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Identifying the extent to which diet quality and physical activity levels relate to obesity and insulin resistance in Iiyiyiu Aschii (Cree) adults

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ABSTRACT

In the James Bay Cree of Canada a nutrition transition has contributed to an increased prevalence of obesity and chronic diseases. A cross-sectional survey was conducted in five Iiyiyiu Aschii (Cree) communities. Dietary characteristics and physical activity levels were evaluated for their association with adiposity and insulin resistance in James Bay Cree adults (n = 486). The current analyses were restricted to those 18 years of age and older without a pre-existing diagnosis of diabetes mellitus. Diet quality, physical activity levels, and other characteristics were evaluated for their associations with obesity, impaired fasting glucose (IFG), and insulin resistance. The results revealed that regular walking (≥ 6 days/week) was inversely associated to adiposity measures and HOMA-IR (Homeostasis Model Assessment of Insulin Resistance). In addition, the consumption of high-sugar drinks was associated with having an at-risk body mass index (BMI) and increased odds ratio (OR) for having an IFG in analyses adjusted for age, sex, and regular walking. The results indicate that promotion of daily walking and cessation of high-sugar drinks may help mitigate nutrition and epidemiologic transition in Cree communities.

RÉSUMÉ

Dans les Cris de la Baie James du Canada une transition nutritionnelle a contribué à une augmentation de la prévalence de l'obésité et les maladies chroniques. Une enquête transversale a été menée dans cinq Iiyiyiu Aschii (Cris) communautés. caractéristiques diététiques et niveaux d'activité physique ont été évalués pour leur association avec l'adiposité et résistance à l'insuline chez les adultes de la Baie James (n = 486). Les analyses en cours ont été limités à ceux de 18 ans et plus sans diagnostic pré-existantes du diabète sucré. Qualité de l'alimentation, les niveaux d'activité physique, et d'autres caractéristiques ont été évaluées pour leur association avec l'obésité, l'hyperglycémie à jeun, et résistance à l'insuline. Les résultats ont révélé que la marche régulière (≥ 6 jours / semaine) était inversement associée à des mesures de l'adiposité et homéostasie Modèle d'évaluation de l'insulinorésistance. En outre, la consommation de boissons riches en sucre a été associée à avoir un indice du corps exposées au risque de masse corporelle et l'augmentation odds ratio pour avoir une hyperglycémie modérée à jeun dans les analyses ajustées pour l'âge, le sexe et la marche régulière. Les résultats indiquent que la promotion de la marche quotidienne et la cessation des boissons à forte teneur en sucre peut aider à atténuer la nutrition et la transition épidémiologique dans les communautés.

CONTRIBUTION OF AUTHORS

From 2008-2009 the first author, alongside many other students, entered and cleaned data from the cross-sectional health survey entitled, "Nituuchischaayihtitaau Aschii" (Let us know our land) a multiple community environment and health study in the Iiyiyiu Aschii (Cree); which was gathered in the communities from 2005-2008. The first author was also responsible for the review of the relevant literature, analysis of the data, preparation of the tables and figures, and drafting of the manuscript.

The co-authors Dr. Egeland, Dr. Plourde and Dr. Dewailly reviewed drafts of the thesis and manuscript then commented with suggestions for improvement, highlighting areas which needed further work. Dr. Egeland also provided editorial assistance and guidance during the analyses, writing, and interpretation of results.

LIST OF ABBREVIATIONS

ADA	American Diabetes Association
AHA	American Heart Association
AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Range
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CBHSSJB	Cree Board of Health and Social Services of James Bay
CCHS	Canadian Community Health Survey
CFG	Canadian Food Guide
CIGMA	Continuous Infusion of Glucose with Model Assessment
CINE	Center for Indigenous Health
DASH	Dietary Approaches to Stop Hypertension
DQI	Diet Quality Index
DRI	Dietary Reference Intakes
EAR	Estimates Average Requirements
EI	Energy Intake
ESRD	End Stage Renal Disease
FBG	Fasting Blood Glucose
FFQ	Food Frequency Questionnaire
FPG	Fasting Plasma Glucose
GDR	Glucose Disposal Rate
HDI	Health Diet Indicator
HEI	Healthy Eating Index
HFCS	High Fructose Corn Syrup
HOMA-IR	Homeostasis Model Assessment of Insulin Resistance
IFG	Impaired Fasting Glucose
IPAQ	International Physical Activity Questionnaire
NAHO	National Aboriginal Health Organization
MAR	Mean Adequacy Ratio
MET	Metabolic Equivalent
NHANES	National Health and Nutrition Examination Survey

NRC	National Research Council
OR	Odds Ratio
RDA	Recommended Dietary Allowance
SD	Standard Deviation
SDHN	School of Dietetics and Human Nutrition
T2DM	Type 2 Diabetes Mellitus
UL	Tolerable Upper Intake Levels
USDA	United States Department of Agriculture
WC	Waist Circumference
WHO	World Health Organization

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[1] INTRODUCTION

Indigenous Peoples in Canada have endured a significant nutrition transition over the past 100 years: a transition which has seen a large percentage of their energy intake previously supplied by traditional foods replaced with highly processed market foods [1-6]. The nutrition transition and other lifestyle changes taking place in indigenous communities have radically changed their health status. Indigenous Peoples in Canada have the highest rates of obesity, Type 2 Diabetes Mellitus (T2DM) and cardiovascular disease in Canada [7]. In northern Quebec, the Cree of James Bay are particularly at high risk of having health associated problems due to obesity, as the prevalence of obesity (BMI $\geq$ 30 kg/m^2) exceeds 50% of their population [8].

The high prevalence of obesity among the Cree and the importance of obesity as a risk factor for insulin resistance, subsequent metabolic complications, and T2DM [8-11], prompted an evaluation of the lifestyle and demographic correlates of obesity and insulin resistance in the Cree population of James Bay.

The literature review covers pertinent background information on the nutrition transition, dietary habits, physical activity, and insulin resistance among Indigenous Peoples in Canada.

[2] LITERATURE REVIEW

2.1. Indigenous Peoples in Canada

Indigenous Peoples in Canada are separated into three distinct groups: First Nations, Métis, and Inuit [9]. The Indigenous population in Canada recently surpassed one million in 2006, and consists of 50,485 Inuit, 389,785 Métis, and 698,025 First Nations [9]. This review will focus on First Nations Cree who live in the communities of James Bay Quebec, representing approximately 2% of the First Nations population.

2.2. Indigenous Health

2.2.1. The Nutrition Transition among Indigenous Peoples

The Indigenous People in Canada have undergone a dramatic nutrition and epidemiologic transition in the last 100 years [3, 5]. In the early 1900’s infectious diseases, such as tuberculosis and measles, were at epidemic levels, during which time many communities were also experiencing food shortages and starvation resulting in nutrient and energy deficiencies [1, 10-11]. The grave situation facing Indigenous communities in the early 1900’s was further exacerbated by the inadequate health-care system at that time [6]. In 1867 the British Crown’s Indian Act (which coincided with Canadian confederation) initiated the permanent displacement of many Indigenous Peoples from their land to reserves, limiting their original access to traditional foods that were regularly hunted and gathered. The changes during this time have been cited as contributing to the poor health status observed among Indigenous Peoples in Canada [6, 12]. Fewer than 30 years after many Indigenous Peoples were on the brink of starvation and suffering from infectious diseases at epidemic levels, increases in obesity and non-communicable diseases have been observed [1, 13]. The Canadian Community Health Survey (CCHS) of 2005 revealed that Indigenous Peoples have the highest prevalence of obesity in Canada with 37.8% of the adult population having a BMI ≥ 30 kg/m^2 compared to 22.6% among non-Indigenous adult Canadians [7]. The shift from undernourishment to obesity in Indigenous communities coincided with decreases in traditional foods in their diet and an increase in their easy access to highly-processed foods that are generally high in refined carbohydrates, fat, and added salt and sugars [1, 4]. A reduction in physical activity due to decreases in hunting and gathering and increases in sedentary work and leisure time activities undoubtedly also contributed to the rise in obesity observed in Indigenous communities [1, 4].

The First Nation Cree communities in James Bay have not been spared from the detrimental nutritional transition; in fact many of the communities have become highly dependent on a “western” diet high in processed foods [8]. Roads, which were created to serve the electric dams near many of the James Bay Cree Communities, have further increased access to Western market foods coming in and out of the communities. Several Cree communities are in relatively close proximity to major Canadian cities [8] and are therefore highly exposed to western influences leading to adoption of a ”western” lifestyle including access to motorized vehicles, modern amenities, and television; all of which reduce daily energy expenditures.

2.2.2. Indigenous Canadian Health Determinants

Numerous factors affect the health status of the Indigenous population in Canada. A list formed by the Health Council of Canada outlined 13 key determinants of health: income and social status, social support networks, education, employment/working conditions, social environment, physical environment, personal health practices and coping skills, healthy child development, biology and genetic endowment, health services, sex, culture, and geography [6]. While the emphasis of the literature review is modifiable health behaviors, particularly among James Bay Cree, information regarding genetic predisposition is briefly reviewed.

2.2.3. Obesity in Indigenous Peoples within Canada

The prevalence of obesity in Canadian Indigenous peoples has been assessed by anthropometric measurements or self-reporting of height and weight in which BMI is the most frequently used indicator of adiposity [7-8, 13-14]. Health Canada has established a standard definition of obesity as an individual that has a BMI of greater than or equal to 30 kg/m^2 [15]. There is a large range of estimates in the literature pertaining to the prevalence of obesity among Indigenous Peoples of Canada [7, 14, 16]. A recent study by Katzmarzyk, cited obesity prevalence in both male and female populations aged 12-64 years at 37.8% [7] based upon the CCHS with a sample size of 280 men and 447 women [7, 17]. In 2005, The Health Council of Canada showed similar obesity prevalence to Katzmarzyk with data from the National Aboriginal Health Organization (NAHO) providing obesity prevalence ranging from 28.1% in 18-34 year olds to 43.5% in 34-54 year olds [2, 7].

2.2.4. Childhood Obesity in the Cree and James Bay Cree Communities in Canada

Ng et al. 2006 and Willows et al. 2007 measured the BMI of Cree children ranging from 2-12 years of age, and both found that approximately 38% of the study populations were obese [14, 18]. Downs et al. 2009 found an obesity prevalence of 43.8% among 9-12 year olds [4]. There are now just as many obese children (BMI ≥ 30 kg/m^2) as overweight children (BMI ≥ 25 kg/m^2), as the prevalence of overweight children in the James Bay Cree was found to be 38%, in 1995 [4, 14, 18-19].

2.2.5. Adulthood Obesity in the Cree and James Bay Cree Communities in Canada

A Cree health study conducted in 2005 reviewed the obesity rates in adults from four different time periods. In 1983, 42% of females and 23% of males were obese, in 1988, 50% of females and 33% of males were obese, while in 1991, 57% of females and 38% of males were obese. Further, in 2001, 54% of the population was obese [8]. A clear trend of rising obesity rates is evident, especially with regards to the Cree women in James Bay.

Egeland et al. 2008 also presented evidence of high BMI, % body fat, and waist circumference (WC) in the Cree community of Mistissini [20]. Of 161 participants, the mean BMI was 34.5 kg/m^2 for women and 31.1 kg/m^2 for men, and the mean WC was 109.2 cm for women and 106.6 cm for men [20]. The normal weight range for BMI is within 18.5 kg/m^2 to 24.9 kg/m^2, and for WC it is less than 88 cm for women and 102 cm for men, indicating that the Cree of Mistissini are at risk for obesity associated health problems [14, 20].

