a sample of 4,567 Canadians aged 12 years and over, self-reported BMI was found to be lower than measured BMI by 0.9 units in males and 1.2 units in females (Shields et al. 2008). Among 854 Canadian children aged 6 to 11 years, parent-reported BMI was observed to over-estimate measured BMI by 1.1 units in boys and 0.3 units in girls from national data collected between 2007 and 2009 (Shields et al. 2011). Data from a sample of 1,464 4-year-old children from the province of Québec in 2002 suggest that although 16% of mothers’ estimates of child BMI were higher than measured values and 14% of mothers under-estimated their child’s BMI, mother-reported BMI was observed to be within 0.1 units of measured values on average (Dubois and Girard 2007). It is not known specifically whether self- or parent-reported BMI is more or less accurate among
Aboriginal compared to non-Aboriginal Canadians, but it is recognized that the data used in this study were subject to some reporting bias.

Another limitation of this study was the rate of attrition in the NPHS. It was assumed that responses were missing at random. Further analysis may be able to reveal any potential patterns in missing data perhaps through the use of models predicting missingness. The PROC MIXED procedure in SAS allows for flexible treatment of missing data. The data of the NPHS are unbalanced, i.e., not every respondent provided complete responses to all eight cycles of the survey. Several methods may be used to assess whether patterns of missingness in the data bias the results, primarily to determine whether missingness is ignorable because it is random (Diggle et al. 2002). One way to model dropout is to determine whether dropout is due to respondents' measurement history. It is also possible to compare characteristics of individuals who respond to all cycles with those who do not. As described by Diggle et al. (2002), Heckman selection models can help estimate whether responses are missing at random (Heckman 1979). If data are not missing at random, it may be possible to determine whether these are related to respondent characteristics. Since dropout can also be related to characteristics not measured in the survey, random effects models may be used (Diggle et al. 2002). With this analysis, unobserved characteristics would be included as a random effect in models.

One simplistic analysis is to drop all respondents who do not have valid responses to all variables of interest for all eight cycles of data. However, an obvious problem with this strategy is that individuals may fail to respond for non-ignorable reasons. Another
example is that all women who reported being pregnant during any of the survey cycles would need to be excluded from the analyses as their BMI measure would be do not be a valid BMI observation. Thus, a complete case analysis would potentially exclude much meaningful information.

Another type of analysis strategy to deal with missingness is to impute missing information either simply by carrying forward the last observation, or more complexly by multiple imputation methods. One advantage of imputation is that no observations would need to be deleted. However, many assumptions need to be made for multiple imputation and it is possible that this strategy may bias the analyses itself.

Since the NPHS had eight cycles over 14 years, a complete case analysis would only involve approximately half of all respondents originally included in cycle 1. In order to determine whether missingness was an issue in the NPHS, a sensitivity analysis was conducted where respondents with four observations of BMI or more were compared with those with two or more BMI observations.

While there may be differences between sexes, the analyses could not be further stratified by sex due to the relatively small sample size of the Aboriginal group. Attempts to stratify the analyses by sex revealed similar results for both sexes within the Aboriginal group. Thus, to preserve statistical power for the purposes of testing differences in rates of change between the Aboriginal and non-Aboriginal groups, the models were not stratified by sex, but sex was included as a covariate in all models.
In summary, Aboriginal Canadians experienced more adverse BMI trajectories with higher initial BMI in youth, followed by continued increase BMI through to late adulthood. Among this sample of Aboriginal Canadians, peak BMI was significant higher. More recent born cohorts consistently had higher BMI. Prevention efforts should be targeted to prevent weight gain prior to obesity development and intervention strategies should be implemented to promote weight loss among those at health risk.
Table 1. Sample sizes and mean age, follow-up time, and number of observations of each birth cohort, by Aboriginal identity.

<table>
<thead>
<tr>
<th>YOB</th>
<th>Cycle Year</th>
<th>1 1994/5</th>
<th>2 1996/7</th>
<th>3 1998/9</th>
<th>4 2000/1</th>
<th>5 2002/3</th>
<th>6 2004/5</th>
<th>7 2006/7</th>
<th>8 2008/9</th>
<th>Mean Follow-Up Time (years)</th>
<th>Mean BMI Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>Mean Age (years)</td>
<td>10 14 16 17 19 21 23</td>
<td>11.3 5.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>54 48 46 43 37 33 21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Aboriginal</td>
<td>1487 1473 1457 1422 1390 1267 1196</td>
<td>12.1 6.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970s</td>
<td>Mean Age (years)</td>
<td>20 23 26 30 32 34</td>
<td>11.8 6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>77 63 64 60 56 59 35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Aboriginal</td>
<td>1909 1881 1754 1641 1532 1415 1372</td>
<td>11.6 6.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960s</td>
<td>Mean Age (years)</td>
<td>30 34 36 38 40 42 44</td>
<td>10.7 5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>89 69 69 58 57 54 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Aboriginal</td>
<td>2527 2493 2370 2233 2103 1983 1939</td>
<td>11.7 6.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950s</td>
<td>Mean Age (years)</td>
<td>39 43 45 47 49 51 53</td>
<td>11.2 6.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>44 39 39 33 32 31 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Aboriginal</td>
<td>2550 2552 2409 2266 2153 2028 2001</td>
<td>12.0 6.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940s</td>
<td>Mean Age (years)</td>
<td>49 53 55 57 59 61 63</td>
<td>11.7 6.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>34 33 29 32 28 28 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Aboriginal</td>
<td>1922 1916 1813 1726 1609 1512 1468</td>
<td>11.9 6.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2a: Individual growth curve modeling results for respondents with 2 or more BMI observations. Correlations between predicted values from PROC MIXED and actual observed.

<table>
<thead>
<tr>
<th>Decade</th>
<th>Effect</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>P-value</th>
<th>n</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>Intercept</td>
<td>18.67</td>
<td>0.13</td>
<td>&lt;.0001</td>
<td>1649</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.64</td>
<td>0.17</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>0.77</td>
<td>0.52</td>
<td>0.143</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.45</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal*Year</td>
<td>0.00</td>
<td>0.06</td>
<td>0.964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970s</td>
<td>Intercept</td>
<td>22.53</td>
<td>0.12</td>
<td>&lt;.0001</td>
<td>2109</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.34</td>
<td>0.16</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>0.33</td>
<td>0.45</td>
<td>0.463</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.25</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal*Year</td>
<td>0.09</td>
<td>0.04</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960s</td>
<td>Intercept</td>
<td>24.09</td>
<td>0.11</td>
<td>&lt;.0001</td>
<td>2788</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.49</td>
<td>0.16</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>1.43</td>
<td>0.47</td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.16</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal*Year</td>
<td>0.07</td>
<td>0.03</td>
<td>0.028</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950s</td>
<td>Intercept</td>
<td>24.66</td>
<td>0.12</td>
<td>&lt;.0001</td>
<td>2698</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1.54</td>
<td>0.17</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>2.18</td>
<td>0.64</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.15</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal*Year</td>
<td>0.04</td>
<td>0.04</td>
<td>0.343</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1940s</td>
<td>Intercept</td>
<td>26.17</td>
<td>0.15</td>
<td>&lt;.0001</td>
<td>2034</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.80</td>
<td>0.21</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>1.25</td>
<td>0.78</td>
<td>0.108</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.09</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aboriginal*Year</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.536</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2b: Individual growth curve modeling results for respondents with 4 or more BMI observations. Correlations between predicted values from PROC MIXED and actual observed.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>P-value</th>
<th>n</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1980s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>18.65</td>
<td>0.13</td>
<td>&lt;.0001</td>
<td>1554</td>
<td>0.43</td>
</tr>
<tr>
<td>Male</td>
<td>0.61</td>
<td>0.17</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal</td>
<td>0.66</td>
<td>0.54</td>
<td>0.223</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.44</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal*Year</td>
<td>0.00</td>
<td>0.06</td>
<td>0.939</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1970s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>22.55</td>
<td>0.12</td>
<td>&lt;.0001</td>
<td>1878</td>
<td>0.30</td>
</tr>
<tr>
<td>Male</td>
<td>1.35</td>
<td>0.17</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal</td>
<td>0.39</td>
<td>0.49</td>
<td>0.418</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.25</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal*Year</td>
<td>0.11</td>
<td>0.04</td>
<td>0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1960s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>24.16</td>
<td>0.12</td>
<td>&lt;.0001</td>
<td>2444</td>
<td>0.22</td>
</tr>
<tr>
<td>Male</td>
<td>1.45</td>
<td>0.17</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal</td>
<td>2.05</td>
<td>0.52</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.16</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal*Year</td>
<td>0.08</td>
<td>0.03</td>
<td>0.029</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1950s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>24.73</td>
<td>0.12</td>
<td>&lt;.0001</td>
<td>2395</td>
<td>0.20</td>
</tr>
<tr>
<td>Male</td>
<td>1.51</td>
<td>0.18</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal</td>
<td>1.68</td>
<td>0.70</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.15</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal*Year</td>
<td>0.02</td>
<td>0.04</td>
<td>0.689</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1940s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>26.23</td>
<td>0.15</td>
<td>&lt;.0001</td>
<td>1827</td>
<td>0.11</td>
</tr>
<tr>
<td>Male</td>
<td>0.83</td>
<td>0.22</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal</td>
<td>1.14</td>
<td>0.83</td>
<td>0.169</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.09</td>
<td>0.01</td>
<td>&lt;.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aboriginal*Year</td>
<td>0.00</td>
<td>0.05</td>
<td>0.965</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3a: Mean individual slopes calculated with PROC SURVEYMEANS for respondents with 2 or more BMI observations. T-test value difference between Aboriginal and non-Aboriginal groups calculated using 500 bootstrap weights.

<table>
<thead>
<tr>
<th>Decade</th>
<th>n</th>
<th>Mean</th>
<th>Standard Error</th>
<th>95% CI for Mean</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>Non-Aboriginal</td>
<td>1593</td>
<td>0.44</td>
<td>0.01</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>56</td>
<td>0.26</td>
<td>0.22</td>
<td>-0.17</td>
</tr>
<tr>
<td>1970s</td>
<td>Non-Aboriginal</td>
<td>2031</td>
<td>0.23</td>
<td>0.01</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>78</td>
<td>0.33</td>
<td>0.05</td>
<td>0.24</td>
</tr>
<tr>
<td>1960s</td>
<td>Non-Aboriginal</td>
<td>2696</td>
<td>0.15</td>
<td>0.01</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>92</td>
<td>0.20</td>
<td>0.03</td>
<td>0.14</td>
</tr>
<tr>
<td>1950s</td>
<td>Non-Aboriginal</td>
<td>2651</td>
<td>0.14</td>
<td>0.01</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>47</td>
<td>0.28</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>1940s</td>
<td>Non-Aboriginal</td>
<td>1996</td>
<td>0.08</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>38</td>
<td>-0.14</td>
<td>0.13</td>
<td>-0.39</td>
</tr>
</tbody>
</table>

### Table 3b: Mean individual slopes calculated with PROC SURVEYMEANS for respondents with 4 or more BMI observations. T-test value difference between Aboriginal and non-Aboriginal groups calculated using 500 bootstrap weights.