2.2.6. The Genetic Predisposition for Weight Gain among Indigenous Peoples

A ‘thrifty’ gene or a genetic predisposition for obesity in Indigenous peoples around the world has been suggested to be one of the major underlying factors for their high rates of obesity [21-22]. The thrifty gene hypothesis suggests that Indigenous people were adapted to endure famine and that they are therefore at greater risk for storage of excess energy as adipose tissue to aid in survival; the greater the fat reserve the longer one can survive when there is no food available [23]. Many specific genes have since been postulated to play a role; however, recent articles by Speakman et al. 2008 and Hegele et al. 2003 have concluded that even if the thrifty gene exists, environmental and nutritional factors play the most important role in Indigenous obesity [21-22].

2.2.7. Non-Insulin-Dependent Diabetes Mellitus in Indigenous Canadians

T2DM has been shown to increase mortality rates due to increases in cardiovascular disease and end stage renal disease [24]. With an increasing number of Indigenous Canadians becoming obese, cases of T2DM within this population have gone up rapidly. Indigenous adults aged 20 or older, have a 3.5 to 5.6 times higher prevalence of Diabetes than non-Indigenous Canadian adults in whom the 2009 prevalence of Diabetes was 6.0% [2, 25]. The increasing rates of T2DM among Indigenous Peoples has been associated with the effects of the nutrition transition such as obesity and low physical activity levels [1, 21].

A study published in 2007 by Horn et al. on the prevalence of T2DM in the First Nation community of Kahnawá:ke, may shed light onto the relative importance of environmental factors for the development of T2DM, as the prevalence of T2DM since the early 1980's has been decreasing rather than increasing [2, 26]. The close proximity of the Kahnawá:ke community to major cities allowed them easy access to awareness programs and health care workers, this support would not be available had it been a remote community. The Kahnawá:ke's prevalence of T2DM is therefore more similar to non-Indigenous Canadians than to Indigenous Canadians [26]. The Kahnawá:ke study indicates that increases in T2DM prevalence in communities can be overcome by increasing the population's access to programs for diabetes prevention [21-22, 26-27].

Community outreach may be effective in combating the epidemic of obesity and T2DM [21-22, 26].

2.2.8. The Prevalence of Non-Insulin Dependent Diabetes Mellitus in Cree Communities

The Cree have some of the highest recorded prevalence rates of T2DM in Canada [8, 28-30]. In 1993, Brassard et al. estimated a 2.7% crude prevalence of diabetes across the eight James Bay Cree communities [28]. Less than ten years later, the prevalence rates of T2DM in the James Bay Cree showed a prevalence of around 13% between 2000-2003 [8, 31]. In 2007, a study looking at the Oji-Cree of Ontario showed a 17.2% prevalence of T2DM, the highest recorded among the Cree peoples in Canada [29]. While diagnostic criteria has changed over time [8], disparities of T2DM persist in the Cree.

2.2.9. Summary of the Key Findings in Indigenous Health

Key findings from the Canadian literature are that: 1). the nutrition transition has had and continues to have an impact on the health of Indigenous Peoples; 2) traditional food plays an important role; 3) obesity and T2DM are increasing across remote Indigenous communities, and in some cases at epidemic proportions; and 4) intervention through government funded programs and increased awareness may help to reverse the poor health status of Indigenous Peoples in Canada.

2.3. Insulin Resistance

2.3.1. Background Information

Insulin resistance is a complication where insulin and insulin receptors become ineffective in lowering blood glucose levels. In the hepatic, adipose, and muscle cells insulin resistance impedes glucose uptake [32-34]. Insulin resistance in adipose cells results in high levels of stored triglycerides resulting in the elevation of free fatty acids in the blood [32-34]. In muscle cells, insulin resistance decreases the storage of glycogen; similarly insulin resistance in hepatic cells weakens glycogen synthesis and local storage of glucose [32-35]. All of the aforementioned symptoms of insulin resistance in hepatic, muscle, and adipose cells are associated with T2DM and the metabolic syndrome [35].

2.3.2. Insulin Resistance and High Sugar Drinks

Only a few studies have evaluated the association of high-sugar drinks with insulin resistance. Many of the peer reviewed articles to date have been limited to children and adolescents when looking at insulin resistance and its association with soft drink consumption. Janssen et al. looked at a small subset of 12 boys and girls between the ages of 13-17 [36] and compared a fermented drink (table beer) to regular soft drinks in how they affected blood glucose and insulin levels after consumption. Consumption of regular soft drinks induced a more significant ($P < 0.01$) increase in both blood glucose and insulin than did the table beer [36]. More recently, studies have begun to look at fructose drinks and their association to insulin resistance. A review by Elliot et al. concluded that there is sufficient evidence to support that fructose drinks increase insulin resistance and decrease insulin sensitivity in animals [37]. Le et al. also found that a high-fructose diet resulted in increases in fasting plasma glucose in 7 healthy nonsmoking white men [38]. Studies conducted with regards to glucose homeostasis and high-sugar drinks have been carried out with relatively small sample sizes; thus, additional research is warranted.

2.3.3 Obesity and High Sugar Drinks

In contrast to the insufficient literature evaluating the role of high-caloric drinks and glucose homeostasis, there are numerous studies that attempted to evaluate the role of high-sugar drinks and obesity [37, 39-44]. In general, the literature is conflicting; however, the literature regarding the deleterious effects of sugar-beverages on weight is more consistent for children and youth [40-41, 44]. DiMeglio et al. looked at 7 men and 8 women who consumed carbohydrates as either liquid (soda) or solid (jelly beans); the study found that body weight (kg) increased significantly when liquid carbohydrates were consumed (67.7 kg to 68.2 kg) and remained the same when solid carbohydrates (68 kg to 68.3 kg) were consumed [39]. Much of the remaining literature with respect to obesity and high sugar drinks focuses on children and adolescents. Ludwig et al. 2001 looked at 548 schoolchildren and their baseline intake of sugar sweetened drinks and changes in this intake over a two-year period. BMI increased significantly for each additional serving of sweetened drinks (Mean = 0.24 kg/m^2; 95% CI [0.10-0.39]; $P < 0.05$), when controlling for baseline anthropometrics, dietary variables and physical activity [45]; BMI also increased significantly (Mean = 0.18 kg/m^2, 95% CI [0.09-0.27]; $P < 0.05$) when total kcal was controlled for in analyses [45]. Nissinen et al. also looked at school children's (n = 2139) consumption of sugar-sweetened beverages from childhood to adulthood in Finland's young Finns study. The consumption of sugar-sweetened beverages and not sugar-sweetened solids was found to be significantly associated to an increased BMI (Beta = 0.45, SE (0.12); $P < 0.01$) in women [41]. Fiorito et al. found that early childhood high-sugar drink consumption predicts consumption later in life; therefore, early identification and intervention may be vital steps in changing the pattern of consumption seen in previous studies [39-41].

A systematic review of sugar-sweetened beverages and weight gain was performed by Malik et al. 2006, reviewing thirty publications. The findings from the review concluded that sugar-sweetened beverages, in particular soda, played an independent role in child and adolescent obesity [46]. Adulthood obesity also showed slight positive associations with soda consumption in the review, although further research is warranted [46].

A number of studies suggest that the high fructose corn syrup (HFCS) used as a sweetener in many high-sugar drinks has a more deleterious effect than table sugar in increasing obesity risk [37, 42-43]. Increases in body weight and energy intake with a high-fructose diet has been identified in animal but not in human study populations [37, 42]; hence, more research is needed.

Literature on the effects of high-sugar drinks and obesity among Indigenous Peoples is lacking. Wharton et al. 2008 indirectly reviewed the association of soda and obesity in Native Americans of Arizona revealing a trend with respect to the per capita usage of HFCS, from 0.23 kg in 1970 to 28.4 kg in 1997, and rising obesity rates: warranting further research on this topic [47].

2.3.4 Homeostasis Model Assessment of Insulin Resistance (HOMA-IR)

The gold standard test for measuring insulin resistance is the euglycaemic hyperinsulinemic clamp, but because of the high cost and burden to study participants other low-cost and less invasive methods are used more frequently in large population-based studies. One method commonly used in population-based studies for measuring insulin resistance is the HOMA-IR because of its uncomplicated reliance upon measures of fasting plasma glucose and insulin. The HOMA-IR was developed in 1985 by

Matthews et al. [34] in which a simple linear equation estimates beta cell function and insulin resistance. The basic calculation for estimating the HOMA-IR is [(fasting plasma glucose mmol/l x fasting insulin μU/ml) / 22.5]. In 1998, a revised HOMA-IR was developed by Levy et al. and named HOMA2-IR which involved a more advanced mathematical model for predicting insulin resistance. The revised version now accounted for variability in hepatic and peripheral glucose resistance and the known increases in the insulin secretion curve occurring above 10 mmol/L, as well as the effect of proinsulin [48]. The HOMA2-IR Calculator is free software provided by the University of Oxford Diabetes Trial Unit, which enables researchers to utilize the more advanced predictive equation rather than relying upon estimates derived from the simple linear equation.

2.3.5. Validity of HOMA-IR

Matthews et al. 1985 compared the HOMA-IR to the euglycaemic hyperinsulinemic clamp and found significant correlation ($r = 0.87$, $P < 0.01$) in 11 healthy and 12 diabetic subjects [34]. Matthews et al. 2008 also tested HOMA-IR as it compared to the continuous infusion of glucose with model assessment (CIGMA); CIGMA is another low-cost procedure for measuring insulin resistance [34]. Matthews found HOMA-IR correlated highly with CIGMA ($r = 0.87$ $P < 0.0001$) for the healthy and diabetic subjects [34].

Yeni et al. 2000 took a sample of 490 non-diabetic volunteers (230 men and 260 women) and measured insulin resistance via the steady state plasma glucose as it compared to different surrogate measures such as the HOMA-IR [49]. Yeni et al. found that HOMA-IR correlated with the direct determination of insulin action ($r = 0.64$, $P < 0.001$) using a log-transformed Pearsons correlation [49].

Emoto et al. 1999 tested the association between HOMA-IR and the euglycemic clamp in 80 T2DM subjects [32]. The log-transformed HOMA-IR showed an association with the clamp technique with an $r = -0.725$, $P < 0.0001$ in all the subjects [32]. Katuski et al. 2001 also found significant correlation between the HOMA-IR and euglycemic clamp in 55 Japanese patients with T2DM [50]. Katsuki et al. analyzed insulin resistance in their subjects before and after a treatment with a new diabetic diet and exercise therapy [50]. Katsuki et al. found a correlation between HOMA-IR and the clamp technique of $r = -0.613$, $P < 0.0001$ before treatment and an $r = -0.734$, $P < 0.0001$ after treatment [50]. Another study published in 2001 by Ferrara et al. compared the HOMA-IR with the euglycemic clamp in older men with impaired glucose tolerance [33]. Ferrara et al. measured the glucose infusion rates (GIRs) in 45 obese men with a mean age of 61 (21 with normal glucose tolerance and 24 with impaired glucose tolerance) [33]. The results found in Ferrara et al. suggest that the use of HOMA-IR in older individuals, 60 or older, may be insufficient because it doesn't correlate well with standard measurements in the obese and in those with impaired glucose tolerance which becomes highly prevalent with advancing age [33]. Similar to Emoto, Yeni, and Katsuki; Kang et al. 2005 tested the validity of the HOMA-IR as compared with euglycemic clamp in a variety of glucose tolerant subjects [51]. Kang et al. tested a total of 90 Korean men and women, with T2DM ($n = 47$), impaired glucose tolerance ($n = 21$), and healthy normal glucose tolerant individuals ($n = 22$) [51]. A significant correlation was seen between the HOMA-IR and the glucose disposal rate (GDR) as measured by the euglycemic clamp in all of the subjects ($r = -0.558$, $P < 0.001$) [51]. Furthermore, Kang et al. found that for normal glucose tolerant subjects, the correlation between HOMA-IR and GDR was ($r = -0.404$, $P < 0.001$); for the impaired glucose tolerant, the correlation was ($r = -0.410$, $P < 0.001$);

and for T2DM subjects, the correlation was (*r* = -0.572, P < 0.001) [51]. Sarafidis et al. 2007 tested the effectiveness of the HOMA-IR in 78 Caucasians (36 men and 42 women) with hypertension and T2DM [52]. Again the HOMA-IR was tested for correlation with the euglycemic clamp, and it was found to be significantly correlated with the clamp value (normalized for weight) over three insulin measurements (*r* = 0.768, P < 0.001) [52]. Sarafidis et al. suggested that the HOMA-IR provided a valid assessment of insulin resistance in individuals with hypertension and T2DM [52].

The consensus indicates that the HOMA-IR method for measuring insulin resistance works as well as the euglycemic clamp, especially in those with impaired glucose tolerance and T2DM; however, it must be noted that it may be limited in normal glucose tolerant, non-obese, or older individuals [33, 49-51].

2.3.6. HOMA-IR in Indigenous Peoples

Despite the relative ease in estimating insulin resistance through the HOMA-IR, there has been limited use of HOMA-IR in research involving Indigenous Peoples [32, 51, 53-54]. Zhou et al. used the HOMA-IR to test the association of insulin and desaturase 5 in the Cree Community of Mistissini, Québec. In 176 participants HOMA-IR was found to be inversely associated with desaturase 5 in normoglycaemic individuals in a linear regression analyses (Beta = -2.11, SE = 0.566; P < 0.001) [54]. The inverse association with desaturase 5 and insulin was previously documented in a few recent studies [53-55] and demonstrates the value of assessing HOMA-IR in research involving Indigenous Peoples.

2.4. Diet Habits of the Indigenous Peoples in Canada

2.4.1. Traditional Food Use

Traditional food use of Indigenous Peoples in Canada has been decreasing over the past decades [5, 55]. Traditional food can be defined as local food, gathered, hunted, and or cultivated [1]. In Canada, the wide variety of Indigenous traditional food has been well documented and varies by geographic region [56-57]. Adoption of a western lifestyle and diet with reduced traditional food consumption in the younger generations has been noted [1, 55]. Land development projects, such as Hydro dams, have also contributed to the rapid transition by physically separating Indigenous Peoples from their traditional food resources [1, 55]. A decrease in the consumption of traditional foods has been postulated to negatively affect the health status of Indigenous communities. Receveur et al. in 1997 assessed the food habits in sixteen Dené and Métis communities (a total of 1012 participants from two seasons: Spring and Fall) using 24 hour recalls, traditional food frequency questionnaires, socio-cultural questionnaires, seasonal food patterns, and food prices [56]. Receveur et al. found statistically significant increases ($P < 0.05$) in both male and female participants for iron (from 15 mg to 25-28 mg in men and women), zinc (from 15 mg to 20-25 in men and women), and potassium levels (from 2590-2565 to 3192-3741 in men and women) on days when traditional food was consumed compared to days with no traditional food consumption [56]. More importantly, Receveur et al. determined that diets higher in market food were also higher in absolute energy, sucrose, fat, and saturated fat [56]. Kuhnlein et al. evaluated 28 First Nation and Inuit communities from the Yukon, North West Territories, Nunavut and Labrador (a total of 3408 participants) [1, 56], and found that traditional food use in all groups was associated with a lower intake of fat, sugar, and carbohydrates and a higher intake of vitamin D, E, protein, riboflavin, vitamin B-6, iron, zinc, copper, magnesium, manganese, phosphorus, potassium, and selenium [1, 56]. Kuhnlein et al. also reported a higher intake of sodium, vitamin C, folic acid, and fiber on days when market foods were eaten. The fortification of market foods is the reason for the higher Vitamin C and folic acid intake observed on days when market foods were eaten [1].

2.4.2. Traditional Foods Use in the Cree and the James Bay Cree

Traditional food consumption has been shown to be slightly lower in Cree communities than in many other Indigenous communities in Canada [8]. Compared to Indigenous communities in the territories, the Cree communities are closer to large Canadian cities which increases the availability and affordability of westernized market food. As outlined by Torrie et al., the decline in consumption of traditional wild meat has been well documented, from an amount of 1.3 kg per day in the 1950's to less than 0.23 kg per day in the 1990's [8]. A similar decrease in the consumption of fish has also been noted among the James Bay Cree, influenced, in part, by the warnings of mercury contamination in their fish [8]. Looking at the proportion of families that had eaten traditional food in the previous two days in 1983-84 in James Bay, there was a higher prevalence of traditional food consumption in the northern most communities of Whapmagoostui and Chisasibi (100% and 98%, respectively), than among the southern most communities of Mistissini and Waswanipi (46% and 61%, respectively) [8]. The communities of Mistissini and Waswanipi both have road access and are closer to major cities within Quebec; therefore, westernized market food can be shipped to their communities with more ease. Many factors have had an impact upon the consumption of traditional food, but it is apparent that there has been a rapid decrease, especially in the southern communities.

2.4.3. Diet from Market Food and Food Security

A survey in James Bay performed by Torrie et al. revealed that only half of the population reported consuming fruits and vegetables on a daily basis [8]. In the James Bay region individuals who reported drinking more than one soft drink per day in 1983-1984 ranged from a low of 31% in Nemaska to a staggering 91% in Whapmagoostui [8]. The rise in sugar-laden soft drink consumption, the low consumption (availability) of fruits and vegetables, coupled with the decrease in consumption of traditional food are major contributing factors to the poor health status of Indigenous Peoples in Canada [1, 56].

2.4.4. Using the Healthy Eating Index as a Dietary Measurement

The Healthy Eating Index (HEI) was developed by Kennedy et al. in the early 1990's as a tool for accessing the diet quality of an individual as it relates to the United States Department of Agriculture (USDA) Food pyramid [58]. It was recently revised in 2005 after its initial creation in order to reflect the changes made to the USDA food pyramid [58-59]. The HEI-2005 scores individuals from 0 to 20, in twelve different categories, with a maximum score of 100 [59]. The twelve different categories include the food group categories: total grains (5 point max), whole grains (5 point max), total vegetables (5 point max), dark green and orange vegetables and legumes (5 point max), total fruit (5 point max), whole fruit (5 point max), milk (10 point max), meat and beans (10 point max), and oils (10 point max), and the dietary guideline categories: saturated fat (10 point max), sodium (10 point max), and kilocalories from solid fat, alcohol, and added Sugar

(SoFAAS) (20 point max) [58-59]. In order to calculate a score for the food group categories the HEI-1995 used the proportion of servings eaten as compared to the USDA food pyramid recommendations; In the HEI-2005, the score is calculated by the proportion of the amount of food in cups or oz as compared to an optimum intake [58-59]. To calculate the scores for the saturated fat and SoFAAS intake, the percentage of their total energy intake is compared to the standards recommended by USDA [59]

2.4.5. How the General Population Scores on the Healthy Eating Index

Kennedy et al. used data from the Continuing Survey of Food (CSF) from 1989-1990 which included 7,500 subjects, and found that their mean HEI-1995 score was 63.9 with only 10% of the subjects scoring above 80 [60-61]. Similarly, Guenther et al. measured the HEI-2005 using two sets of data, the CSFII 1994-96 and the National Health and Nutrition Examination Survey (NHANES) 2001-02; in both data sets the mean HEI -2005 was 58.2 [60-61]. From the NHANES data from Guenther et al., low income individuals scored a total HEI of 56.5 only 1.2 points lower than high income individuals [60-61]. A poor diet is classified as a HEI score of < 50-65, and a good diet as a score ≥ 80-85 [58, 62-63]. The HEI has not been routinely incorporated into research characterizing diet quality among Indigenous Peoples.

2.4.6. Validity of the HEI as Dietary Marker

Hann et al. tested the validity of the HEI scores as compared to plasma biomarkers, derived from the USDA database, revealing actual dietary exposure [62]. Hann et al. 2001 used 340 women aged 21-80, and found significant ($P \leq 0.05$), albeit somewhat weak, positive correlations between HEI and the plasma concentrations of carotene (r = 0.41), lutein (r = 0.24), vitamin C (r = 0.33) and folate (r = 0.26) [62]. Weinstein et al.

found similar results to Hann et al. when comparing the HEI to the nutrient plasma concentration, using data from the NHANES 1988-1994 survey [62-63]. Weinstein used both men and women aged 17 and older and found significant correlations ($P < 0.01$) between their plasma levels of biomarkers (serum folate, carotene, lutein, vitamins C and E) and their HEI scores [63]. The correlations of actual plasma nutrient levels and the HEI scores in both Hann and Weinstein et al. support the use of the HEI as a dietary marker, where a score of 80-100 indicates a healthy diet [62-63]. Both studies mention that it is important to recognize that their results may only be applicable to the general population in the United States, and further tests must be performed on specific ethnic groups (including Indigenous people) [62-63].

Guenther et al. evaluated the creation of their HEI-2005 in 2008 in order to test its validity [61]. Guenther used 8,650 participants who had completed 24-hour diet recalls from the NHANES 2001-2002 survey to test the content, construct, and concurrent validity of the HEI [60-61]. Content validity was tested by comparing the components of the HEI against the USDA dietary guidelines; the results indicated that all the key recommendations from the USDA were captured in the HEI [60-61]. Next, the construct validity of HEI was performed by computing HEI scores for peer-reviewed menus issued by My Pyramid, Dietary Approaches to Stop Hypertension (DASH), American Heart Association (ASA), and Harvard's healthy eating pyramid; all menus scored very high, > 98, with the exception of the Harvard pyramid because it does not recommend milk products as the best possible source of calcium [60-61]. Finally, the concurrent criterion validity of the HEI was evaluated, which evaluates whether the HEI can distinguish between health conscious and non-health conscious groups, such as nonsmokers and smokers; the smokers had a mean HEI score of 44.7 whereas the non-smokers mean score was 53.3 ($P < 0.01$) [60-61].

2.4.7. Using a 24-hour Food Recall to Calculate an HEI Score

In Freedman et al., the HEI was shown to be effective in predicting nutrient intake even when only one 24-hour recall was available [64]. Freedman et al. used data collected from 738 women; to test three methods for calculating a HEI score when only one 24 hour recall is available [64]. These methods were named as follows: the mean of individual scores, the score of the ratio of nutrient or food group to energy intake a.k.a the population ratio, and the score of the mean of the individual ratios [64]. Using computer simulation, each method was used to determine a theoretical HEI score, and it was determined that the population ratio (the food group to energy intake ratio) is the least biased and is recommended to be used when computing a HEI score when only one 24-hour recall is available [64].

2.4.8. The HEI, Obesity and Non-Communicable Diseases

Using the HEI as a predictor of obesity and non-communicable diseases is not well established within the literature. Guo et al. looked a cross-sectional study using adults aged 20 to 75 from the NHANES III survey, with 10,930 subjects [65]. Anthropometric data was taken to assess the weight status of the participants, and 24-hour recalls were used to obtain dietary data. It was discovered that subjects with poor HEI scores had a high odds ratio (OR = 1.8, 95% CI [1.4-2.5]) for obesity ($BMI \geq 30$ kg/m^2) [65]. Guo et al. indicated that those eating according to dietary guidelines have lower BMI’s than those who have a lower quality diet [65].