<table>
<thead>
<tr>
<th>Decade</th>
<th>n</th>
<th>Mean</th>
<th>Standard Error</th>
<th>95% CI for Mean</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>Non-Aboriginal</td>
<td>1502</td>
<td>0.44</td>
<td>0.01</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>52</td>
<td>0.23</td>
<td>0.22</td>
<td>-0.21</td>
</tr>
<tr>
<td>1970s</td>
<td>Non-Aboriginal</td>
<td>1810</td>
<td>0.24</td>
<td>0.01</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>68</td>
<td>0.38</td>
<td>0.04</td>
<td>0.30</td>
</tr>
<tr>
<td>1960s</td>
<td>Non-Aboriginal</td>
<td>2369</td>
<td>0.15</td>
<td>0.01</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>75</td>
<td>0.23</td>
<td>0.03</td>
<td>0.17</td>
</tr>
<tr>
<td>1950s</td>
<td>Non-Aboriginal</td>
<td>2355</td>
<td>0.14</td>
<td>0.01</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>40</td>
<td>0.17</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>1940s</td>
<td>Non-Aboriginal</td>
<td>1794</td>
<td>0.08</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td>33</td>
<td>0.10</td>
<td>0.06</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
### Predicted BMI Trajectories by Year, Aboriginal Identity, and Birth Cohort

<table>
<thead>
<tr>
<th>Year</th>
<th>YOB 1980s</th>
<th>YOB 1970s</th>
<th>YOB 1960s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YOB 1950s</td>
<td>YOB 1940s</td>
<td>All YOBs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Aboriginal</td>
<td>18</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>26</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Aboriginal</td>
<td>18</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>26</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

**Group**
- **Non-Aboriginal**
- **Aboriginal**
Figure 2

**Predicted BMI Trajectories 1994-2009 by Age, Aboriginal Identity, and Birth Cohort**

The graph compares predicted BMI trajectories over age for non-Aboriginal and Aboriginal populations across different birth cohorts. The x-axis represents age, ranging from 5 to 85 years, while the y-axis represents predicted BMI, ranging from 15 to 32. The graph is divided into two sections: Non-Aboriginal on the left and Aboriginal on the right, each showing various cohort trajectories indicated by different line styles and colors.
Chapter 5  Lifestyle Factors Associated with Obesity in Aboriginal Youth

A version of this manuscript is published in:

Abstract
Objective: To determine associations of diet, physical activity and TV viewing time with obesity among Aboriginal and non-Aboriginal youth in conjunction with socioeconomic variables.
Design: Cross-sectional study of differences between Aboriginal and non-Aboriginal groups and associations between lifestyle and socioeconomic factors with obesity were examined.
Setting: Population data from the Canadian Community Health Survey Cycle 2.2 conducted in 2004 in the ten provinces of Canada.
Subjects: 198 Aboriginal and 4,448 non-Aboriginal Canadian youth aged 12 to 17 years.
Results: Compared to non-Aboriginal youth, physical activity participation among Aboriginal youth was higher, but consumption of fruits/vegetables and dairy products was lower, and more Aboriginal youth were "high" TV watchers. Low income adequacy was associated with decreased odds for obesity among Aboriginal youth in contrast to higher odds among non-Aboriginal youth. Non-Aboriginal "high" TV watchers consumed more soft drinks and non-whole grain products than “low” TV watchers.
Physical activity participation did not differ between "high" and "low" TV watchers for both groups, and was associated with lowered odds for obesity only among Aboriginal youth.

Conclusions: Socio-demographic and lifestyle risk factors associated with obesity differ between Aboriginal and non-Aboriginal youth. These findings may be useful for guiding intervention efforts.
Introduction

According to the Canadian Community Health Survey Cycle 2.2 (CCHS 2.2) conducted in 2004, the prevalence of obesity among Canadians aged 12 to 17 years has tripled over 25 years from 3% in 1979 to 9% in 2004, while prevalence of overweight has doubled from 14% to 29% over the same time period (Shields, 2006). Estimates of the off-reserve Aboriginal (First Nations, Métis, and Inuit) population in the ten provinces indicate that Aboriginal youth within this age group have the highest prevalence of overweight (41%) and obesity (20%), approximately 2.5 times higher than the national average. Poor dietary habits, low physical activity, and high sedentary behaviours have been shown to be important determinants of obesity among Aboriginal youth living in select communities (Hanley et al. 2000; Nakano et al. 2005; Receveur et al. 2008; Macaulay et al. 1997; Horn et al. 2001). However, such studies do not have direct comparison groups, so it is unclear whether lifestyle behaviours of Aboriginal youth, particularly those not living in First Nations communities, are comparable to levels among non-Aboriginal youth. Differential associations between obesity risk and diet, physical and sedentary activity variables may exist among Aboriginal youth compared to non-Aboriginal youth. The objectives of this study were to determine associations of diet, physical activity and TV viewing time with obesity among Aboriginal and non-Aboriginal youth in conjunction with socioeconomic factors in a nationally representative sample of youth aged 12 to 17 years.
Methods

Study population

Data were from the CCHS 2.2, a cross-sectional survey of health status and nutrition information for the Canadian population from January 2004 to January 2005. Detailed survey methodology is available elsewhere (Statistics Canada 2008b). Briefly, the target population was respondents from all age groups living in private occupied dwellings in the ten provinces. Residents of the three territories, persons living on Indian reserves or Crown lands, persons living in institutions, full-time members of the Canadian Forces, and residents of some remote regions were excluded. The overall response rate was 76.5%. Data for 4,646 non-pregnant, non-breastfeeding youth aged 12 to 17 years with valid dietary information were available for analysis. Permission from the parent/guardian was obtained for interviews with all youth. Interviews were completed with the youth directly but the parent/guardian provided information on socioeconomic status variables.

Ethnicity

Respondents were asked the question, “People living in Canada come from many different cultural and racial backgrounds. Are you: White? Chinese? South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc.)? Black? Filipino? Latin American? Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese, etc.)? Arab? West Asian (e.g., Afghan, Iranian, etc.)? Japanese? Korean? Aboriginal Peoples of North America (North American Indian, Métis, Inuit)? An “Other-Specify.” category was also included. Respondents were permitted to select more than one category. For this study, all respondents who selected the category “Aboriginal Peoples of North America” (including
those who may have selected additional categories) were classified as Aboriginal and all others as non-Aboriginal.

**Anthropometric measurements**

Height and weight were measured by trained interviewers using a portable scale and measuring tape. Weight was recorded to the nearest 0.01 kg. Height was recorded to the nearest 0.5 cm. Measured height and weight information was available for only 3,506 youths. Obesity status was determined using the age-and-sex-specific BMI cut-off points established by the International Obesity Task Force (Cole et al., 2000).

**Daily energy expenditure**

Respondents were asked to report participation in leisure-time physical activities over the 3 months previous to the interview. Energy expenditure for each activity (EE) was calculated using the equation $EE=(N*D*MET\ value)/365$, where $N=$ number of times a respondent engaged in an activity over a 12 month period, $D=$ average duration in hours of the activity, and $MET\ value=$ energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity (kcal/kg/hour)/365 to convert yearly data into daily data (kcal/kg/day, KKD). For example, 1 KKD can be interpreted as the energy expenditure equivalent of 20 minutes of walking at a leisurely pace. Independently established MET values (Ainsworth et al., 2000) corresponding to the low intensity value for each activity were used as intensity level was not asked of respondents (Statistics Canada, 2008c). Leisure activities included walking for exercise, gardening or yard work, swimming, bicycling, dance, home exercises, hockey, skating, in-line skating, running, golfing, exercise class, skiing or snowboarding, bowling, baseball, tennis, weight training, fishing, volleyball, basketball, and soccer. “Other” activities were
assigned a MET value of 4, which is the mean value of all listed activities excluding running. Respondents were classified as “active” if EE $\geq$ 3.0KJD.

*Socioeconomic measures*

Household income status was determined by two categories based on total household income and number of people living in the household. Low income adequacy was defined as <$15,000 if one or two people, <$20,000 if three or four people, and <$30,000 if five or more people. Middle or high income adequacy was $\geq$15,000 if one or two people, $\geq$20,000 if three or four people, and $\geq$30,000 if five or more people.

Household education status was classified into secondary school graduation (yes/no) using the highest level of education acquired attained by any member of the household. Although more detailed income and education categories were available, some categories yielded insufficient cell sizes and were collapsed in order to meet the minimum cell size requirements set by Statistics Canada.

*Television watching*

Respondents were asked how many hours per week during the previous 3 months they usually spent watching TV. Although this variable was categorized into three groups 0-5 hours/week, 6-14 hours/week, and 15-20+ hours/week, the two lowest categories were collapsed due to the small number of children in the lowest category. For this study, the two levels of TV watching were “high” TV watchers for those who watched greater than 14 hours of TV per week and “low” TV watchers who watched 14 or fewer hours of TV per week (approximately corresponding to the American Academy of Pediatrics recommendation of 2 hours or less per day (American Academy of Pediatrics, 2001).
Daily dietary intakes

Dietary information was collected using a 24-hour dietary recall of all foods and beverages consumed during the 24-hour period prior to the interview, from midnight to midnight, using the computer-based Automated Multiple-Pass Method (AMPM) developed by the United States Department of Agriculture (USDA) and adapted for Canada. The AMPM was programmed to automatically probe the respondent for all required information. Trained interviewers also recorded information about the time the food was consumed, the eating occasion, and the location where it was prepared. The Nutrition Survey System (NSS) food and nutrient database system developed by the Bureau of Nutritional Sciences (BNS) and the Bureau of Biostatistics and Computer Applications at Health Canada was used to assign food descriptions and nutrient values to all foods and beverages reported. For this study, specific food groupings used were fats/butter/oils, whole grains, non-whole grains, meats, milk, dairy (includes milk), fruits, vegetables, soft drinks, salty snacks, and sweets (i.e., candy and chocolate). These groupings were developed by the BNS at Health Canada in the early 1990s based on the British and American food group systems. Because not all youth consumed soft drinks, salty snacks, candy, and chocolate in the 24 hours prior to the interview, these foods were collapsed into one “junk foods” category because of their high caloric content and low nutrient value.

Statistical analyses

Since the CCHS 2.2 has a complex sampling design, sample weights, primary sampling units, and stratification information specific to the CCHS 2.2 provided by Statistics Canada were used in all analyses. Statistical analyses were completed using the
SURVEY procedures available in SAS (version 9.2, SAS Institute Inc., Cary, NC). To obtain population-specific estimates, analyses were stratified by Aboriginal identity. All proportions, including prevalence of obesity, high TV watching, physical activity level, and socioeconomic variables, were determined by Aboriginal identity using PROC SURVEYFREQ. Rao-Scott chi-square tests available within PROC SURVEYFREQ, which applies a design effect correction to the Pearson chi-square statistic, were used to determine whether proportions were significantly different between Aboriginal and non-Aboriginal youths. Mean age, physical activity levels, and dietary intakes of nutrients and foods were determined using PROC SURVEYMEANS and differences were tested for statistical significance using t-values determined with PROC SURVEYREG. Overall significance level was set at $\alpha=0.05$. For differences between Aboriginal and non-Aboriginal groups where multiple comparisons were performed, a Bonferroni-adjusted significance level was set at $\alpha=0.002$.

For analyses involving obesity status, specific sample weights adjusted for non-response in measured height and weight were used. Logistic regression (PROC SURVEYLOGISTIC) was used to predict obesity and linear regression (PROC SURVEYREG) was used to predict physical activity and dietary variables from combinations of demographic, socioeconomic factors, and behavioural factors.

**Results**

Aboriginal identity was self-ascribed by 198 youth (51.4% male). The characteristics of the Aboriginal and non-Aboriginal samples are summarized in Table 1. Almost half of
Aboriginal youth were from households with education level of less than at least high school graduation compared with just 15% of non-Aboriginal youth. Similarly, more than one-third of Aboriginal youth were from low income adequacy households compared with just one-tenth of the non-Aboriginal sample.

Among lifestyle behaviours, a higher proportion of Aboriginal youth were high TV watchers compared to non-Aboriginal youth, but Aboriginal youth were more physically active (p<0.05). After adjustment for multiple comparisons, Aboriginal and non-Aboriginal youths did not differ in the average amount of energy consumed per day, but Aboriginal youth consumed less dairy products and vegetables. No differences in intake of other nutrients or food groups were apparent.

Measured height and weight information was available for 3,568 non-Aboriginal and 138 Aboriginal youth. In general, a significant proportion of youths were considered overweight for both groups; however, higher prevalences were observed for both overweight (+11%, p=0.02) and obesity (+8%, p=0.01) among Aboriginal youths.