2.4.9. The Use of the HEI in Canada

Translating the HEI for use in the Canadian population is possible because of the many similarities between the Canadian Food Guide (CFG) and the USDA Food Pyramid. Dubois et al. compared and adapted the HEI-1995 to the CFG by adjusting the recommended servings for the grains, fruits and vegetables, milk, and meat, from the US guidelines to the CFG, e.g. from 2-3 servings for milk to 2 servings; the same adjustments were made for the percentage of energy from fat and saturated fat seen in the HEI [66]. The adjusted HEI-1995 was compared with Patterson's Diet Quality Index (DQI) and Huijbregts' Health Diet Indicator (HDI) using the Quebec Nutrition Survey [66]. The HEI-1995 index scored the highest on the Mean Adequacy Ratio (MAR) at 0.287 compared to 0.001 for the DQI and 0.079 for the HDI[66]. The HEI-1995 also had the highest MAR for self perception of healthy eating habits at 0.206 compared to 0.117 and 0.109 for the DQI and HDI respectively [66]. The MAR is a measurement used to average the proportion of dietary recommendations for each nutrient that are being met by an individual [66]. As a result, the HEI is suggested as the preferred overall diet indicator for use in Canadian populations [66].

In 2005, Shatenstein et al. adapted the HEI to the dietary guidelines of the CFG. Shatenstein's version has nine components instead of twelve which are each worth ten points with the exception of the fruits and vegetables category which is worth twenty points. Similar to the original HEI, the Canadian version provides a score out of 100 possible points [67]. The dietary variety of the original HEI was also modified by Shatenstein because it was developed for diet recalls, and could not be used with the Food Frequency Questionnaire (FFQ) used in the Shatenstein study [67]. In order to adapt the dietary variety section to CFG, Shatenstein made it representative of Canada's recommendation using a variant of the diet diversity score [67]. The results from the adaptation showed that the Canadian HEI score was significantly correlated with crude nutrient intakes as estimated by the FFQ [67]. In females, vitamin C (r = 0.54), thiamin (r = 0.34), vitamin B-6 (r = 0.28), folate (r = 0.46), iron (r = 0.25), fiber (r = 0.40), total fat (r = -0.22), saturated fat (r = -0.26) from the FFQ showed significant (P < 0.01) associations to the Canadian HEI [67]. In men, vitamin C (r = 0.47), vitamin B-12 (r = -0.26), folate (r = 0.37), fiber (r = 0.36), total fat (r = -0.36), saturated fat (r = -0.42), and cholesterol (r = -0.36) respectively had intakes significantly (P < 0.01) associated to the Canadian HEI [67].

The HEI is only a tool to score how well individuals adhere to a food guide; subsequently the food guide itself must be validated.

2.4.10. Using Canada's Food Guide as a Dietary Marker

Canada's Food Guide (CFG) was first developed in 1942, and has progressively developed into Canada's primary dietary guide. The latest version of CFG (released in 2007) distinguishes four categories of food for healthy eating: vegetables and fruit, grain products, milk and alternatives and meat and alternatives; recommended servings for age and sex are then allocated for each of the categories [68].

Katamay et al., simulated diets for each of the sex and age group recommendations outlined by the CFG, the simulated diets followed the recommendations [69]. The purpose of the simulated diets was to determine if following CFG would result in meeting the Estimated Average Requirements (EAR) or Adequate Intake (AI) levels for selected nutrients [69]. When the CFG recommendations were adequately met the EAR were also met in greater than 90% of the nutrients which have an established EAR, such as folate, iron, magnesium, niacin, phosphorus, etc., [69]. When the CFG recommendations were met, nutrients with only an AI available such as calcium, and alpha-linoleic acid were also adequate, with the exception of vitamin D in adults older than 50; the AI for vitamin D rises 2 fold at this age, and this increase has not been specifically addressed in the CFG [69]. A similar test to Katamay et al. involving human subjects instead of computer simulation is needed.

2.4.11. Canada's Food Guide for Indigenous People

The use of CFG for the dietary assessment of Indigenous Peoples within Canada has not been adequately addressed in the literature. A study performed by Taylor et al. looked at Mi'kmaq children aged 1 to 18 years and evaluated their adherence to the CFG recommendations [70]. Taylor et al. found that the Mi'kmaq children consumed fewer vegetables than non- Indigenous children in Prince Edward Island, whereas the consumption of other food groups was virtually the same between Indigenous and non-Indigenous children [70].

Recent advances have been made with the Canadian Food Guide, one of which was a separate CFG for First Nations, Inuit, and Métis published in 2007 [71]. The CFG for First Nations, Inuit, and Métis differs from the original CFG through its incorporation of traditional food choices and addressing problem areas within Indigenous dietary trends [71]. The additional food choices provided in the example section of the food guide include: bannock in the grain products, and traditional meats and wild game under the meat and alternatives [71]. The First Nation, Inuit, and Métis CFG also emphasize foods to limit in ones diet, such as pop, potato chips, candy, etc. as well as an added disclaimer warning those who do not drink milk to ensure that they do eat foods which will provide them with enough nutrients [71].

2.5. Physical Activity as a Health Marker

2.5.1. Physical Activity and Obesity

The amount of physical activity that an individual engages in each day can have major implications on their health status. Increasing physical activity decreases the chances of being or becoming obese [72-74]. Conversely, the more sedentary activities one takes part in, e.g. television watching or working on a computer, the more likely one is to be obese [73, 75].

Chen et al. evaluated the leisure time physical activity among 81,512 subjects in the Canadian Community Health Survey and how it associated to weight and obesity [72]. The leisure time physical activity was expressed as a metabolic equivalent (MET), and as Chen et al. describes, “METs are the energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity” [72]. Obese men and women both had a lower mean value of leisure time physical activity than compared with normal weight subjects at mean MET’s of 1.65 and 1.23 respectively [72]. Shields et al. presented results from their inactivity study that appear to correlate with Chen et al. [72] in that the higher the leisure time physical activity level in a sample of 46,612 respondents of men and women, the greater the decrease in the odds ratio of being obese [73]. Both Shields et al. and Chen et al. used data from a cross-sectional survey [72-73]. In a longitudinal study performed by Brien et al. on fitness and weight gain similar results were documented as those observed in the cross-sectional studies [76]. The study of Brien et al. included 459 adults from the Canadian Physical Activity Longitudinal Study, which followed the subjects for up to 20 years. The maximal oxygen uptake of the subjects was measured at baseline, which represents the body's ability to transport and utilize oxygen and is a good reflection of physical fitness. If a subject had a high maximal oxygen uptake at baseline, representing good physical fitness, it was associated with a significantly lower OR of being obese ~20 years later (OR = 0.87, 95% ,CI [0.76-0.99]; $P < 0.05$) than those with a low maximal oxygen uptake at baseline [76].

2.5.2. Physical Activity and Obesity in Indigenous People in Canada

The level of physical activity of Indigenous and non-Indigenous Canadians is similarly low [7, 77]. Katzmarzyk et al. used a sample of 1,176 Indigenous and 23,103 non-Indigenous from the 2004 CCHS [7]. Both groups had their leisure time physical activity questioned for the 3 months before the interview, and then subsequently measured the physical activity in kcal/kg/day values for men, women, girls and boys [7]. The men's kcal/kg/day was 1.7 for Indigenous and 1.9 for non- Indigenous, and the women's kcal/kg/day scores were both 1.6 for Indigenous and non-Indigenous; therefore, no significant differences were seen in activity levels [7]. In 2007, Young et al. presented descriptive data concerning the physical activity of Indigenous People in Canada from the First Nations Regional Longitudinal Health Survey. The survey indicated that 27% of men and 15% of women were getting sufficient amounts of physical activity, meaning at least 30 min of moderate to vigorous exercise 4 days a week [78].

2.5.3. Physical Activity in the Cree

Descriptive statistics from the 1991 Santé-Québec survey describes the overall physical activity level in the James Bay Cree from inactive to very active through self administered questionnaires [8]. Inactive individuals are those who are "usually sitting during the day and do not move around very much”, relatively inactive individuals “stand or walk around quite a lot during the day, but do not carry or lift things very often”, moderately active individuals “usually lift or carry light loads, or have to climb stairs or hills often”, very active individuals “do heavy work or carry very heavy loads” [8]. The percentage of inactive females and males was 42% and 24% respectively [8]. The total percentage of moderately and very active Cree was 18% and 21% respectively, similar to the results seen in the First Nations Regional Longitudinal Health Survey by Young et al. [8, 78].

Two studies carried out a shuttle run to test the physical activity capacity of 178 obese and 82 non-obese Cree children [4, 13]. The shuttle run is a test which involves a continuous run between two points that are 20m apart, and a beep set at increasingly shorter intervals tells you when to move from one point to the other [4, 13]. The mean time for the shuttle run by the Cree Children in the two studies ranged from 3.1-3.27 min in normal weight individuals, and 1.9-2.29 minutes in obese children; the higher the minutes the better the physical activity level [4, 13]. On average the physical activity level is poorer in the obese children.

2.5.4. Walking and Obesity

Walking is a form of physical activity usually measured by the use of a pedometer or an accelerometer. A longitudinal study performed from 1985-1986 and published in 2009 by Gordon-Larsen et al., measured the walking patterns as it relates to weight change in 4995 men and women aged 18-30 [79]. A questionnaire pertaining to the subject’s physical activity in 12 different categories was recorded, and from this information a walking score was derived. Obese individuals at baseline who walked a half of an hour per day showed reductions in weight gain of -0.25kg/y; $P < 0.001$ [79]. Bond Brill et al. 2002, also found that walking ≥ 30 min/day was as just as effective ($P < 0.05$) in lowering obese women's WC as walking ≥ 60 min/day [80]. Walking 30 minutes or more per day may decrease the risk of gaining weight as well as help with weight loss [20, 79-81].

2.5.5. Walking and Insulin Resistance

Physical activity has been postulated in affecting insulin sensitivity, the metabolic syndrome, and T2DM [82-84]. Mayer-Davis et al. looked at 1467 ethnically diverse men and women in the U.S. for differences in insulin sensitivity across levels of vigorous to non-vigorous activity [82]. Insulin sensitivity improved as the level of non-vigorous activity (includes walking) increased ($\log r = 0.06$; $P < 0.05$) [82]. Miyatake et al. looked at 31 overweight males (BMI ≥ 25 kg/m^2) in a one year study before and after they increased their walking intensity and duration. Insulin resistance, measured by HOMA-IR, significantly improved from ($P < 0.01$) a HOMA-IR score of 2.8 to 2.1 [83]. Finally, Gray et al. used a control (n = 24) and intervention group (n = 24), and asked the intervention group to increase their walking by 4000 steps [85]; no significant changes were observed in the control or the intervention group in insulin [85]. However, the study by Gray et al. lacks a proper gradient as the participants were already walking quite regularly before they started [83, 85]. It is clear that physical activity improves insulin sensitivity [84], but it is not apparent as to how much of an effect walking plays in this association [82-83, 85].

2.5.6. Walking as a Health Marker in the Indigenous People of Canada

Egeland et al. assessed the physical activity level in 161 adults in the Cree community of Mistissini [20]. An International Physical Activity Questionnaire (IPAQ) was used to gather the Cree's physical activity; those who indicated moderate to no walking were considered non-walkers, and those who reported walking 6-7 days for 60 min per day were considered regular walkers [20]. The regular walkers had a significantly lower ($P < 0.01$) BMI, % Body Fat, and WC than non-walkers [20]. Reported walking levels appeared to be an excellent predictor for weight status [20].