Logistic regressions predicting obesity are presented in Table 2. Unadjusted odds ratios for socio-demographic and lifestyle variables indicate that for Aboriginal youth, “high” TV watching and physical activity level were significant predictors of obesity. Watching TV for less than 15 hours per week was associated with 32% lowered odds for obesity, while an increase of 1 KKD of physical activity was associated with 19% lowered odds. For non-Aboriginal youth, unadjusted odds ratios were significant for sex, income
adequacy, and TV watching level. Females and youths from low income adequacy level households were less likely to be obese. Similar to Aboriginal youths, “low” TV watching was associated with approximately one-third lowered odds for obesity among non-Aboriginal youth, but no significant relationship with physical activity level was apparent.

Various combinations of the socio-demographic (i.e., sex, age, education and income) and lifestyle (i.e., TV watching and physical activity level) variables were entered into logistic regression models. Since similar estimates were obtained across models and the Akaike information criterion was the lowest for the models with all six covariates, indicating best model fit out of all the combinations attempted, the final models including all six variables are presented for each group (Table 2). In these multivariate-adjusted analyses, “low” TV watching was associated with lowered odds for obesity independent of age, sex, income, education, and physical activity level for both Aboriginal and non-Aboriginal groups. Among Aboriginal youth, physical activity level remained a significant predictor for obesity, while strong associations between obesity and both education and income adequacy level emerged. Lower household education was associated with over two times greater odds, while low income adequacy level was associated with almost half lowered odds for obesity. Among non-Aboriginal youth, multivariate-adjusted odds ratios were similar to unadjusted analyses.

Since TV watching level was a strong predictor of obesity among both Aboriginal and non-Aboriginal youth, associations between TV watching and dietary intakes and
physical activity levels were assessed. Tables 3 and 4 present associations between daily intakes of select nutrients and foods by TV watching among Aboriginal and non-Aboriginal youth, respectively. After adjustment for multiple comparisons, no statistically significant differences in dietary intakes between “low” and “high” TV watchers were observed among Aboriginal youth. Non-Aboriginal “high” TV watchers consumed more non-whole grain foods and soft drinks compared to “low” TV watchers. Physical activity participation did not differ between “high” and “low” TV watchers in both Aboriginal [high TV: 4.2 KKD (95% CI: 3.3-5.0) vs. low TV: 4.3 KKD (95% CI: 4.2-4.4), p=0.92] and non-Aboriginal groups [high TV: 3.0 KKD (95% CI: 2.9-3.2) vs. low TV: 3.3 KKD (95% CI: 3.2-3.5), p=0.08]. Among Aboriginal youth, 51.5% (95% CI: 48.1-54.8) was considered “active” in the “low” TV watching group compared to 52.7% (95% CI: 28.4-77.1) in the “high” TV watching group (p=0.93). No difference was also apparent among non-Aboriginal youth [high TV: 39.9% (95% CI: 37.3-42.5) vs. low TV: 43.2% (95% CI: 41.1-45.3), p=0.16].

Discussion

Prevalence of overweight and obesity among off-reserve Aboriginal Canadian youth is significantly higher than non-Aboriginal youth. This explorative study attempted to identify risk factors for this disparity by directly comparing socioeconomic, lifestyle, and dietary variables factors between Aboriginal and non-Aboriginal youths. There is currently no other available evidence simultaneously describing such relationships in a nationally-representative sample of off-reserve Aboriginal Canadian youth.
Direct comparisons with the non-Aboriginal population are useful for providing Canadian context for lifestyle behaviours and can help illustrate the magnitude of health disparities that plague Aboriginal Canadians (Tjepkema 2002). Additionally, gaps identified may be used for setting specific targets for improvement. In this study, almost half of Aboriginal youth watched greater than 15 hours or more of TV per week—two times the proportion estimated among non-Aboriginal youth. TV viewing has been consistently linked to obesity in cross-sectional and longitudinal studies compared to other sedentary behaviours such as video game playing and computer use (Rey-Lopez et al. 2008). This study confirms the independent relationship between TV viewing and obesity and highlights this behaviour as a key area for intervention among Aboriginal youth.

TV viewing may contribute to obesity by negatively influencing food consumption. Although non-Aboriginal high TV watchers were found to consume more soft drinks, no significant differences were observed among Aboriginal youth, but this was likely due to low statistical power. The Aboriginal sample, juxtaposed against the non-Aboriginal appeared comparatively weaker because they make up only 2% of the Canadian population. On average, each Aboriginal respondent in this study represented about 300 youth. In comparison, each non-Aboriginal respondent represented over 600 youth. Thus, the Aboriginal group is arguably a finer survey sample than is made apparent by the unweighted sample size. In addition, though the confidence intervals around the estimates of nutrient and food intakes are wide, they create points of reference that were previously non-existent. The current estimates of intakes help fill a long-standing knowledge gap in information on dietary patterns of off-reserve Aboriginal youth.
Physical activity has been previously reported as an important predictor of obesity among Aboriginal youth using these same data (Katzmarzyk 2008). This study adds the finding that this is not the case in non-Aboriginal Canadian youth. Taken together, these results suggest that obesity status may affect physical activity participation differentially between Aboriginal and non-Aboriginal youth. Obese Aboriginal youth of this study were significantly less likely to participate in leisure-time physical activity compared to their non-obese peers. Identification of this high-risk group has important implications as obese youth are at a greater need of increased energy expenditure through physical activity participation. As a component of any successful body weight reduction strategy, it may be useful to identify barriers to physical activity participation in this group and subsequently promote culturally appropriate activities that are appealing and inclusive. The lack of a relationship between TV viewing and physical activity participation as measured in this study suggests the independence of these behaviours.

As expected, lower household education status was associated with increased risk for obesity among Aboriginal youth. With over 40% of Aboriginal households having less than highschool graduation as the highest education level attained, improvement of access to educational opportunities can help significantly close the health disparity gap. Education level can affect food choices (Barker et al. 2008) and physical activity opportunities (Fairclough et al. 2009). Specific intervention strategies that have been found to be effective in promoting lifestyle change among lower education groups include programs that enhance self-efficacy (Hankonen et al. 2009). Innovative, family-based programs delivered by Aboriginal health counsellors that empower youth and their
families with increased knowledge of healthy lifestyle practices can evoke positive changes in diet and physical activity behaviours (Anand et al. 2007).

The opposite income-obesity relationship found between Aboriginal and non-Aboriginal youth may be partly attributed to the limitations of the income adequacy variable. While other income based variables were available, household income adequacy is a standard variable commonly reported across major Statistics Canada surveys and it was used here to allow for comparisons despite its limitations. In the context of this study, the failure of this variable to capture location of residence (e.g., urban or rural) requires that the income-obesity relationship be interpreted with caution. Aboriginal Canadians tend to reside in rural or remote areas where cost of living may differ significantly from other locations. Thus, the seemingly paradoxical positive relationship between income and obesity observed among Aboriginal youth may actually be an artefact of lowered purchasing power for the same amount of income as their non-Aboriginal counterparts. One potential consequence is increased food insecurity among Aboriginal households (Willows et al. 2008) and perhaps undernutrition, precluding development of obesity for some. Further, the diversity of the Aboriginal Canadian population complicates interpretation of the income-obesity relationship as food practices and likely other lifestyle behaviours can vary widely between different Aboriginal cultures (Power 2008). This study was unable to explore access to or availability and utilization of food or physical activity environments. Future research is needed to more closely examine the impact of income on health-promoting lifestyle behaviours and obesity development.
The conflicting relationships with obesity among Aboriginal youth between the socioeconomic variables household education attainment and income adequacy suggest that these two variables are not interchangeable. Socioeconomic issues have consistently been identified as important contributing factors for health disparities between Aboriginal and non-Aboriginal Canadians (Frohlich et al. 2006) and undoubtedly merit further study. Detailed discussion of socioeconomic status as a determinant of Aboriginal health is beyond the scope of this study. Complex socioeconomic relationships that are difficult to interpret often emerge because of diverse historical experiences and distinct cultural variations within Aboriginal communities (Jacklin 2009). As a national survey, the CCHS 2.2 was not designed for community-level analyses, but results can be used to draw attention to general disparities that may exist. Despite the small sample size of the Aboriginal group, significant differences among several key variables still emerged, indicative of large disparities between Aboriginal and non-Aboriginal groups.

Additional limitations of this study include the cross-sectional nature of the analyses, from which no cause and effect relationships may be derived. Also, all information regarding Aboriginal identity, TV watching, physical activity, diet, education, and income level were self-reported. Due to the small sample of the Aboriginal youth, analyses could not be further stratified by sex or age. In order to preserve statistical power and confidentiality, more detailed socioeconomic or food groups could not be used. Education and income levels were only divided into two groups due to low numbers in certain categories. The mean dietary intakes reflect the 24 hours previous to the interview and may not be appropriate indicators of usual intakes. For these analyses,
no individual level extrapolations can be made as analyses were performed at the population level. In addition, many Aboriginal Canadians were not part of the sampling frame primarily due to geographical reasons, so cautious interpretation of the associations described in this study are required and should be restricted to the sample intended.
### Table 1. Socio-demographic and lifestyle characteristics of Canadian youth aged 12 to 17 years by Aboriginal identity. (95% CIs calculated using Taylor linearization method.)

<table>
<thead>
<tr>
<th>Sample Characteristics</th>
<th>Aboriginal n=198</th>
<th>Non-Aboriginal n=4448</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>95% CI</td>
</tr>
<tr>
<td>Male</td>
<td>51.4</td>
<td>48.3 54.5</td>
</tr>
<tr>
<td>&quot;High&quot; TV Watching (≥15 hrs/week)*</td>
<td>46.6</td>
<td>43.2 50.0</td>
</tr>
<tr>
<td>Household Education (≥highschool)*</td>
<td>56.6</td>
<td>53.3 60.0</td>
</tr>
<tr>
<td>Income Adequacy (middle or high)*</td>
<td>63.7</td>
<td>47.6 79.8</td>
</tr>
<tr>
<td>Active (kcal/kg/day≥3.0)</td>
<td>52.1</td>
<td>43.1 61.1</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>95% CI</td>
</tr>
<tr>
<td>Age (y)</td>
<td>14.0</td>
<td>13.6 14.3</td>
</tr>
<tr>
<td>Physical Activity (kcal/kg/day)**</td>
<td>4.2</td>
<td>3.9 4.5</td>
</tr>
<tr>
<td>Total Energy (kcal)</td>
<td>2377.2</td>
<td>2243.4 2511.0</td>
</tr>
<tr>
<td>Pct. Energy Protein (%)</td>
<td>14.7</td>
<td>12.6 16.8</td>
</tr>
<tr>
<td>Pct. Energy Carbohydrate (%)</td>
<td>53.2</td>
<td>49.3 57.2</td>
</tr>
<tr>
<td>Pct. Energy Fat (%)</td>
<td>32.0</td>
<td>30.1 33.9</td>
</tr>
<tr>
<td>Pct. Energy Saturated Fat (%)</td>
<td>9.7</td>
<td>9.5 10.0</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>14.9</td>
<td>14.1 15.8</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>143.4</td>
<td>137.1 149.6</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>3393.9</td>
<td>3139.1 3648.6</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>926.0</td>
<td>870.7 981.3</td>
</tr>
<tr>
<td>Meats (g)</td>
<td>142.9</td>
<td>78.4 207.5</td>
</tr>
<tr>
<td>Fruits &amp; Vegetables (g)</td>
<td>186.1</td>
<td>168.7 203.4</td>
</tr>
<tr>
<td>Vegetables (g)*</td>
<td>99.4</td>
<td>90.5 108.4</td>
</tr>
<tr>
<td>Fruits (g)</td>
<td>86.6</td>
<td>72.1 101.1</td>
</tr>
<tr>
<td>Milk (g)</td>
<td>277.9</td>
<td>254.3 301.5</td>
</tr>
<tr>
<td>Dairy (g)*</td>
<td>315.5</td>
<td>295.4 335.5</td>
</tr>
<tr>
<td>Fats, Butter, Oils (g)</td>
<td>54.6</td>
<td>43.6 65.6</td>
</tr>
<tr>
<td>Whole Grains (g)</td>
<td>52.1</td>
<td>44.6 59.6</td>
</tr>
<tr>
<td>Non-Whole Grains (g)</td>
<td>86.3</td>
<td>81.1 91.5</td>
</tr>
<tr>
<td>Regular &amp; Diet Soft Drinks (g)</td>
<td>307.8</td>
<td>250.6 365.1</td>
</tr>
<tr>
<td>Salty Snacks and Sweets (g)</td>
<td>94.6</td>
<td>88.2 101.0</td>
</tr>
<tr>
<td>&quot;Junk&quot; Foods (g)</td>
<td>384.4</td>
<td>329.1 439.7</td>
</tr>
<tr>
<td>Obese</td>
<td>17.7</td>
<td>14.7 20.6</td>
</tr>
<tr>
<td>Overweight</td>
<td>41.0</td>
<td>37.3 44.6</td>
</tr>
</tbody>
</table>

* significant difference between Aboriginal and non-Aboriginal p<0.001
** significant difference between Aboriginal and non-Aboriginal p<0.05
Table 2. Logistic regression analysis of the associations between socio-demographic and lifestyle factors and prevalence of obesity among Canadian youth aged 12 to 17 years, odds ratios (OR) and 95% confidence intervals. (95% CIs calculated using Taylor linearization method.)