2.5.7. The Validity of the Tools used to Assess Walking

Pedometers are one of the main tools used to measure the amount of walking an individual engages in per day. A pedometer is placed on the waist band and measures steps by the motion of the hips; therefore, it is imperative that it is worn correctly at all times because errors occur frequently [86-87]. In 2008 Smith et al. accessed the accuracy of the pedometer when engaging in various activities [87]. Smith et al. determined that the pedometer is only an accurate tool for walking and may not be as effective for higher intensity activities [87]. The type of pedometer can also increase the accuracy assessing physical activity, and Smith et al. found the SW-701 to be one of the most accurate [87]. Comparisons between the pedometer and a manual count and accelerometer were conducted in 2003, and both validated the use of the pedometer as a comparably equal tool [88-89]. The accelerometer is a better tool than the pedometer when detecting adults with slow gaits, such as seniors; however, the accelerometer has a high error rate of detecting non-steps [88]. The pedometer is a low cost alternative to the accelerometer, when one's goal is to measure walking.

2.5.8. The Validity of the International Physical Activity Questionnaire

De Cocker et al. evaluated the International Physical Activity Questionnaire (IPAQ) scores as they compared with pedometer data, using 1,239 participating adults in Belgium who completed an IPAQ over a telephone interview in conjunction with wearing a self-monitored pedometer for 7 days [86]. Results from De Cocker et al. 2007, showed positive correlations between the physical activity reported in the IPAQ compared to the pedometer data; similar results were seen in 2008 when De Cocker found correlations between pedometer counts and total physical activity ($r = 0.37$) and moderate physical activity ($r = 0.33$) [86, 90].

Egeland et al. tested the concurrent validity of the IPAQ for its use in the James Bay Cree population [20]. Significant decreasing trends for the % body fat across the low to high Total MET score ($P \leq 0.05$) and across the low to high vigorous MET score ($P \leq 0.001$) were seen; as well, a decreasing trend of % body fat, BMI and WC from non-walkers to regular walkers ($P \leq 0.01$) was also documented [20]. The decreasing trend of BMI, WC, and % body fat as the level of physical activity increased validates the IPAQ as a useful tool in this particular study [20]. The IPAQ has been shown to be an effective tool for assessing a population's physical activity level [20, 86, 90].

[3] OBJECTIVES

The proposed research was designed to provide a Cree-specific context for promoting beneficial health strategies and to identify high-priority risk factors for future interventions. The knowledge obtained will help target specific behavioral risk factors that are contributing to insulin resistance and obesity.

The main objectives are:

1) To describe the prevalence of obesity and insulin resistance present among James Bay Cree.
2) To describe the prevalence of individual dietary and other behavioral risk factors present among James Bay Cree.
3) To evaluate the extent to which dietary and other behavioral risk factors relate to insulin resistance and obesity.

[4] METHODS

4.1. Study Population

The data collection was carried out from 2005-2008 in Cree communities of Mistissini, Wemindji, Eastmain, Waskaganish and Chisasibi. A total of 1099 (approximately 10% of each communities population) randomly selected individuals were approached, of whom 665 adults 18 years or older agreed to participate, providing a participation rate of 61%. Subjects who had been diagnosed with diabetes mellitus were excluded from the present analyses as a diagnosis would likely lead to health behaviour changes and their inclusion would therefore bias the evaluation and identification of any dietary or behavioural risk factors. The remaining sample size for the current analyses was n = 486.

4.2. Ethics

The human ethics research approval was obtained from the Laval and McGill University Boards in collaboration with McMaster University, and the research was coordinated by the Cree Board of Health and Social Services

Communities consented to participate through Band Council Resolutions, which were later authorized in writing. Further research agreements allowed for the information to be published for audiences outside of Iiyiyiu Aschii. Adults aged 18 years and older who participated in this study signed informed consent forms.

An alphanumeric code was used for identifying the completed questionnaires to ensure that the participant's information was kept confidential.

4.3. Diet

4.3.1. Dietary Recall Collection

Assessment of dietary intake in the communities was carried out through one 24 hour diet recall, a repeat recall on a random 20% subsample, as well as through FFQ. The FFQ obtained dietary intake of an exhaustive list of traditional food by season and of an abbreviated list of market foods, as there are limited choices of the latter in most communities. Assisting with the dietary recalls, interviewers and translators were selected from the James Bay Communities and trained to perform the dietary assessments. To implement quality control, all of the completed questionnaires were reviewed by a SDHN dietician and graduate student member of the research team in order to guarantee their adequacy and completion.

The 24 hour recall used the graduated food models of portion sizes from Santé Québec, Montreal, Canada. The participants were asked to accurately describe all they had eaten the previous day with the help of food models. The food models incorporated a multitude of shapes and sizes related to real food portions. A multiple pass technique using fives steps was used for the recalls; the five steps include: A quick list of common foods consumed in the area, forgotten foods, details about specific recipes and probing, a review of the recall, and a final question concerning any vitamin or mineral supplements taken. Confidentiality was ensured to each participant during the recalls.

4.3.2. Macronutrient and Dietary analysis

CANDAT (Godin London Inc., London, Ontario) software was used to estimate the daily nutrient intake in the participant's diets. CANDAT utilizes the Canadian nutrient file established by Health Canada in 2001, as well as supplementary food items not present on the Canadian nutrient file such as the Center for Indigenous Peoples' Nutrition and Environment (CINE's) data on traditional food. CANDAT and STATA 10.0 was used to analyze the data from the 24-hour recalls and to calculate the total energy (mean kcal/d), total carbohydrates (mean % of energy), total protein (mean % of energy), total fat (mean % of energy), total saturated fat (mean % of energy) total traditional food (mean % of energy), and total fiber (mean grams) intake. The amount of high-sugar beverages (regular soda, crystal drink mixes, and sport drinks) consumed was also evaluated using the 24-hr recall data [46, 91].

4.3.3. Calculating a Healthy Eating Index

A score for the Canadian version of the HEI was generated for each participant by using modifications to the HEI-2005 guidelines, developed by the USDA [59, 67]. The US HEI scores individuals on 12 different categories for a possible score of up to 100 [59]. The twelve categories included in the US HEI are as follows:

Categories with a maximum score of 5:

- Total fruit (max.score ≥ 0.8 cup eq/1000 kcal)
- Whole fruit (max.score ≥ 0.4 cup eq/1000 kcal)
- Total vegetables (max.score ≥ 1.1 cup eq/1000 kcal)
- Dark green, orange vegetables and legumes (max.score ≥ 0.4 cup eq/1000 kcal)
- Total grains (max.score ≥ 3.0 oz eq/1000 kcal)
- Whole grains (max.score ≥ 1.5 oz eq/1000 kcal)

Categories with a maximum score of 10:

- Milk (max.score ≥ 1.3 cup eq/1000 kcal)

- Meat and beans (max.score ≥ 2.5 oz eq/1000 kcal)
- Oils (max.score ≥ 12 g/1000 kcal)
- Saturated fat (max.score ≤ 7% of energy)
- Sodium (max.score ≤ 0.7 g/1000 kcal)

Category with a maximum score of 20:

- Kilocalories from solid fat, alcohol, and added sugar (max.score ≤ 20% of energy).

A maximum score of 100 denotes that the individual is eating in perfect accordance to the USDA food pyramid. This particular study was carried out in Canada; therefore, the HEI was adapted to the Canadian context in which the score reflected the level of adherence to the Canada’s Food Guide (CFG) for First Nations, Inuit, and Métis. The CFG for the First Nation, Inuit, and Métis has similar serving recommendations as the general CFG, but differs in the food choice examples, i.e. bannock, traditional meats, and game [71].

The Canadian HEI was developed in much the same way as the USDA HEI in that it was adapted from each countries respective national health guidelines [67]. The Canadian HEI has 10 components and is outlined in Table 1.

Table 1. The Canadian Healthy Eating Index Components and Guidelines

Components	Score range	Criteria for maximum score	Criteria for minimum score
1. Intake of grain products	0-10	Females 18-49: 6-7 servings, 50+: 6 servings Males 18-49: 8 servings, 50+: 7 servings	0 servings
2. Intake of vegetables and fruit	0-20	Females 18-49: 7-8 servings, 50+: 7 servings Males 18-49: 8-10 servings, 50+: 7 servings	0 servings
3. Intake of milk products	0-10	Adults 18-49: 2 servings Adults 50+: 3servings	0 servings
4. Intake of meat and alternatives products	0-10	Females 18-49: 2 servings, 50+: 2 servings Males 18-49: 3 servings, 50+: 3 servings	0 servings
5. Total fat intake (%)	0-10	< 30% total energy from fat	≥ 45% total energy from fat
6. Saturated fat intake (%)	0-10	< 10% total energy from saturated fat	≥ 15% total energy from saturated fat
7. Cholesterol intake	0-10	≤ 300 mg cholesterol	≥ 450mg cholesterol
8. Sodium intake	0-10	≤ 2,400 mg sodium	≥ 4,800 mg sodium
9. Dietary variety	0-10	≥ 1 portion from each of the 4 food groups of CFG	< 1 serving from each of the 4 food groups of CFG

The serving amounts are from average energy intakes (women 18-49 yrs: 2200 kcal/d, women 50+ yrs: 1600 kcal/d, men 18-49 yrs: 2800, men 50+ yrs: 2200 [67]. The scores which are situated between the maximum and the minimum will be calculated by proportionality [67]. The maximum score for the Canadian HEI is 100, and a score greater than 80 represents a healthy diet [60, 67].

When calculating the HEI score, repeat recalls were combined with original recalls using the National Research Council (NRC) method for the adjustment of distribution for usual intakes. The NRC method measures the within and between person intakes: adjusted intake = [(participants mean - group mean) x (SD within/SD between)] + group mean [92]. The NRC method is used to ensure accuracy when looking at components of the HEI that take into account Adequate Macronutrient Distribution Intakes (AMDR) [92-93].

4.4. Physical Activity Assessment

IPAQ was used for the analysis of physical activity levels in the communities. The IPAQ was developed in an attempt to standardize the measurement of individual physical activity across all nations and cultures. Two versions of the IPAQ were initially developed, but only the short version was utilized in this research because the long version was rejected by the community members due to concerns of its length and research burden to participants [94]. The short version of the IPAQ, developed in 1996 by the International Consensus Group, is appropriate for this study as it was intended to be used in surveillance studies [94]. The short form of the IPAQ was calculated to be culturally adaptable for adults (aged 15-69 years), and its use on any other age group is not recommended. The short IPAQ was created to evaluate physical activity in domestic activities, leisure time, transportation related activities and work. Calculation of a total score of physical activity involves adding the duration (in minutes) and the frequency (in days) of moderate-intensity, vigorous intensity, and walking activities [94]. Mean values as well as inter quartile ranges were computed for the three levels of activities, and all scores were expressed as Metabolic Equivalents (MET) in minutes/week [94]. METs stand for multiples of resting metabolic rate at a standard body weight of 60 kg, and a MET-minute is calculated by multiplying the MET score of a particular activity by the minutes performed [94]. An average MET score was calculated for a wide range of activities using the Ainsworth et al. Compendium of Physical Activity [94].