<table>
<thead>
<tr>
<th></th>
<th>Unadjusted</th>
<th>Multivariate Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Aboriginal n=138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (ref = male)</td>
<td>0.97</td>
<td>0.59</td>
</tr>
<tr>
<td>Age (y)</td>
<td>0.99</td>
<td>0.86</td>
</tr>
<tr>
<td>Household Education (ref = ≥ high school grad.)</td>
<td>1.39</td>
<td>0.95</td>
</tr>
<tr>
<td>Income Adequacy (ref = high)</td>
<td>0.86</td>
<td>0.63</td>
</tr>
<tr>
<td>TV Watching Level (ref = high)</td>
<td>0.68</td>
<td>0.48</td>
</tr>
<tr>
<td>Physical Activity Level (kcal/kg/day)</td>
<td>0.81</td>
<td>0.73</td>
</tr>
<tr>
<td>Non-Aboriginal n=3368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (ref = male)</td>
<td>0.64</td>
<td>0.48</td>
</tr>
<tr>
<td>Age (y)</td>
<td>1.08</td>
<td>0.99</td>
</tr>
<tr>
<td>Household Education (ref = ≥ high school grad.)</td>
<td>1.22</td>
<td>0.85</td>
</tr>
<tr>
<td>Income Adequacy (ref = high)</td>
<td>1.70</td>
<td>1.24</td>
</tr>
<tr>
<td>TV Watching Level (ref = high)</td>
<td>0.67</td>
<td>0.50</td>
</tr>
<tr>
<td>Physical Activity Level (kcal/kg/day)</td>
<td>0.98</td>
<td>0.94</td>
</tr>
</tbody>
</table>

* Multivariate adjusted for age, sex, household education, income adequacy, TV watching level, physical activity level
Table 3. Mean daily dietary intakes of nutrients and foods by TV watching level – Aboriginal Canadian youth aged 12 to 17 years. (95% CIs calculated using Taylor linearization method.)

<table>
<thead>
<tr>
<th></th>
<th>Aboriginal Low TV (≤ 14 hrs/wk) n=133</th>
<th>Mean</th>
<th>95% CI</th>
<th>Mean</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy Intake (kcal)</td>
<td>2443.6 2319.4 2567.7</td>
<td>2301.0</td>
<td>2080.9</td>
<td>2521.0</td>
<td></td>
</tr>
<tr>
<td>Pct. Energy Protein (%)</td>
<td>13.6 12.4 14.7</td>
<td>15.9</td>
<td>12.7</td>
<td>19.1</td>
<td></td>
</tr>
<tr>
<td>Pct. Energy Carbohydrate (%)</td>
<td>52.8 50.9 54.7</td>
<td>53.7</td>
<td>47.2</td>
<td>60.2</td>
<td></td>
</tr>
<tr>
<td>Pct. Energy Fat (%)</td>
<td>33.5 32.6 34.5</td>
<td>30.4</td>
<td>27.0</td>
<td>33.7</td>
<td></td>
</tr>
<tr>
<td>Pct. Energy Saturated Fat (%)</td>
<td>10.0 9.6 10.4</td>
<td>9.4</td>
<td>9.0</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>16.4 15.3 17.5</td>
<td>13.2</td>
<td>12.1</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>150.1 138.2 162.1</td>
<td>135.6</td>
<td>125.6</td>
<td>145.5</td>
<td></td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>3421.0 3197.2 3644.9</td>
<td>3362.7</td>
<td>3003.2</td>
<td>3722.2</td>
<td></td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1014.6 948.6 1080.5</td>
<td>824.3</td>
<td>755.7</td>
<td>892.9</td>
<td></td>
</tr>
<tr>
<td>Meats (g)</td>
<td>131.8 89.3 174.2</td>
<td>155.7</td>
<td>64.8</td>
<td>246.7</td>
<td></td>
</tr>
<tr>
<td>Fruits and Vegetables (g)</td>
<td>235.2 211.7 258.8</td>
<td>129.6</td>
<td>108.3</td>
<td>150.9</td>
<td></td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td>115.2 103.3 127.2</td>
<td>81.3</td>
<td>61.2</td>
<td>101.5</td>
<td></td>
</tr>
<tr>
<td>Fruits (g)</td>
<td>120.0 105.9 134.1</td>
<td>48.3</td>
<td>30.5</td>
<td>66.0</td>
<td></td>
</tr>
<tr>
<td>Milk (g)</td>
<td>349.0 327.0 371.0</td>
<td>196.3</td>
<td>154.5</td>
<td>238.0</td>
<td></td>
</tr>
<tr>
<td>Dairy (g)</td>
<td>391.1 368.9 413.4</td>
<td>228.6</td>
<td>195.0</td>
<td>262.1</td>
<td></td>
</tr>
<tr>
<td>Fats, Butter, Oils (g)</td>
<td>60.5 51.2 69.8</td>
<td>47.8</td>
<td>33.3</td>
<td>62.3</td>
<td></td>
</tr>
<tr>
<td>Whole Grains (g)</td>
<td>90.8 80.5 101.1</td>
<td>7.7</td>
<td>5.5</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Other Grains (g)</td>
<td>91.0 81.1 100.9</td>
<td>80.9</td>
<td>66.0</td>
<td>95.7</td>
<td></td>
</tr>
<tr>
<td>Soft Drinks (g)</td>
<td>257.7 232.5 282.8</td>
<td>365.4</td>
<td>229.1</td>
<td>501.8</td>
<td></td>
</tr>
<tr>
<td>Salty Snacks and Sweets (g)</td>
<td>62.2 58.3 66.1</td>
<td>131.8</td>
<td>116.5</td>
<td>147.0</td>
<td></td>
</tr>
<tr>
<td>Junk Foods (g)</td>
<td>301.5 276.4 326.7</td>
<td>479.5</td>
<td>352.3</td>
<td>606.8</td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Mean daily dietary intakes of nutrients and foods by TV watching level – Non-Aboriginal Canadian youth aged 12 to 17 years. (95% CIs calculated using Taylor linearization method.)

<table>
<thead>
<tr>
<th></th>
<th>Low TV (≤ 14 hrs/wk) n=3340</th>
<th>Mean</th>
<th>95% CI</th>
<th>High TV (&gt; 14 hrs/wk) n=1108</th>
<th>Mean</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Energy Intake (kcal)</strong></td>
<td></td>
<td>2422.6</td>
<td>2374.8</td>
<td>2470.4</td>
<td>2498.7</td>
<td>2422.0</td>
</tr>
<tr>
<td>Pct. Energy Protein (%)</td>
<td></td>
<td>14.7</td>
<td>14.4</td>
<td>15.0</td>
<td>14.2</td>
<td>13.7</td>
</tr>
<tr>
<td>Pct. Energy Carbohydrate (%)</td>
<td></td>
<td>54.4</td>
<td>53.9</td>
<td>54.8</td>
<td>54.2</td>
<td>53.4</td>
</tr>
<tr>
<td>Pct. Energy Fat (%)</td>
<td></td>
<td>30.8</td>
<td>30.4</td>
<td>31.1</td>
<td>31.5</td>
<td>30.9</td>
</tr>
<tr>
<td>Pct. Energy Saturated Fat (%)</td>
<td></td>
<td>10.5</td>
<td>10.3</td>
<td>10.7</td>
<td>10.7</td>
<td>10.5</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td></td>
<td>16.4</td>
<td>15.9</td>
<td>16.8</td>
<td>16.1</td>
<td>15.5</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td></td>
<td>149.7</td>
<td>145.6</td>
<td>153.8</td>
<td>157.0</td>
<td>149.8</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td></td>
<td>3464.4</td>
<td>3385.8</td>
<td>3543.0</td>
<td>3601.6</td>
<td>3466.4</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td></td>
<td>1154.2</td>
<td>1117.3</td>
<td>1191.1</td>
<td>1119.2</td>
<td>1052.4</td>
</tr>
<tr>
<td>Meats (g)</td>
<td></td>
<td>122.7</td>
<td>115.8</td>
<td>129.6</td>
<td>125.8</td>
<td>117.3</td>
</tr>
<tr>
<td>Fruits and Vegetables (g)</td>
<td></td>
<td>262.5</td>
<td>251.1</td>
<td>273.9</td>
<td>244.2</td>
<td>222.9</td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td></td>
<td>140.4</td>
<td>133.0</td>
<td>147.8</td>
<td>132.1</td>
<td>118.1</td>
</tr>
<tr>
<td>Fruits (g)</td>
<td></td>
<td>122.1</td>
<td>113.9</td>
<td>130.3</td>
<td>112.1</td>
<td>93.4</td>
</tr>
<tr>
<td>Milk (g)</td>
<td></td>
<td>393.3</td>
<td>373.4</td>
<td>413.3</td>
<td>388.8</td>
<td>344.3</td>
</tr>
<tr>
<td>Dairy (g)</td>
<td></td>
<td>456.1</td>
<td>435.6</td>
<td>476.6</td>
<td>439.6</td>
<td>395.0</td>
</tr>
<tr>
<td>Fats, Butter, Oils (g)</td>
<td></td>
<td>55.4</td>
<td>52.8</td>
<td>58.1</td>
<td>53.5</td>
<td>49.2</td>
</tr>
<tr>
<td>Whole Grains (g)</td>
<td></td>
<td>27.2</td>
<td>24.4</td>
<td>29.9</td>
<td>19.2</td>
<td>14.9</td>
</tr>
<tr>
<td>Other Grains (g)*</td>
<td></td>
<td>96.7</td>
<td>93.0</td>
<td>100.5</td>
<td>115.5</td>
<td>107.3</td>
</tr>
<tr>
<td>Soft Drinks (g)*</td>
<td></td>
<td>242.9</td>
<td>225.1</td>
<td>260.8</td>
<td>305.4</td>
<td>274.6</td>
</tr>
<tr>
<td>Salty Snacks and Sweets (g)</td>
<td></td>
<td>54.6</td>
<td>49.6</td>
<td>59.5</td>
<td>59.9</td>
<td>50.6</td>
</tr>
<tr>
<td>Junk Foods (g)</td>
<td></td>
<td>275.4</td>
<td>257.1</td>
<td>293.7</td>
<td>331.2</td>
<td>301.0</td>
</tr>
</tbody>
</table>

* significant difference between "high" and "low" TV watchers p<0.003
Chapter 6  Socioeconomic Correlates of Obesity in the Aboriginal Population

A version of this manuscript is published in:

Abstract
Large disparities exist between Aboriginal and non-Aboriginal Canadians in both obesity and socioeconomic status (SES). The purpose of this paper was to compare the associations between obesity and two indicators of SES, education and income, using the nationally-representative Canadian Community Health Survey (CCHS) cycle 2.2 (2004) among 334 off-reserve Aboriginal Canadians and 6,259 non-Aboriginal population aged 25 to 64 years in the ten provinces. Obesity status was determined by body mass index derived from measured height and weight information. Lower education and lower income Aboriginal men were less likely to be obese overall, with those who have a lower education level but higher household income least likely to be obese. Aboriginal men of high SES, i.e., those who have attained at least high school graduation level and have high household income were most likely to be obese. High SES Aboriginal women were least likely to be obese. Obesity was most prevalent among low income Aboriginal women regardless of education level. These associations persisted after adjustment for physical activity level, fruit and vegetable consumption, smoking, marital, and employment status in the models. Employment was highly negatively associated with
obesity among Aboriginal men and women. SES-obesity relationship was generally weak among non-Aboriginal adults, with a small positive association with income among men. Controlling for other socioeconomic and lifestyle factors, odds for obesity were lower by 80% among Aboriginal men and 64% among women who were employed during the previous 12 months to the survey. The knowledge that both high and low SES Aboriginal Canadians, of varying socio-demographic characteristics and lifestyle, experience high rates of obesity can lead to new hypotheses of how obesity develops in this population and influence how interventions are planned.
Introduction

Aboriginal Canadians have been recognized as having the highest prevalence of obesity compared to other ethnic groups in Canada, with 68% of the population being overweight and 38% obese (Tjepkema 2006). At the same time, Aboriginal Canadians are also among the most socioeconomically disadvantaged ethnic groups (Wilson and Macdonald 2010). Despite the marked disparities between Aboriginal and non-Aboriginal Canadians for both socioeconomic status (SES) and obesity, few studies have directly explored socioeconomic patterning of obesity in the Aboriginal population. One reason may be that most Aboriginal Canadians are persistently of lower SES compared to other Canadians and it has generally been assumed that low SES is a contributing factor to increasing obesity and poorer health in this population (MacMillan, MacMillan et al. 1996). In one analysis combining male and female Aboriginal respondents using data from the Canadian Community Health Survey (CCHS) cycle 2.2 (2004), lower education level was actually associated with lower odds for overweight among Aboriginal adults (Garriguet 2008). In contrast, the opposite relationship between education and obesity was observed among non-Aboriginal Canadians. No associations between overweight and obesity with household income categories were significant. However, it should be noted that household income was categorized into just two categories (low and middle/high) using an income measure derived from total household income and the number of people living in the household. It is plausible that this classification may have been insufficiently sensitive to detect differential associations between groups.
More detailed analyses of SES variables and their relationship with obesity are needed. In the context that many Aboriginal Canadians are experiencing rapid socioeconomic changes (Richmond and Ross 2009), it is important to identify whether obesity is disproportionately affecting certain socioeconomic groups so that appropriate intervention and prevention efforts may be developed. The purpose of this paper is to examine the associations between obesity and two indicators of SES, education and income. The SES-obesity relationship will be determined among Aboriginal and non-Aboriginal Canadians by sex, using nationally-representative data of the off-reserve Aboriginal Canadian population in the ten provinces. The information builds upon previously published reports by reporting associations by sex, differentiating trends between two levels of education attainment, and incorporates analysis of a more comprehensive income variable that enables capturing of potential differences over the income distribution.

**Methods**

**Study population**

The CCHS 2.2 is a cross-sectional survey that collected information related to health status and nutrition information for the Canadian population. The CCHS 2.2 was conducted from January 2004 to January 2005. Details of the survey are available elsewhere (Statistics Canada 2009). Data analyzed in this report are for 334 off-reserve Aboriginal and 6,259 non-Aboriginal non-pregnant, non-breastfeeding individuals aged 25 to 64 years living in the ten provinces with measured height and weight and non-missing information on education and income distribution variables.
Anthropometric measurements

Height and weight were measured by trained interviewers using a portable scale and measuring tape. Weight was recorded to the nearest 0.01 kg. Height was recorded to the nearest 0.5 cm. Body mass index (BMI) was calculated by dividing weight in kg by squared height in squared metres. Overweight was defined as a BMI of $\geq 25 \text{ kg/m}^2$ and obesity was defined as a BMI of $\geq 30 \text{ kg/m}^2$.

Distribution of household income

For each respondent, Statistics Canada provided a variable representing their relative measure of household income in deciles. Adjusted ratios of household income to the low income cut-off and corresponding to their household and community size were calculated by dividing the original ratios by the highest ratio for all survey respondents (values from 0 to 1). From this ratio, a household income distribution decile measure was derived. Each of the ten categories, from lowest to highest, included approximately the same percentage of residents from each province and provides a relative measure of each respondent’s household income to the household incomes of all other respondents.

Highest education level attained

Respondent education status was classified into four categories using the highest level of education acquired by the respondent (yes/no): less than secondary school graduation; secondary school graduation; some post secondary education; and post secondary graduation.

Employment status

Whether a respondent was employed the week previous to the survey was coded as a binary variable (yes/no). Respondents were defined as “employed” if they replied “yes”
to having worked at job or business during the past 12 months including part-time jobs, seasonal work, contract work, self-employment, baby-sitting and any other paid work, regardless of the number of hours worked.

Marital Status

Respondents who indicated they were currently married (or common-law) at the time of the survey were considered married and all others (including widowed, separated, divorced, never married) as not married.

Lifestyle variables

Diet. Two summary variables reflecting diet quality and physical activity were selected as a proxy for lifestyle factors. Daily consumption of fruits and vegetables was calculated from a series of questions asking respondents how often they consumed juices, fruit, green salad, potatoes, carrots, and other vegetables. The questions regarding specific fruit and vegetables items were expressed in number of times and allowed reporting unit to be per day, week, month, or year. A subsequent question, “Not counting carrots, potatoes, or salad, how many servings of other vegetables do you usually eat?” was also reported as number of times. The values from these questions were summed, creating a daily consumption of fruits and vegetables variable with units being times or servings per day.

Physical activity. Respondents were asked to report participation in leisure-time physical activities over the 3 months previous to the interview. Energy expenditure for each activity (EE) was calculated using the equation $EE = (N \times D \times MET \text{ value})/365$, where $N$=number of times a respondent engaged in an activity over a 12 month period, $D$=average duration in hours of the activity, and $MET$ value=energy cost of the activity
expressed as kilocalories expended per kilogram of body weight per hour of activity (kcal/kg/hour)/365 to convert yearly data into daily data (kcal/kg/day, KKD). For example, 1 KKD can be interpreted as the energy expenditure equivalent of 20 minutes of walking at a leisurely pace. Leisure activities included walking for exercise, gardening or yard work, swimming, bicycling, dance, home exercises, hockey, skating, in-ling skating, running, golfing, exercise class, skiing or snowboarding, bowling, baseball, tennis, weight training, fishing, volleyball, basketball, and soccer. “Other” activities were assigned a MET value of 4, which is the mean value of all listed activities excluding running.

**Smoking status.** Respondents who reported smoking cigarettes daily or occasionally were considered smokers. All others were considered non-smokers, including former smokers.

**Statistical analyses**

Descriptive statistics were used to estimate the percentages of people who were overweight or obese by Aboriginal identity, sex, education level, and household income decile. Logistic regression was used to determine associations by Aboriginal identity and sex, between socioeconomic characteristics and obesity. Data manipulation and statistical analyses were completed using SAS (version 9.2, SAS Institute Inc., Cary, NC). Since the CCHS 2.2 has a complex design, primary sampling units and strata variables were used in PROC SURVEYMEANS, PROC SURVEYREG, and PROC SURVEYLOGISTIC procedures to obtain estimates and variances. Level of statistical significance was p<0.05.
Results

Descriptive characteristics

Descriptive characteristics of the sample by Aboriginal identity are presented in Table 1. Females overrepresented the Aboriginal sample comprising two-thirds of the studied population, while a relatively even ratio was available for the non-Aboriginal sample. Mean age of the non-Aboriginal female sample was older than that of the non-Aboriginal by approximately 4 years.

In general, Aboriginal Canadians had higher BMI. Mean BMIs for Aboriginal men and women were both at or near the obesity cutoff of BMI $\geq 30$ kg/m$^2$, whereas mean BMIs for non-Aboriginal men and women exceeded the overweight cutoff of BMI $\geq 25$ kg/m$^2$. Close to three-quarters of Aboriginal adults in the 25 to 64 age group were classified as overweight with over one-third of Aboriginal males and close to half of females being obese. Whereas Aboriginal women were more obese than men ($p=0.003$), more non-Aboriginal men were overweight than women ($p<0.001$).

Within sexes, significantly higher BMIs and proportions of overweight and obesity were observed among Aboriginal compared to non-Aboriginal women. Although estimated values were higher for Aboriginal men, none of the differences in BMI and BMI classifications were statistically significant compared to non-Aboriginal men.

Disparity in education level was more prominent among men. Only half of Aboriginal men in this sample have attained an education level of high school graduation or higher, a
proportion that is almost 20% lower than non-Aboriginal men. Two-thirds of non-Aboriginal women have graduated from high school, with the proportion among Aboriginal women being insignificantly lower at approximately 62%. The adjusted household income level of Aboriginal adults was near the fifth decile, while non-Aboriginal adults were more advantaged on average by one decile.

Non-Aboriginal men and women reported consuming more fruits and vegetables compared to Aboriginal adults and the two groups did not differ in their participation in leisure-time physical activity. More Aboriginal women smoke daily or occasionally compared to non-Aboriginal women, but no significant difference in smoking status was apparent among men.

Association of obesity with education and income level

Logistic regression results predicting obesity from demographic, socioeconomic, and lifestyle factors within Aboriginal and non-Aboriginal groups are presented in Table 2. Figure 1 illustrates predicted probabilities for obesity for Aboriginal and non-Aboriginal males and females by education level and income distribution.

Adjusting for age, education was significantly associated with obesity among both non-Aboriginal men and women, with income significantly associated with obesity only in women. After adjustment for physical activity level, fruit and vegetable consumption, smoking, marital, and employment status in the models, household income was positively associated with obesity among men and no longer significant among women.
Interactions between income and education levels were not significant, indicating that their relationships with obesity did not differ by education or income group. Graphically, probability for obesity is higher among non-Aboriginal men and women who did not graduate from high school. Among men, higher household income was associated with higher probability for obesity, while the opposite relationship was observed among women.

Different relationships were observed among Aboriginal adults. First, a significant interaction between education and income levels emerged. Among Aboriginal men, similar relationships were observed in models adjusting only for age and those that were multivariate adjusted. Lower education and lower income Aboriginal men were less likely to be obese overall, with those who have a lower education level but higher household income least likely to be obese. Aboriginal men of high SES, i.e., those who have attained at least high school graduation level and have high household income were most likely to be obese.

Opposite, but weaker, relationships between education and income levels were apparent among Aboriginal women. High SES Aboriginal women were least likely to be obese. Obesity was most prevalent among low income Aboriginal women regardless of education level. In the lower half of the income distribution, women who did not complete high school were less likely to be obese than those who attained a higher education level. However, in the upper half of the income distribution, higher education
level was negatively associated with obesity, though this difference narrowed and became insignificant after adjusting for demographic and lifestyle covariates.

**Association of obesity with demographic and lifestyle factors**

Odds ratios for obesity for the covariates included in the multivariate adjusted models are presented in Table 3. These odds ratios take into account the education and household income levels of respondents. Age was positively associated with obesity in all groups except among Aboriginal males. Married non-Aboriginal women were less likely to be obese by 26% compared to non-married women, but the opposite association was observed among Aboriginal women, among whom being married or common-law was very positively associated with obesity.

Employment was not significantly associated with obesity among non-Aboriginal adults, but highly negatively associated with obesity among Aboriginal men and women. Controlling for other socioeconomic and lifestyle factors, odds for obesity were lower by 80% among men and 64% among women who were employed during the previous 12 months to the survey.

Among lifestyle factors included in this study, daily or occasional smoking was associated with lower obesity significantly, except among Aboriginal females. Physical activity was not related to obesity status among Aboriginal men, but negatively associated with obesity for other groups. Higher fruit and vegetable consumption was negatively associated with obesity among men, but not in women.
Discussion

At the extremes of the SES gradient, Aboriginal and non-Aboriginal men and women aged 25 to 64 years exhibited similar general trends in SES-obesity relationships. The most socioeconomically advantaged Aboriginal men and the most socioeconomically disadvantaged women were most likely to be obese in this study. Consistent with previous reports using the same CCHS 2.2 data (Ward, Tarasuk et al. 2007; Garriguet 2008; Kuhle and Veugelers 2008), lower education attainment was associated with increased odds for obesity among non-Aboriginal Canadians with income level exerting small, but opposing effects between men and women.