A categorical score is also possible using the IPAQ, and the physical activity level can fall under three categories: low, moderate, and high [94]. A low categorical score denotes the lowest level of physical activity [94]. The moderate activity level is classified as any individual who does three or more days of vigorous activity for 20 minutes per day, or does five or more days of moderate activity (or walking) for 30 minutes per day, or completes five or more days of any combination of moderate to vigorous activities reaching a minimum total activity of at least 600 MET- minutes/week [94]. A high activity level is defined as someone who is vigorously active for at least three days, completing a minimum total physical activity of at least 1500 MET- minutes/week, or achieves 7 or more days of any combination of activity reaching a minimum total physical activity of at least 3000 MET-minutes/week [94].

The calculations used to transform the data into MET minutes per week are as follows:

- *Walking MET-minutes/week = 3.3 * walking minutes * walking days*

- *Moderate MET-minutes/week = 4.0 * moderate-intensity activity minutes * moderate days*

*-Vigorous MET-minutes/week = 8.0 * vigorous-intensity activity minutes * vigorous-intensity days*

-Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores

In order to normalize the distribution of the physical activity data, which is generally skewed, it is recommended to truncate the data [94]. Therefore, all Moderate and Vigorous METs cannot exceed 180 minutes per day [94]. Moderate activities include walking, yoga, dancing, ice-skating, and canoeing. Examples of vigorous activities are jogging, running, circuit weight training, swimming, fast bicycling, tennis, soccer, and ice hockey.

The construct validity of the IPAQ concerning its use in regards to the Cree communities was recently evaluated by Egeland et al. [20]. Significant inverse correlations between percentage body fat and physical activity was documented in the participants; however, BMI and waist circumference showed no correlations [20]. The study from Egeland et al. also revealed that the IPAQ may be a useful surveillance tool for estimating walking levels among the Cree [20].

4.5. Blood Profile Database

The participants in the Iiyiyiu Aschii study had fasting plasma glucose determined by a spectrophotometric assay (Vitros 950, Vitro Chemistry, Ortho-Clinical Diagnostics, Rochester, NY). The American Diabetes Association (ADA) cut-off of a Fasting Plasma Glucose (FPG) ≥ 5.6 mmol/L was used to determine individuals as having impaired fasting glucose (IFG). Fasting blood glucose was determined through the analysis of the plasma using a spectrophotometric assay (Vitros 950, Vitro Chemistry, Ortho-Clinical

Diagnostics, Rochester, NY) and fasting insulin concentrations were measured using a commercial double-antibody radioimmunoassay (LINCO Research, St Louis)

4.6. Insulin Resistance

4.6.1. Identifying Insulin Resistance via HOMA-IR

The Homeostasis Model Assessment of Insulin resistance (HOMA-IR) was used to calculate insulin resistance. The basic calculation for estimating the HOMA-IR is [(fasting plasma glucose mmol/l x Insulin μU/ml)/22.5]. The HOMA-IR calculator (Oxford University, 2004), developed through Oxford university is the preferred program for calculating HOMA-IR as it takes into account human physiology, was utilized in the current study [32, 34, 54]. The HOMA-IR calculator uses the most recent HOMA-IR model, developed by Levy et al. in 1998 [48].

4.7. Anthropometric and Clinical Assessments

The weight and body fat percentage of each participant was measured using the Tanita bioelectrical impedance scale (Tanita Corporation of America, Inc**,** Arlington Heights, Illinois). From the anthropometric measurements of height and weight each participant's body mass index (BMI) was calculated by kg/m^2. The reference for the calculation and categories for BMI from Health Canada 2003 was used [15]:

- BMI below 18.5 kg/m^2 = underweight
- BMI 18.5-24.9 kg/m^2 = normal weight
- BMI 25.0- 29.9 kg/m^2 = overweight
- BMI 30 and above kg/m^2 = obese

4.8. Data Analysis

All statistical analyses were completed using STATA (STATA version 10.0, StataCorp, Texas, USA). Descriptive data are presented as means (SD) and percentages. Differences in dietary habits, physical activity levels and other characteristics were evaluated between the non obese (BMI < 30 kg/m^2) and obese (BMI ≥ 30 kg/m^2) participants, by use of a student's t-test and a chi square test for proportions.

Physical activity levels in the participants were analyzed via walking levels. Categories of walking were looked at by sex, age, adiposity, and HOMA-IR. For skewed variables, statistical analyses were conducted using log-transformed data.

Multivariable analyses were performed using linear and logistic regressions adjusting for important co-variates. Dietary characteristics were evaluated separately with other co-variates including age and sex, and then selected combinations of dietary characteristics were considered. A logistic regression was used for evaluating characteristics associated with IFG (0 = normal, 1 = impaired). Based upon the logistic regression, the Odds Ratio (OR) and the 95% confidence intervals of each variable were presented. For the continuous outcome variables of BMI and HOMA-IR, linear regressions were conducted and the results presented as beta coefficients with a standard error.

The following manuscript contains an in depth analysis of walking and high sugar drink consumption as they relate to obesity, insulin resistance, and impaired fasting glucose. Many of the dietary and behavioral variables presented in the methods section are also included in the manuscript, in general descriptive tables. Results left out of the manuscript include those of HEI scores, MET scores, and CFG comparisons (see Appendices), as they did not fit the scope of the paper. The manuscript is an accurate representation of the breadth of this study.

[5] MANUSCRIPT

High-Sugar Drink Consumption and Walking as They Relate to Obesity, Insulin Resistance, and Impaired Fasting Glucose in Iiyiyiu Aschii (Cree) Adults.

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Context Indigenous Peoples in Canada have endured a nutrition transition which together with other lifestyle changes has contributed to an epidemiologic transition with increased prevalence of obesity and chronic diseases. James Bay Iiyiyiu Aschii (Cree) adults are at an increased risk of having health associated problems due to the nutrition transition and thus obesity, as their prevalence of obesity (BMI $\geq$ 30 kg/m^2) exceeds 50% of the population [1].

Objective To describe the prevalence of individual dietary and other behavioral risk factors present among James Bay Cree, and evaluate the extent to which the risk factors relate to insulin resistance and obesity.

Design Cross-sectional study conducted from 2005-2008.

Setting and Participants A cross-sectional survey was conducted in five Iiyiyiu Aschii (Cree) communities. The current analyses were restricted to those 18 years of age and older without a pre-existing diagnosis of diabetes mellitus. Diet quality, physical activity levels, and other characteristics were evaluated for their associations with obesity, impaired fasting glucose (IFG), and insulin resistance.

Main Outcome Measure BMI, insulin resistance, and impaired fasting glucose.

Results Regular walking (6 or more days per week) was inversely associated to BMI and HOMA-IR ($P < 0.05$), whereas consumption of high-sugar drinks was associated with having an increased BMI (Beta = 1.09; SE = 0.48; $P < 0.05$) in analyses adjusted for age, gender, and regular walking. Consumption of high-sugar drinks was also associated with a greater odds ratio of IFG (OR = 1.49; CI [1.02-2.17]; $P < 0.05$) in regression analyses adjusting for age, gender, BMI and regular walking.

Conclusion High-sugar drink intake was associated with BMI, IFG and HOMA-IR. The results indicate that promotion of walking $\geq$ 6 days/week and the reduction of high-sugar drink consumption are two modifiable behaviors that could lead to healthier communities.

Indigenous Peoples in Canada have endured a significant nutrition transition over the past 40 years: a transition which has seen a large percentage of their energy intake previously supplied by traditional foods replaced with highly processed market food [2-5]. The nutrition transition and other lifestyle changes taking place in aboriginal communities in Canada has contributed to an epidemiologic transition associated with high rates of obesity, diabetes and cardiovascular disease [3-5]. In northern Quebec, the Cree of James Bay (Iiyiyiu Aschii) are at particularly high risk of having health associated problems due to adiposity, as their prevalence of obesity exceeds 50% of the population [1, 3].

Given the public health implications of high rates of obesity [4, 6], further research is warranted regarding the dietary and other lifestyle behaviors associated with obesity and insulin resistance in high-risk communities. Previous research has provided descriptive accounts of how obesity and diabetes prevalence is rising, with a focus on traditional food and its' role in these changes [1, 7-10]. Broader investigation of dietary and physical activity habits and their association with obesity and diabetes have been limited to individual Cree communities [6, 9, 11-12]. This study explores dietary and walking habits effect on obesity, insulin resistance, and IFG in five Cree communities.

METHODS

Study Population

The data used for the present analysis is from a cross-sectional health survey entitled, "Nituuchischaayihtitaau Aschii" (Let us know our land) a multiple community environment and health study in the Iiyiyiu Aschii (Cree). The five communities represented in the current analyses consist of the inland community of Mistissini surveyed in 2005, and four of the five coastal communities Wemindji, Eastmain, Waskaganish and

Chisasibi; which were evaluated in 2007 & 2008. Ethical approval of the research was obtained from Laval, McMaster and McGill universities and the research was coordinated by the Cree Board of Health and Social Services. A total of 1099 randomly selected individuals from a representative sample were approached, of whom 665 adults 18 years or older agreed to participate, providing a participation rate of 61%. Subjects who had been diagnosed with diabetes mellitus were excluded from the present analyses as a diagnosis would likely lead to health behaviour changes and their inclusion would therefore bias results toward the null hypothesis. The remaining sample size for the current analyses was n = 486.

Dietary Assessment

Assessment of dietary intake was carried out through one 24 hour diet recall, with a repeat 24 hour diet recall on a random 20% of the study population, as well as through a Food Frequency Questionnaire (FFQ). The FFQ is a validated [13-14] instrument which gathers dietary intake of an exhaustive list of past-year traditional food intake by season and an abbreviated list of market foods. The abbreviated market FFQ assessed usual beverage consumption in which high-sugar drinks were defined as soda pop, powder drink mixes, sport drinks and fruit drinks. For the current analyses, fruit juice or diet soda were not included. High-sugar drink consumption was estimated by asking the participants how often they consumed these beverages over the last 30 days. The daily frequency of high-sugar drinks measures how often an individual reports independently consuming these beverages throughout the day regardless of the amount; therefore, exact volume was not measured.

The 24-hour dietary recall was used to identify important dietary patterns within groups. Interviewers who were trained to perform the dietary assessments were community members fluent in the Cree language. All of the completed questionnaires were reviewed by a research assistant in the field. In the current survey, 24 hour recall assessments used graduated food models of portion sizes to estimate dietary intake (Santé Québec, Montreal, Canada). Participants were asked to accurately describe all food they consumed the previous day. The USDA 5-step multiple-pass method[15] was used in the 24 hour dietary assessment as follows: a quick list of common foods, forgotten foods, details and probing, review. Each participant was asked to recall any vitamin and mineral supplements. Data from the 24 hour recalls was entered into the CANDAT nutrient analysis software (Godin London Inc., London, Ontario) and was double verified. CANDAT utilizes the Canadian nutrient file established by Health Canada in 2007 [16], which incorporates the Center for Indigenous Peoples' Nutrition and Environment (CINE's) data on the nutrient content of traditional food.

Past day dietary intake was [17] assessed for its association with BMI, IFG and HOMA-IR. The dietary variables included total energy intake (kcal/d), fiber (grams/d), as well as the percentage of past-day energy from protein, carbohydrates, fat, saturated fat, traditional food, and high-sugar foods intake. High-sugar food was identified as any food with added sugar that contained greater than 25% of its energy as sugar. A score for the Canadian version of the Healthy Eating Index (HEI) was generated for each participant by using Canadian modifications to the HEI-2005 guidelines, developed by Shatenstein et al [18]. Because cutoffs are required in calculating the HEI score, repeat recalls were used to adjust the distribution of intakes [19].