This study enhances previous analyses by reporting that two distinct interactions between education and income levels exist among Aboriginal men and women that were not present in the non-Aboriginal sample. Aboriginal men who have not pursued education higher than high school graduation are generally less likely to be obese overall. Because this was a cross-sectional study, this finding does not suggest that low schooling reduces risk for obesity. More likely, certain characteristics of individuals who do not complete high school distinguish themselves from those who do. For instance, some high school dropouts are more apt to engage in risky health behaviours that may lower their body weight.

The negative relationship between income level and obesity was much stronger among Aboriginal women who have at least graduated from high school. One reason may be the higher prevalence of food insecurity among Aboriginal households (Power 2008), which
has been strongly linked to obesity, particularly among women (Townsend, Peerson et al. 2001; Adams, Grummer-Strawn et al. 2003). Approximately one-third of Aboriginal households in the CCHS 2.2 experience moderate to high levels of food insecurity and solutions to alleviate the problem should take into consideration cultural circumstances around food procurement and eating patterns (Willows, Veugelers et al. 2009).

Probability for obesity was higher for low income Aboriginal women as well as those of high income but low education. In two comprehensive reviews on the associations between SES and obesity in the literature published over the past few decades, education has been noted as a stronger predictor of obesity, particular among women (Sobal and Stunkard 1989; McLaren 2007). This was not apparent among the Aboriginal women in this study as the education-obesity relationship differed by income level. One reason may be that among Aboriginal women, education and income levels interact strongly. In addition to having the highest prevalence of obesity in the Canadian adult population, Aboriginal women are highly disadvantaged socioeconomically. Census estimates indicate that in 2006, only 6% of Aboriginal Canadian women have an education level of university bachelor’s degree or higher, compared with 16% of non-Aboriginal women (Statistics Canada 2009). Mean income of Aboriginal women was about $21,000 in 2006, approximately $6,700 lower than non-Aboriginal women (Statistics Canada 2006b). However, Aboriginal women who have attained a university Bachelor’s degree actually have higher median incomes than non-Aboriginal Canadian women of that education level (McLaren 2007). As the highest SES Aboriginal women were least likely
to be obese in this study, improving opportunities for Aboriginal women to pursue higher education is a valuable target for intervention.

Many mechanisms through which SES can affect development of obesity have been proposed. Among unobservable factors that are difficult to extrapolate from statistical analyses of population data, economists have introduced the idea of high “discount rates”. Low SES, obese persons may have high discount rates, referring to such individuals choosing not to trade off current costs for future benefits, such as the pursuit of higher education for higher future earnings or prescribing oneself to restrictive diets for future lower body weight (Baum and Ruhm 2009). One can speculate that the low prevalence of obesity among high SES in some populations can be attributable to low discount rate individuals who choose to attain high levels of education that translate to high income earnings, and these same individuals are more apt to adopt healthy lifestyle choices to trade off for better health in the future.

Among more easily measurable factors, education and income level can influence eating and lifestyle behaviours that directly determine how much one weighs. Several hypotheses have been previously tested in the Canadian population using data from the CCHS 2.2 (Kuhle and Veugelers 2008). Not surprisingly, both dietary and physical activity habits were found to be associated with SES, with Canadians of lower income and education consuming fewer fruits and vegetables and participating in less physical activity than their higher SES counterparts. However, these relationships fail to account for the positive SES-obesity relationship among Canadian men. In addition, lower
income status can dictate where one lives, affecting the neighbourhood environs from which individuals obtain food and pursue recreation opportunities, but neighbourhood factors did not change SES-obesity associations significantly (Kuhle and Veugelers 2008).

Occupation was not included in the present study due to the small size of the Aboriginal sample. SES is often a reflection of one’s occupation, which can also clearly have an affect on some determinants of obesity. For example, occupation can influence one’s physical activity levels by imposing whether physical exertion is necessary or impossible throughout one’s working hours. Occupation can also determine one’s regular interpersonal interactions that dictate perceived social acceptability of obesity. Gender differences in body image perceptions provide some explanation of the differential relationships between men and women. In a study of occupational prestige in relation to BMI, higher prestige occupations were almost consistently associated with lower BMI among Canadian women while among men, senior and middle management occupations were positively associated with BMI (McLaren and Godley 2009). Thus, in occupations of authority, a larger body size may be beneficial in establishing power in men, but not in women. This may at least partially elucidate why Aboriginal men of higher household income deciles were most likely to be obese, while the opposite was the case among Aboriginal women.

Although a larger body size in males is seemingly valued in the labour market, the inability of BMI to distinguish between fat and fat-free body mass should be considered
in interpreting the results of the current study. High BMI among males in the present study, in management occupations (McLaren and Godley 2009), and among high income respondents in the general Canadian population (Kuhle and Veugelers 2008) may be due to these males having muscular builds rather than high fat mass. Indeed, according to a recent study of body composition data from the United States, males with high fat mass actually earned lower wages compared to those with lower body fat, regardless of gender (Wada and Tekin 2010). Further, obesity, when appropriately measured as excess fat, should theoretically contribute to lowered work productivity and absenteeism (Gates, Succop et al. 2008). As expected, employment was significantly negatively associated with obesity among Aboriginal men and women. This is somewhat paradoxical among Aboriginal men, however, as those with high household incomes were more likely to be obese while the unemployed are also likely to be obese. Perhaps this is reflective of the high obesity prevalence among both groups of Aboriginal men who are distinctly unemployed as well as those distinctly of higher household income.

Alternatively, obesity can affect SES. “Wage penalties” on obese persons have been observed (Baum and Ford 2004; Baum and Ruhm 2009). Typically, obese women, and to a lesser extent, obese men, earn lowered wages for comparable employment. Wages (from employment) were not available in the CCHS 2.2. While personal income was available, there were large numbers of missing cases for this variable and in preliminary analyses, household income distribution closely reflected personal income of respondents.
One advantage of this study is the use of an adjusted income variable that takes into account the low income cut-off and respondent household and community size. As a large proportion of the Aboriginal population reside in rural or remote areas where cost of living may be higher than in major urban areas, an adjusted income measure will more accurately reflect the cost of living and purchasing power. Taking into account household size is another advantage pertinent to studies of Aboriginal Canadians as living in a crowded dwelling (defined as more than one person per room in the dwelling) is twice as common among the off-reserve First Nations population (7%) compared to the non-Aboriginal population (3%), a population that forms the majority of the Aboriginal sample used in this study.

Several reasons partially explain the disproportionate male:female ratio in this study. First, in the CCHS 2.2, female respondents (n=18,600) outnumber males (n=16,500). This is a similar phenomenon often observed in health surveys from various regions around the world where response rates are often higher among females compared to males (Groves 2006; Klein 2011; Korkeila 2001; Wilks 2007).

Second, Aboriginal females outnumber Aboriginal males in the Canadian population. Based on Census 2006 estimates (Statistics Canada 2009), the male:female ratio reporting Aboriginal identity (aged between 25 and 64, off-reserve First Nations, Métis, Inuit living in the ten provinces) was 46:54. While the CCHS 2.2 sampling frame attempted to oversample Aboriginal adults aged 19 to 50 to allow for sufficient sample size for analyses of dietary intakes, it is evident from this analysis of the measured height and
weight information that Aboriginal males refused to be measured by the interviewer. The male:female ratio among the Aboriginal sample in the survey overall was approximately 44:55, closely replicating the target population. However, among those with measured height and weight information, the male:female ratio was 33:66 even with the sampling weights adjusted for non-response applied. Thus, it appears that the nonresponse weighting adjustments made by Statistics Canada did not sufficiently account for this difference.

However, it is important to note that the present analysis would only be affected by nonresponse bias if Aboriginal males of certain characteristics disproportionately failed to respond (Smith 1983). Comparing education levels among the Aboriginal male sample with that of the Census 2006 (Statistics Canada 2009), nonresponse did not appear to differ by education level. Comparing other variables pertinent to this analysis between Aboriginal males who refused to allow measurement of their height and weight and those who did not, no differences were observed for income distribution, employment status, or other covariates.

The results of this study are consistent with the general observation that the SES-obesity relationship can vary substantially between populations. Positive, negative, and curvilinear associations emerge due to complex interactions between demographic and lifestyle factors that affect SES and obesity (McLaren 2007). In order to disentangle these, one suggestion is to conduct qualitative, ethnographic studies that would be better able to explore aspects of the SES-obesity relationship not practically measurable.
quantitatively (Young 1996). Use of culturally-sensitive approaches can more effectively extract attitudes and social values unique to specific indigenous populations.

The knowledge that both high and low SES Aboriginal Canadians, of varying sociodemographic characteristics and lifestyle, experience high rates of obesity can lead to new hypotheses of how obesity develops in this population and influence how interventions are planned. Further examination of different socio-cultural factors can reveal important strategies for modifying behaviour to reduce obesity development and improve body weight management among Aboriginal Canadians.
Table 1. Descriptive characteristics of sample aged 25-64 years, by Aboriginal identity and sex, from CCHS 2.2 (2004). (95% CIs calculated using Taylor linearization method.)

<table>
<thead>
<tr>
<th></th>
<th>Males Non-Aboriginal n=2848</th>
<th></th>
<th>Males Aboriginal n=114</th>
<th></th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean 95% CI</td>
<td>Mean 95% CI</td>
<td>p-value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>43.8 43.3 44.4</td>
<td>42.8 42.0 43.6</td>
<td>0.537</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>74.1 71.6 76.5</td>
<td>65.0 59.4 70.7</td>
<td>0.093</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>90.4 88.8 92.1</td>
<td>70.0 66.8 73.2</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker (%)</td>
<td>30.2 27.5 32.9</td>
<td>42.9 37.7 48.0</td>
<td>0.039</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.7 27.4 28.0</td>
<td>29.4 28.7 30.1</td>
<td>0.173</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese (%)</td>
<td>26.4 23.7 29.1</td>
<td>35.3 31.3 39.3</td>
<td>0.210</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight (%)</td>
<td>69.6 66.8 72.4</td>
<td>71.8 66.3 77.2</td>
<td>0.673</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Activity (kcal/kg/day)</td>
<td>1.6 1.5 1.7</td>
<td>1.6 1.4 1.7</td>
<td>0.800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits and Vegetables (servings/day)</td>
<td>3.9 3.8 4.0</td>
<td>3.1 3.0 3.3</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;= High School Graduation (%)</td>
<td>68.5 65.5 71.5</td>
<td>49.0 44.0 54.0</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income Distribution (deciles)</td>
<td>6.0 5.9 6.2</td>
<td>4.8 4.6 5.0</td>
<td>0.012</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Females Non-Aboriginal n=3411</th>
<th></th>
<th>Females Aboriginal n=220</th>
<th></th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean 95% CI</td>
<td>Mean 95% CI</td>
<td>p-value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>44.3 43.8 44.9</td>
<td>40.0 39.5 40.5</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>73.8 71.5 76.0</td>
<td>68.4 64.9 71.8</td>
<td>0.227</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>79.3 77.4 81.3</td>
<td>66.5 63.2 69.8</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker (%)</td>
<td>23.5 21.4 25.7</td>
<td>57.9 54.2 61.6</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.1 26.7 27.5</td>
<td>30.1 29.5 30.7</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese (%)</td>
<td>24.9 22.8 27.1</td>
<td>44.5 40.9 48.2</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight (%)</td>
<td>55.1 52.3 58.0</td>
<td>72.5 69.6 75.3</td>
<td>0.008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Activity (kcal/kg/day)</td>
<td>1.6 1.5 1.7</td>
<td>1.7 1.6 1.8</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits and Vegetables (servings/day)</td>
<td>4.6 4.5 4.7</td>
<td>3.8 3.7 3.9</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;= High School Graduation (%)</td>
<td>66.4 63.6 69.2</td>
<td>61.8 58.3 65.4</td>
<td>0.374</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income Distribution (deciles)</td>
<td>5.9 5.7 6.0</td>
<td>4.8 4.6 5.0</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Multivariate logistic regression estimates predicting obesity from sociodemographic, SES, and lifestyle factors by Aboriginal identity and sex.

<table>
<thead>
<tr>
<th></th>
<th>Non-Aboriginal</th>
<th>Aboriginal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males n=2844 Females n=3398</td>
<td>Males n=112 Females n=220</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.609 0.57 0.281 0.707 0.35 0.046</td>
<td>0.922 0.38 0.015 -1.368 0.26 &lt;.0001</td>
</tr>
<tr>
<td>Age (years)</td>
<td>0.014 0.01 0.044 0.021 0.01 &lt;.001</td>
<td>-0.013 0.01 0.079 0.046 0.01 &lt;.0001</td>
</tr>
<tr>
<td>Employed (yes/no)</td>
<td>-0.289 0.29 0.311 -0.278 0.15 0.067</td>
<td>-1.616 0.34 &lt;.001 -1.010 0.18 &lt;.0001</td>
</tr>
<tr>
<td>High School Graduation (yes/no)</td>
<td>-0.532 0.17 0.001 -0.316 0.14 0.024</td>
<td>-0.738 0.31 0.019 0.495 0.18 0.005</td>
</tr>
<tr>
<td>Income Level (deciles)</td>
<td>0.074 0.03 0.013 -0.003 0.02 0.913</td>
<td>-0.002 0.13 0.989 -0.060 0.03 0.032</td>
</tr>
<tr>
<td>Smoker (yes/no)</td>
<td>-0.476 0.17 0.006 -0.335 0.14 0.016</td>
<td>-0.494 0.21 0.021 -0.166 0.17 0.323</td>
</tr>
<tr>
<td>Physical Activity Level (KKD)</td>
<td>-0.109 0.05 0.022 -0.236 0.05 &lt;.001</td>
<td>0.007 0.03 0.824 -0.306 0.05 &lt;.0001</td>
</tr>
<tr>
<td>Fruit and Vegetable Consumption (servings)</td>
<td>-0.112 0.04 0.005 -0.064 0.04 0.075</td>
<td>-0.224 0.06 &lt;.001 0.048 0.04 0.218</td>
</tr>
<tr>
<td>Married (yes/no)</td>
<td>-0.196 0.17 0.247 -0.303 0.13 0.024</td>
<td>0.264 0.35 0.455 0.507 0.16 0.001</td>
</tr>
<tr>
<td>Education*Income</td>
<td>0.391 0.09 &lt;.001</td>
<td>0.391 0.09 &lt;.001</td>
</tr>
</tbody>
</table>
Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for obesity for age, physical activity level, fruit and vegetable consumption, marital, smoking, and employment status - adjusted for education level and household income level, by Aboriginal identity and sex.

<table>
<thead>
<tr>
<th></th>
<th>Non-Aboriginal</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males n=2844</td>
<td>Females n=3398</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.01</td>
<td>1.00</td>
<td>1.03</td>
<td>1.02</td>
<td>1.01</td>
<td>1.03</td>
</tr>
<tr>
<td>Employed (yes/no)</td>
<td>0.75</td>
<td>0.43</td>
<td>1.31</td>
<td>0.76</td>
<td>0.56</td>
<td>1.02</td>
</tr>
<tr>
<td>Smoker (yes/no)</td>
<td>0.62</td>
<td>0.44</td>
<td>0.87</td>
<td>0.72</td>
<td>0.54</td>
<td>0.94</td>
</tr>
<tr>
<td>Physical Activity Level (KKD)</td>
<td>0.90</td>
<td>0.82</td>
<td>0.99</td>
<td>0.79</td>
<td>0.72</td>
<td>0.87</td>
</tr>
<tr>
<td>Fruit and Vegetable Consumption (servings)</td>
<td>0.89</td>
<td>0.83</td>
<td>0.97</td>
<td>0.94</td>
<td>0.87</td>
<td>1.01</td>
</tr>
<tr>
<td>Married (yes/no)</td>
<td>0.82</td>
<td>0.59</td>
<td>1.15</td>
<td>0.74</td>
<td>0.57</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Aboriginal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males n=112</td>
<td>Females n=220</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>0.99</td>
<td>0.97</td>
<td>1.00</td>
<td>1.05</td>
<td>1.03</td>
<td>1.06</td>
</tr>
<tr>
<td>Employed (yes/no)</td>
<td>0.20</td>
<td>0.10</td>
<td>0.39</td>
<td>0.36</td>
<td>0.26</td>
<td>0.52</td>
</tr>
<tr>
<td>Smoker (yes/no)</td>
<td>0.61</td>
<td>0.40</td>
<td>0.93</td>
<td>0.85</td>
<td>0.61</td>
<td>1.18</td>
</tr>
<tr>
<td>Physical Activity Level (KKD)</td>
<td>1.01</td>
<td>0.94</td>
<td>1.08</td>
<td>0.74</td>
<td>0.66</td>
<td>0.82</td>
</tr>
<tr>
<td>Fruit and Vegetable Consumption (servings)</td>
<td>0.80</td>
<td>0.71</td>
<td>0.90</td>
<td>1.05</td>
<td>0.97</td>
<td>1.13</td>
</tr>
<tr>
<td>Married (yes/no)</td>
<td>1.30</td>
<td>0.65</td>
<td>2.60</td>
<td>1.66</td>
<td>1.23</td>
<td>2.25</td>
</tr>
</tbody>
</table>
Figure 1. Probability for obesity* among Aboriginal and non-Aboriginal Canadian adults aged 25 to 64 years from CCHS 2.2 (2004) by household income and education level.

*multivariate adjusted for physical activity level, fruit and vegetable consumption, smoking, marital, and employment status
Chapter 7 Discussion and Conclusions

This thesis provides a snapshot of obesity among Aboriginal Canadians from different perspectives. A useful approach in research on any population health issue is to: (1) describe the extent and magnitude of the problem; (2) analyze the risk factors responsible for the health problem; and (3) design and evaluate interventions to prevent and control the problem. This thesis comprises three studies that address (1) and (2). The design and evaluation of interventions is beyond the scope of the thesis, although in the literature review, some successful programs relevant to the Aboriginal people were discussed.

Historically, much primary data collection has been conducted in single or clusters of Aboriginal communities with small populations. The availability of national health surveys for secondary analyses permits the assessment of a broad range of public health issues among the Métis, Inuit, and off-reserve First Nations population living in the ten provinces. Another advantage of these data is the possibility to make direct comparisons with the non-Aboriginal population from the same surveys using the same questionnaires. As indicated previously in this thesis, however, it is acknowledged that since the true Aboriginal Canadian population is incompletely enumerated from the national census, the results of all analyses contained in this thesis may not represent the true off-reserve First Nations, Métis, and Inuit population living in the ten provinces.

The results from the descriptive and analytical studies in this thesis, taken together with the literature review, provide the basis for the design of public health interventions to
prevent and control obesity, and ultimately the improvement of the health of Aboriginal people.

7.1 Summary and Synthesis

Beyond prevalence figures, a detailed description of obesity trends among Aboriginal Canadians is lacking, despite the high burden of obesity. Patterns of BMI change over time in this population are not well understood as few longitudinal data are available. As the distributions of BMI in many populations around the world are shifting to the right, describing BMI trajectories can help distinguish how age, period, and cohort effects are contributing to the increasing prevalence of obesity and elucidate how this population came to be the most obese ethnic group in Canada. Cohort effects among Aboriginal Canadians are of particular interest as certain cohorts experienced rapid lifestyle changes along with significant social and cultural stresses through forced acculturation.

From the examination of longitudinal data from the NPHS, this thesis adds the knowledge that with the exception of older Aboriginal Canadians, the entire population is uniformly becoming more obese, with individuals who were born in the 1960s and 1970s exhibiting particularly steep BMI increase. One consequence of such trends is that prevalence of obesity will likely continue to rise in this population without public health intervention.

As lifestyle factors are potential targets of intervention, determining the strength of their association with obesity is needed. Since obesity develops over very long periods of time, the preferred longitudinal method of risk factor assessment is time-consuming and
costly. While cross-sectional analyses may not establish the causes of obesity
development, they can nevertheless identify significant associations that can form the
basis for the design of interventions. Many behavioural and socioeconomic correlates
that were identified were not unexpected, but some findings were particularly surprising
for their magnitude.

The lack of significant differences between the eating habits of Aboriginal and non-
Aboriginal youth was unexpected, although this may partially be the result of low
statistical power. As obesity is viewed as a nutrition-related condition, assumptions of
poor eating habits among those afflicted are often made. While inaccurate measurement
of dietary habits and reverse causation (e.g., obese individuals dieting) may be to blame,
seemingly null results point to the possibility that minor, statistically indistinguishable
differences in eating habits over the long term slowly lead to steady weight gain. One
simplistic way to illustrate body weight change is to consider that consistent over- or
under-consumption of 100 kcal per day for 35 days would amount to 3,500 kcal of weight
gain or loss of 1 pound of body weight (Hall 2008). But over time, individuals over- or
under-consume foods differently each day and there is no consensus on what methods
would adequately capture the spectrum of how diets of individuals or groups can differ
(Willett 1998).

Aboriginal youth’s current eating habits were assessed and potential areas of
improvement were identified. The utility of the estimated mean consumption of such
foods (and corresponding 95% confidence intervals) should be emphasized and
differences between Aboriginal and non-Aboriginal Canadians were secondary to the actual descriptive value of the estimates. As with all three studies in this thesis, the non-Aboriginal population serves as a reference group, solely for point of reference purposes rather than as a benchmark. Differences between groups should not be interpreted as one being “better” than the other. For example, the finding that Aboriginal youth consume few fruits and vegetables and milk products highlights the need to encourage increased consumption of such foods along with lowering the intake of soft drinks and salty snacks and sweets. There is little data previously on food and nutrient consumption levels of Aboriginal youth.

The well-established TV watching-obesity relationship is confirmed among off-reserve Aboriginal youth, which suggests that the reduction of TV watching time should be a main target for obesity prevention and management. What is new is that Aboriginal youth who watch more than two hours of TV per day also report poor food choices. The results of this study establish baseline information on current diet and physical activity habits which will allow for comparisons at later time points for assessment of change.

The socioeconomic patterning of obesity was examined because socioeconomic factors are determinants of lifestyle while at the same time, obesity can lead to social consequences. This thesis provides the first evidence that stark differences in employment status between obese and non-obese Aboriginal Canadians were observed. While some employment disadvantage for obese individuals was expected, the magnitude of the employment-obesity relationship was quite large. As unemployment rates among
Aboriginal adults are already known to be higher than their non-Aboriginal counterparts, there is a particular need to improve employment opportunities for Aboriginal men and women who are also obese.

This thesis could not assess how lifestyle behaviours have changed from traditional patterns, although the ethnographic and historical literature is replete with such descriptions (Waldram, Herring et al. 2006). The CCHS is an excellent beginning with which to monitor changes into the future, with repeated cross-sectional surveys in the same population.

Adding to the two previous published reports on lifestyles of Aboriginal Canadians using the CCHS 2.2 (Garriguet 2008; Katzmarzyk 2008), two general conclusions may be drawn:

1. Aboriginal and non-Aboriginal populations differ in certain lifestyle habits pertaining to diet and physical activity;
2. Obese Aboriginal Canadians differ from non-obese in lifestyle and socioeconomic factors.

Like many populations around the world undergoing what has been termed the fifth stage of the epidemiologic transition, "the age of obesity and inactivity" (Gaziano 2010), Aboriginal Canadians are increasingly affected by obesity and obesity-related chronic illnesses. What sets this population apart, however, is the pervasiveness of the problem compounded by social disadvantage. Of particular concern is the early onset of obesity
among Aboriginal youth. Not only are Aboriginal people more likely to be obese, they are also more likely to be obese at higher levels, and past BMI trajectories point to continued increase well into the future. There is an urgent need for the design and implementation of effective interventions to avert these worsening trends.