In order to assess the extent of under-reporting in the diet recalls, energy intake (EI) was divided by the basal metabolic rate (BMR) for each participant. The BMR was estimated using a Tanita bioelectrical impedance instrument (Tanita Corporation of America, Inc**,** Arlington Heights, Illinois). In a study of this size relying upon one 24-hour recall, an EI:BMR ratio under 1.5 is considered evidence of under-reporting [20].

Physical Activity

The walking levels of the Iiyiyiu Aschii participants were measured via the short form of the International Physical Activity Questionnaire (IPAQ) [6] The short form of the IPAQ is a culturally adaptable tool for assessing activity levels for adults (aged 15-69 years); it was solely used to access walking levels in this analysis [21-22].

In the Cree community of Mistissini walking correlated more strongly with adiposity measures than total reported MET scores and was therefore used as the physical activity indicator variable in all analyses [6]. Participants were asked how many days, during the last 7 days, they walked for at minimum of 10 minutes per day. Walkers were then divided into a dichotomous variable[6]: non-daily walkers and regular walkers in which non-daily walkers were those who walked 0-5 days per week for a minimum 10 min/day and daily walkers were those who walked 6-7 days per week for a minimum 10 min/day [6].

Impaired Fasting Glucose and HOMA-IR

Nurses collected venous blood samples for determination of fasting plasma glucose and insulin. Fasting blood glucose was determined through the analysis of the plasma using a spectrophotometric assay (Vitros 950, Vitro Chemistry, Ortho-Clinical Diagnostics, Rochester, NY), and fasting insulin concentrations were measured using a commercial double-antibody radioimmunoassay (LINCO Research, St Louis). The American Diabetes Association (ADA) cutoff of a FPG $\geq$ 5.6 mmol/L was used to determine individuals as having an impaired fasting glucose (IFG). The HOMA2-IR, a recent modification to the Homeostasis Model Assessment of Insulin resistance (HOMA-IR), was used to calculate insulin resistance using a calculator program (Oxford University, 2004)

Anthropometric Indices

The weight and body fat percentage of each participant was measured using the Tanita bioelectrical impedance instrument (Tanita Corporation of America, Inc**,** Arlington Heights, Illinois). Body Mass Index (BMI) was calculated (kg/m^2) from each of the participants measured weight (kg) and height (cm).

Statistical Analysis

Dietary habits, physical activity levels, demographic characteristics, and other behavioral habits were evaluated between obese and non-obese participants by use of student's t-tests for differences in means and chi-square tests for differences in proportions. Skewed variables, including HOMA-IR, were log-transformed prior to analyses.

Multivariable analyses were performed using linear and logistic regressions. A logistic regression was used for evaluating characteristics associated with IFG (0 = normal, 1 = impaired) adjusting for age, sex, BMI, regular walking and high-sugar drinks in all models. For IFG, the adjusted odds ratio (OR) and the 95% CI are presented. Linear regressions evaluated BMI and HOMA-IR as continuous outcome variables. For BMI, each dietary characteristic was evaluated separately in analyses adjusting for age, sex, regular walking and high-sugar drink intake. For HOMA-IR, analyses adjusted for the above mentioned variables and BMI. The linear regression results were presented as beta coefficients (SE). Tests for incremental and linear trends were calculated by assigning the medians of intake for high sugar drinks, walking, and the Canadian HEI score in tertiles, Table 4. All P values are two tailed where *P* ≤ .05 was considered statistically significant while *P* values between .06 and .10 were considered of borderline significance. All statistical analyses were conducted using STATA 10.0 (STATA version, StataCorp, Texas, USA).

RESULTS

A high prevalence of obesity (64% of the population) was identified in the 5 communities and 61 % of the obese were women (Figure 1). Further, women were over-represented among the increasing gradients of obesity: where 45% of those classified as non-obese (BMI < 30) were female in contrast to 54% of class 1 (BMI 30-35), 64% of class 2 (BMI 35-40), and 74% of class 3 (BMI ≥ 40) obese respectively.

Dietary Habits

There was a significantly lower percentage of energy as carbohydrate intake among the obese when compared to the non-obese. For men, the % of E as fat was higher among the obese whereas for women the % of E as protein was higher among the obese (**Table 1**). Further, the HEI score was significantly (P < 0.01) lower for both obese men and women compared to non-obese men and women (Table 1).

For all other dietary variables, there were no significant associations observed with obesity. Under-reporting was prevalent in all categories of BMI and gender. There was a significantly (P = .01) lower mean EI:BMR ratio between obese (1.13, SD = 0.5) and non-obese women (1.4, SD = 0.7) (Table 1), indicating high levels of under-reporting of food intake in obese women.

Walking

From approximately 90% of the participants (n = 436) who answered the amount of time they walked per day, it was determined that their median min./walk/day = 43, their 25%ile min./walk/day = 17, and their 5%ile min./walk/day = 4.

There were a total of 245 participants who identified themselves as daily walkers compared to 232 non-daily walkers. No age differences were noted between daily and non-daily walkers. However, 48% of daily walkers were men compared to 38.2% of non-daily walkers (P = .09). The mean BMI and the geometric mean HOMA2-IR was significantly ($P \leq .01$) lower in daily walkers compared to non-daily walkers in unadjusted analyses (**Table 2**).

Multivariate Analyses

BMI

In multivariable modeling, women had a significantly higher BMI (Beta = 2.49; SE= 0.55; P < .001) relative to men. Daily walkers (Beta = -2.21; SE= 0.55; P < .001) showed a significantly lower BMI as compared to non-daily walkers. Further, the daily frequency of high-sugar drinks over a one month period was positively associated with BMI (Beta = 1.09; SE= 0.48; P = .02) in analyses adjusting for age, sex, and walking (**Table 3**). Total energy and the percentage of energy from traditional food, however, were not significantly associated to BMI when adjusting for the aforementioned covariates **(Table 3).** In further exploration of dietary variables, the percentage of energy from carbohydrates was negatively associated to BMI (Beta = -0.08; SE= 0.04; P = .03) in analyses adjusting for age, sex, walking and frequency of high-sugar drinks, total energy and percentage of energy from traditional food (Table 3). Further, the Canadian HEI was inversely associated (Beta = -0.11, SE = 0.06;P = .07) with BMI **(Table 3)**.

Participants who reported no walking days compared to participants who walked greater than six days per week saw a significant decreasing trend (P <.001) in their BMI when adjusting for age and sex **(Table 4).** Walking 4-6 days/week (Beta = -1.88, SE = 1.14;P = .01) and 7 days/week (Beta = -3.43 SE = 1.02;P = .001) was associated with a significantly lower BMI compared to walking 0 days/week. A significant increasing trend (P = <.001) was also observed in BMI across the three frequencies of high-sugar drinks (**Table 4**) adjusting for age and gender. Any consumption of high-sugar drinks when compared to no consumption resulted in a significant increase in BMI, **(Table 4)**. Participants in the medium (Beta = -1.94, SE = .75; P = .005) and the high (Beta = -1.44, SE = .78; P = .03) tertile categories for Canadian HEI score had significantly decreased BMI's as compared to the reference value, (Table 4). BMI decreased with increasing HEI (Table 4).

HOMA-IR

In multivariable modeling, women had significantly higher log-HOMA-IR than men (Beta = 0.09; SE= 0.04; P = .03), and BMI was positively associated with log-HOMA-IR (Beta = 0.05; SE = 0.01, P < .001), but daily walking and frequency of high-sugar drink consumption was not significantly associated to log-HOMA-IR in a model considering the aforementioned variables with age (Table 3). A significant decrease (*P* = .007) in HOMA-IR was observed across low to high categories of walking, (Table 4). In the high sugar drinks category (Table 4) a significant increase (*P* = .01) in HOMA-IR was observed as the intake increased. A significant increase in log HOMA-IR scores was documented from non to high daily walkers (P = .007), as well as across the increased consumption of high-sugar drinks (P = .01), **(Table 4).**

IFG

In multivariable logistic regression, advancing age (in years) was positively associated with IFG (OR = 1.06, 95% CI [1.04-1.08]; P < .001), as was BMI (OR = 1.09, 95% CI [1.05-1.14]; P < .001), and high-sugar drink consumption (OR = 1.49, 95% CI [1.02-2.17]; P = .04) **(Table 3)**. Additional multivariable models did not identify other significant dietary correlates of IFG.

There were no interactions recorded between any variables in all three models of the multivariate analyses.

COMMENT

The primary findings of this study demonstrate that a low intake of high sugar drinks is associated with a lower BMI and HOMA-IR in the James Bay Cree. The findings also suggest that as the amount of days the participants spent walking increased, adiposity and HOMA-IR decreased. It has been well documented [2, 4, 23] that a nutritional transition has taken place in the Cree Communities of James Bay; however, the specific details of the nutrition transition that are most deleterious to health are unclear. The current study is novel in that it identified that the consumption of high-sugar drinks was positively associated to BMI and to IFG after controlling for important co-variates in multivariable modeling. To our knowledge, this is the first study to identify that sugar drink consumption is associated to BMI and IFG in an Indigenous adult population.

While sweetened beverage consumption has been postulated to have an effect on obesity risk in Indigenous peoples [24], the full weight of evidence on studies involving non-Indigenous adults are contradictory [25]. The current results, however, are compatible with the majority of literature suggesting a deleterious effect of sugar-sweetened beverage consumption on weight, WC, and BMI among children [25-30]; and adds to the limited literature on this topic for adults [31]. However, the findings observed in the current study may not be entirely generalizable to other populations, as the Cree traditional food system was generally high in protein and low in carbohydrates compared with the traditional food system of other Indigenous Peoples and western societies engaged in horticulture [1, 4]. Increases in body weight and energy intake with a high-fructose diet have yet to be identified in human study populations; however, a number of studies have shown that the fructose content of high-fructose corn syrup (HFCS) used in many sugary drinks has a more deleterious effect than table sugar in increasing obesity risk [32-36].

Walking, one popular type of physical activity in the Cree was a strong predictor of the three main outcome variables of BMI, HOMA-IR, and IFG. The results indicate that the absence of regular walking was one of the most significant individual behavioral risk factors associated with adiposity and insulin resistance. Health Canada recommends individuals to accumulate 30-60 minutes of moderate activity (includes brisk walking) 4 days a week [37], and the U.S. Department of Health & Human Services recommends 150 minutes of moderate-intensity aerobic activity per week [38]. As verification to the recommendations, the participants of this study who met or exceeded them showed positive benefits in adiposity and overall health. Furthermore, walking has previously been shown to help with weight loss in obese adult men and women [6, 39-41], as seen in a subset of this studies population in Egeland et al 2008 [6]. The current study helps build upon previous work concerning physical activity and indigenous people in Canada, and supports the well established link between physical activity and insulin sensitivity [42-44].

Consistent with previous literature [1, 6], women had the highest obesity prevalence in the five Cree communities; of the 61% of the population that was classified as obese, 64% were female.

The significant negative correlation that was seen between the % of E as carbohydrates and BMI in Model 3 (Table 3) may have been amplified due to the high under reporting documented in the obese population. The EI:BMR ratio in the obese population was as high as 1.43, SD = 0.66 (Table 1).

A major limitation of the analyses is that it relied upon just one 24-hour dietary recall in 80% of the participants. The 24 hour diet recall is effective as a group measure however it most useful when there are repeat recalls [45].

The dietary habits of the James Bay Cree do not generally fit the same pattern as non-indigenous Canadians, making it difficult to compare an indigenous diet to guidelines such as the Canadian Food Guide (CFG) and the HEI. Dietary guidelines do not take into account many traditional foods on which indigenous peoples have survived on for centuries. Therefore, extremely low scores were observed upon tabulation of the Canadian HEI and servings for the CFG in this population.