### 7.2 Study Limitations

As the studies in this thesis were secondary analyses of existing national surveys, they are subject to the constraints of the data available. The fact that the sample populations were predominantly off-reserve First Nations peoples, with relatively smaller numbers of Métis and Inuit from the ten provinces, is both a constraint and an advantage. It is a constraint because much of Canada’s Aboriginal population are not in the sampling frames of the surveys used, namely First Nations peoples living on reserves and a large majority of the Inuit population who live in the three northern territories. However, demographic trends during the past two decades have made this less of a constraint. In the 2006 Census, a slight majority (54%) of Aboriginal people in Canada live in urban, non-reserve communities. For First Nations people, those residing off-reserve now outnumber those who reside on-reserve. Given the frequent population flow between reserves and urban communities, the differences between on- and off-reserve First Nations people are becoming less profound.

By focusing on the off-reserve Aboriginal population, the CCHS and NPHS are filling an important gap. While many populations are understudied, several factors make the off-reserve Aboriginal population deserving of particular attention. First, it is clear that the health of this population is poorer than that of non-Aboriginal Canadians. Much less is
known about off-reserve Aboriginal people than those living on-reserve, who have been favoured by researchers in the past, partly because of ease of access since they live in geographically circumscribed, small communities (Young 2003). The off-reserve Aboriginal respondents in the CCHS and NPHS live and conduct their daily activities alongside non-Aboriginal counterparts in the same urban or rural environments, allowing comparisons.

As a government agency, one responsibility of Statistics Canada is to obtain objective statistical information from the whole country, including the northern territories. Due to financial limitations and the high costs of conducting large surveys in remote regions, particularly longitudinal ones, certain populations and locations of Canada have routinely been excluded. Periodically, Statistics Canada attempts to capture such groups with specific surveys. One of the more significant efforts of relevance to this thesis was the Aboriginal Peoples Survey (APS) which was first conducted in 1991 immediately after the 1991 Census. The APS aimed to collect health information from Aboriginal persons, both on- and off-reserve, who participated in the census. The APS has now been conducted two more times after the 2001 and 2006 censuses. While the data available include significant numbers of respondents, no direct reference or comparison population such as the non-Aboriginal population was available. The APS is valuable for making comparisons within the Aboriginal population, but not suitable for comparison with Canadians nationally.
One may criticize the “pan-Aboriginal” approach in data analysis. Aboriginal peoples in Canada form a very diverse population encompassing many cultural and linguistic groups. Not only are there First Nations, Inuit and Métis, but diverse groups exist within each. For example, within the First Nations group, there are over 630 First Nations communities. While many Aboriginal peoples are represented by organizations such as the Assembly of First Nations (www.afn.ca), Inuit Tapiriit Kanatami (www.itk.ca), and Métis National Council (www.métisnation.ca), health and social services delivery for each Aboriginal Canadian may differ greatly even within each group. By extension, this jurisdictional difficulty should be considered in the planning of health policies.

Due to small numbers, further breakdown into different Aboriginal groups would have resulted in too low statistical power to conduct the studies at all. Many Aboriginal respondents in fact reported multiple ethnicities and relatively few reported identifying with only one. Thus, the decision to create one single Aboriginal group was made in light of the fact that the alternative would be to report no Aboriginal ethnicities. In effect, health data from approximately 2,000 Aboriginal participants would then be indistinguishable from all other ethnicities or combined with non-indigenous ethnicities.

The dichotomization of certain variables slightly tempers the influence of outliers, but it is important to recognize dichotomization’s own limitations. The appropriateness of BMI categorizations has been debated, but in the interest of comparability with other studies, the internationally recognized definitions were used. The decision to dichotomize into “obese” vs. “all others” in this thesis was based on the evidence of strong health risks
associated with $\text{BMI} \geq 30 \text{ kg/m}^2$. While the sample could have been dichotomized into “overweight” vs. “all others”, an assumption was made that the health risks for being obese exceed that of being overweight. An alternative was to create cutoffs from the data using percentiles or perhaps in a quantile regression, for example. Again, justification for using arbitrary cutoffs would require additional support from the literature that increased health risk is associated with certain specific BMI values.

### 7.3 Future Research

Much new research can still be done on obesity in the Aboriginal population, utilizing data already collected from large scale, expensive, national health surveys.

One approach is to go back in time and make use of earlier surveys. The Nutrition Canada Survey of the 1970s is a remarkable resource. As a national survey involving both First Nations and Inuit samples who underwent an extensive battery of anthropometric, clinical, and laboratory tests, it has not been replicated on the same scale since. Cross-sectional comparisons of anthropometric and metabolic indices over three decades in the Canadian Aboriginal population would provide historical indications of epidemiological change. It should also be possible to link participants in the Nutrition Canada to the Canadian Mortality Database and thus enable a retrospective (or historical prospective) cohort to be conducted on the long term differential impact of obesity on mortality between Aboriginal and non-Aboriginal Canadians.

Statistics Canada has also now released data from the Canadian Health Measures Survey (CHMS) conducted between 2007 and 2009. Some anthropometric measures not
available in the CCHS or NPHS such as skinfold measurements would also be useful in comparing body fat distribution between generations of Aboriginal Canadians. Although the sample size of Aboriginal people in the CHMS is very small, general observations may still be possible. In addition, the CHMS provides data from blood and urine samples that may allow inferences about dietary habits or disease status. As with the studies in the current thesis, direct comparisons with the non-Aboriginal population can provide perspective on whether the Aboriginal population has experienced lifestyle changes of greater magnitude.

If the role of research is to improve the health of Aboriginal people, then the methods do not matter as much as the research questions to be asked. Health surveys are powerful methods in collecting certain types of information, but they cannot address all the important questions about the health priorities of Aboriginal people. Data linkage with other sources of health data, for example, disease registries and health care administrative databases maintained by different health agencies in different jurisdictions represent a potentially powerful tool for research and health needs assessment. Furthermore, quantitative methods can be complemented, supplemented, or replaced by qualitative ones depending on the nature and complexity of the research question. Continuation of prospective, longitudinal surveys such as the NPHS should be a priority in order to allow for examination of chronic disease development from a life course epidemiology perspective.
7.4 Public Health Implications

The research studies included in this thesis recognize and confirm that obesity is rapidly increasing in the Aboriginal population, that obesity is associated with certain dietary and physical activity habits, and that it affects individuals differentially according to their socioeconomic position. The next step is to utilize this information to influence public health action. While conducting an intervention trial is beyond the scope of this thesis, there already exists a substantial body of knowledge on obesity interventions, some of which were implemented in Canadian First Nations and American Indian communities. These studies, reviewed in Section 2.7, identified certain successful ingredients of community-based programs: a high level of community control by involving community members in decision-making processes; respect for local culture and values, involvement of the whole community and not just individuals at high risk; and flexibility in programming to meet a particular community’s changing needs.

The treatment and prevention of obesity are faced with formidable challenges. Lifestyle interventions are usually implemented after behaviours relating to diet and exercise are already well established. Obese individuals are often asymptomatic and do not feel ill and may lack the motivation to change their behaviour. Not all the intervention studies reviewed was able to demonstrate weight loss among participants, but this does not necessarily indicate failure. In many studies, children were not overweight at baseline and growth and maturation often could not be accounted for. In addition, minor lifestyle changes that may not be discernable statistically can be sufficient in preventing obesity in adulthood (Bjorntorp 1997). It has been estimated that an obese 50-year-old subject
A person weighing 150 kg has approximately 80 kg of body fat accumulated over 30 to 40 years. This is equivalent to an overconsumption of approximately 50 excess kcal per day and only a weight gain of 2 kg per year. The avoidance of weight gain may be equally beneficial to participants as the achievement of weight loss. These observations highlight the need for longitudinal designs where follow-up outcomes of participants for a decade or longer can be observed.

It is well recognized that excess intra-abdominal or visceral fat more so than overall obesity is the stronger risk factor for the metabolic changes associated with obesity. Both diet and exercise modifications can positively influence abdominal fat distribution. Too restrictive diets are difficult to adhere to and mainstream Canadian diets often fail to accommodate family resources and cultural considerations in Aboriginal communities. Exercise training programs involving games and sustained periods of moderate-to-high intensity physical activity can reduce health risk and delay or prevent complications in individuals with type 2 diabetes. Physical exercise has beneficial effects on body composition, which in turn, improves insulin sensitivity. Moreover, physical activity of higher intensities has the added benefit of improving cardiorespiratory fitness, which is associated with lower mortality in non-obese and obese individuals.

Children may not adhere to their formal intervention programs consistently (Glaser 1997). However most children enjoy active play and if physical activity is enjoyable and occurs in motivating and supportive environments, exercise programs are more likely to be adhered to. This is especially important for older children and adolescents, since this
group may find it difficult to establish exercise routines due to time constraints, lack of resources, or negative peer influences (Hansen, Fulop et al. 2000).

As children spend a substantial portion of their day in school and that schools offer a structured environment, school-based obesity programs are ideally suited for children. School food services can be modified by decreasing access to food choices that are calorie-dense but not rich in nutrients (e.g., soda, candy bars), increasing access to fresh fruits and vegetables, providing lower-fat, but tasty food choices, and working with food service providers in planning school menus. Physical environments can be modified to provide safe spaces for supervised play and sports activities. School administrations can set an example by giving a higher priority for physical education, such as providing incentives for teachers to organize intramural games and competitions, improving the quality of physical education by hiring physical education specialists, and increasing curriculum time allocated to physical education. School recreation facilities can be made available to school or family events during and after school hours, encouraging family participation (e.g., “family fun nights”) in physical activity with their children.

Health promotion goes beyond individual behavioural change. Food environments can be modified by changing the availability of foods in public institutions, changing access to foods (e.g., through pricing), working with food industry to provide consumers with useful nutrition information. Physical activity opportunities can be created by generating community support for increasing safety of neighbourhoods, and promoting physically active commuting options. People can be encouraged to make more use of parks and
recreation facilities by reducing economic barriers (e.g., reduce fees), providing family-centred programs, creating incentives for participation especially to entice never-participants (e.g., free swimming lessons), and having community leaders participate in special events (e.g., walk-a-thons) to generate publicity.

7.5 Conclusions

In conclusion, by investigating trends and determinants of obesity among off-reserve Aboriginal people using data from two different national health surveys, this thesis was able to identify potential areas of change:

1. Obesity has increased among Aboriginal Canadians faster than non-Aboriginal Canadians. While all Aboriginal adults and children under age 50 warrant some intervention, the cohort born in the 1960s and 1970s require particular attention. What potential life events that promoted the rapid increase in body size should be investigated. Members of the 1970s cohort is still now within child-bearing age range and is well established into adulthood. Significant lifestyle interventions should be aggressively delivered now to avoid promoting poor health outcomes as this population ages.

2. The lifestyle of Aboriginal children needs to improve. There are many areas for dietary intervention, particularly in increasing fruits and vegetables consumption and reduction of soft drinks and salty snacks. Regardless of whether these were significantly different between Aboriginal and non-Aboriginal Canadians, or between obese and non-obese individuals, these are changes to eating patterns that should be adopted in their own right for health reasons.
3. Socioeconomic conditions among Aboriginal Canadians need to improve. Given the high risk for obesity among Aboriginal women along with their socioeconomic disadvantage in general, policies should particularly aim to increase education and employment opportunities for this vulnerable population.
References


Health Canada (2003). *Canadian Guidelines for Body Weight Classification in Adults*. Ottawa, ON, Her Majesty the Queen in Right of Canada. Cat no: H49-179/2003E.


Statistics Canada (2001). Statistics Canada - 2001 Census - Selected Educational Characteristics (29), Aboriginal Origin (14), Age Groups (5A) and Sex (3) for Population 15 Years and Over, for Canada, Provinces, Territories and Census Metropolitan Areas, 2001 Census - 20% Sample Data. Ottawa, ON, Statistics Canada Catalogue No. 97F0011XCB2001051.


Statistics Canada. (2008c). "Canadian Community Health Survey Cycle 2.2 (2004) Nutrition: General Health File (including vitamin and mineral supplements) and 24-Hour Dietary Recall Master And Share Files Derived Variables"