The total HEI score was significantly higher in the non-obese Cree adult population than in the obese, although both had scores that were classified as poor at 55 and 53 respectively. The non-indigenous Canadian average score on the HEI ranges from a mean of 69 - 75, as documented in Woodruff et al and Shatenstein et al [18, 46-47];

however, there is need for studies using participants from all provinces & territories to obtain a more accurate mean HEI for Canadians. Although the Cree do have a lower overall HEI score than non indigenous Canadians from previous literature, they both are categorized as “needs improvement” for scores ranging from 50 - 80 [18, 47]. The Canadian HEI may not be culturally appropriate for indigenous peoples, but it does accurately predict differences in adiposity in the five Cree communities; as we saw a slight positive correlation ($P < 0.1$) with the Canadian HEI in association to obesity in the linear regression analyses.

The second limitation was the incompletion of the walking portion in regards to the interview administered IPAQ. The IPAQ short form asks the amount of days/week the participant walked separate from how many hours and minutes per day walked [22]. Many of the participants did not choose to answer the second part of the question which asks for the specific amounts of time, and since the IPAQ short form is self administered no further probing was performed [22]. Additional information pertaining to the amount of time walked each day in hours or minutes would have given us the opportunity to establish a cutoff for the amount of time required each day for the minimum and maximum effect on BMI.

A culturally acceptable food guide for indigenous Canadians needs to be adopted for future editions of the CFG. Historically, the Indigenous people of James Bay have thrived on a diet which is low in vegetables, grains and dairy and high in traditional meat and foraged fruit; thus, a traditional diet must be encouraged along with the inclusion of healthy items, as outlined in CFG, from a western diet [48]. Implementing public policies for greater health education in the Cree communities that make a clear distinction between what westernized market foods are part of a healthy diet and which ones are not is necessary. Policy changes may have to be implemented at the Provincial and National level in order to lower the cost of healthy market items in remote indigenous communities; possibly in the form of subsidies and local food initiatives.

The adoption of walking six days per week and the cessation of high-sugar drink consumption are two significant daily habits which target specific behavioural health risks. Powerful public health messages in the James Bay Cree communities, such as the recently started campaigns for “drop the pop”, are desperately needed; this study could further strengthen these initiatives.

Figure 1. The Percentage of the Population Classified as Non-Obese or Obese by Gender in Five James Bay Cree Communities: 2009.

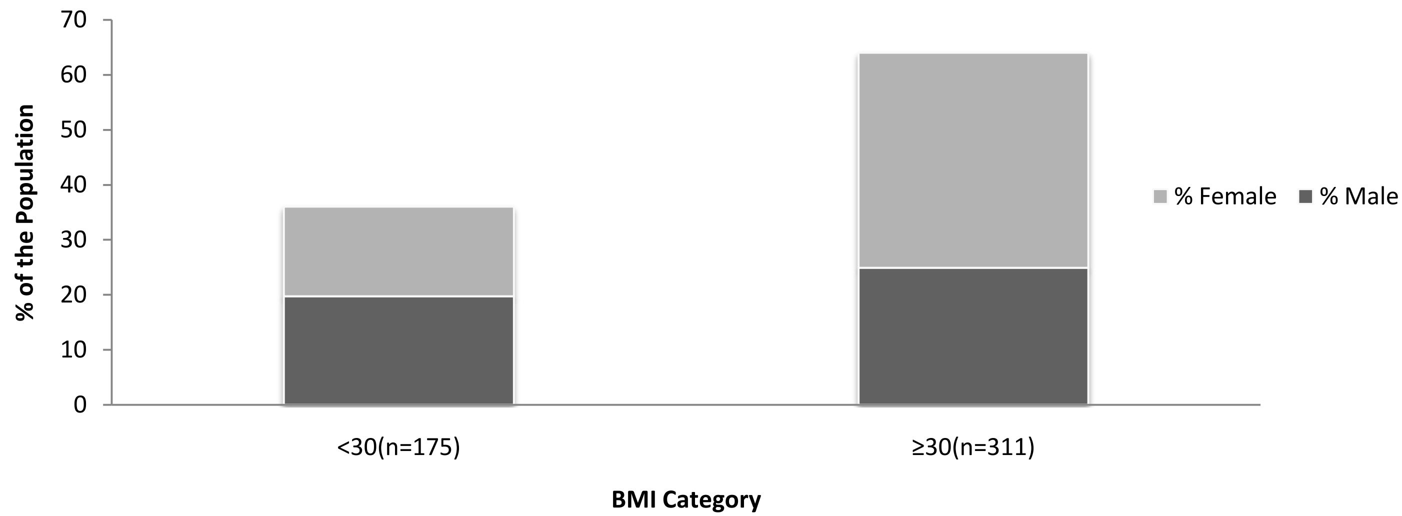

Table 2. Demographic Characteristics and Diet Quality by Obesity Status & Gender among Five James Bay Cree Communities.

	Female			**Male**		
Characteristics	**BMI<30 (n=79) Mean (SD)**	**BMI≥30 (n=187) Mean (SD)**	***P* Value[1]**	**BMI<30 (n=96) Mean (SD)**	**BMI≥30 (n=117) Mean (SD**	***P* Value[1]**
Age, y	37 (16)	35 (14)	.40	34 (15)	39 (12)	.01
Smoking, %	66	54	.08	56	53	.72
24 Hour Recall, mean (SD)						
Total energy, kcal/day	2106 (946)	1995 (820)	.40	2440 (1074)	2566 (1180)	.42
EI:BMR, ratio	1.43 (0.66)	1.13 (0.47)	.01	1.29 (0.57)	1.19 (0.53)	.22
Protein, energy %	17.2 (5.9)	18.9 (6.7)	.05	19.2 (7.5)	20.0 (6.9)	.42
Carbohydrates, energy%	48.0 (14.3)	44.3 (13.3)	.03	44.2 (11.7)	39.6 (12.1)	.01
Fat, energy %	35.9 (3.7)	36.7 (3.3)	.12	36.0 (3.4)	37.3 (3.9)	.02
Saturated fat, energy %	11.3 (1.1)	11.5 (1.1)	.17	11.6 (1.1)	11.8 (1.3)	.13
Sugar	20.2 (15.3)	19.4 (13.9)	.62	20.2 (16.0)	17.0 (12.9)	.13
Traditional Food, energy %	0.92 (0.27)	0.94 (0.24)	.25	0.91 (0.29)	0.95 (0.22)	.13
Fiber, g/day	11.7 (6.6)	11.1 (7.1)	.52	13.0 (7.9)	13.1 (10.1)	.97
Canadian HEI	56.4 (7.0)	54.4 (8.3)	.07	53.5 (8.4)	50.3 (8.1)	.01
FFQ, drinks/day						
High-sugar Drinks	0.45+/-0.67	0.50 (0.61)	.16	0.39 (0.54)	0.45 (0.64)	.30
Alcohol	0.25 (1.1)	0.14 (0.55)	.30	0.31 (2.13)	0.16 (0.88)	.50

[1] Students t-test for differences in means or chi-square test for differences in proportion

Table 3. Mean Age, Gender, BMI and HOMA-IR by Two Categories of Walking: Non-Daily Walkers and Regular Walkers among Five James Bay Cree Communities: 2009.

Characteristic	**Activity Category** Non-daily Walkers (n=232)	**Activity Category** Daily Walkers (n=245)	***P Value***
Frequency	0-5 days/week	6-7 days/week	
Age, y	36.4	36.3	.97
Males, %	38.2	48.0	.09
BMI, mean(SD)	33.6 (6.2)	31.3 (6.0)	<.001
HOMA-IR[2], Geometric mean (CI)	8.2 (6.9 to 9.6)	5.7 (4.8 to 6.6)	.002
Impaired Fasting Glucose, %	28.5	31.8	.34

[1] Students t-test for differences in means or chi-square test for differences in proportion
[2] Geometric means and 95% CI presented for skewed variables which were log transformed.

Table 4. Linear and Logistic Regression Analyses for BMI, IFG, and HOMA-IR among Five James Bay Cree Communities: 2009.

	BMI (Continuous) Beta(SE) (n=475)	*P* Value	HOMA-IR[1] (Continuous) Beta(SE) (n=473)	*P* Value	IFG (0,1) Odds Ratio [CI] (n=473)	*P* Value
Intercept						
Model I[2]						
Age	0.04 (0.02)	.04	0.01 (0.01)	.11	1.06 [1.04 - 1.08]	<.001
Sex[3]	2.49 (0.55)	<.001	0.09 (0.04)	.03	1.46 [0.94 - 2.29]	.10
BMI	n/a		0.05 (0.01)	<.001	1.09 [1.05 - 1.14]	<.001
Daily Walking	-2.21 (0.55)	<.001	-0.04 (0.04)	.30	1.38 [0.89 - 2.16]	.15
High-sugar Drinks	1.09 (0.48)	.02	0.04 (0.04)	.27	1.49 [1.02 - 2.17]	.04
Model II[4]						
Total Kcal	0.01 (0.01)	.94	0.01 (0.01)	.07	1.0 [1.00 - 1.00]	.83
%E Traditional Food	0.03 (0.03)	.28	-0.01 (0.01)	.29	0.98 [0.96 - 1.01]	.15
Model III[5]						
Protein, energy %	0.05 (0.05)	.33	-0.01 (0.01)	.42	1.00 [0.96 - 1.04]	.72
Carbohydrates, energy%	-0.08 (0.04)	.03	-0.01 (0.01)	.64	1.01 [0.99 - 1.03]	.69
Fat, energy %	0.11 (0.13)	.41	0.01 (0.01)	.67	0.98 [0.92 - 1.04]	.82
Saturated fat, energy %	0.32 (0.45)	.48	0.02 (0.02)	.62	1.04 [0.86 -1.27]	.83
Canadian HEI	-0.11 (0.06)	.07	-0.01 (0.01)	.40	1.02 [0.98 -1.07]	.49
Fiber	-0.02 (0.04)	.87	0.01 (0.01)	.53	0.98 [0.93 - 1.02]	.43

[1] Log of HOMA-IR.
[2] Each variable presented was considered together in a multivariable model.
[3] 0=male, 1=female.
[4] Each dietary factor considered separately in a model adjusting for age (years), sex, BMI, regular walking (yes vs. no), and frequency of high-sugar drink consumption.
[5] Dietary factors considered separately in a model adjusting for variables in Model 1 & 2.

Table 5. Supplementary table of linear and logistic regression analyses by body mass index, impaired fasting glucose and HOMA-IR in five James Bay Cree Communities

Categories	BMI Beta (SE)	*P* Value	HOMA-IR[1] Beta (SE)	P Value	IFG OR (95%CI)	*P* Value
Regular walking						
None (0 days/week)	0[Reference]		0[Reference]		0[Reference]	
Low (1-4 days/week)	-1.05 (1.12)	.31	0.01 (0.08)	.96	1.39 (0.57 - 3.38)	.47
Med (4-6 days/week)	-1.88 (1.14)	.01	0.04 (0.08)	.66	1.40 (0.56 - 3.52)	.48
High (7 days/week)	-3.43 (1.02)	.001	-0.03 (0.08)	.70	1.75 (0.55 - 4.02)	.19
P value for trend		<.001		.007		.92
High-sugar drinks						
None (median = 0)	0[Reference]		0[Reference]		0[Reference]	
Low (median = 0.14)	1.31 (0.75)	.01	0.02 (0.06)	.77	0.90 (0.49 -1.63)	.72
Med (median = 0.43)	3.06 (0.79)	<.001	0.06 (0.06)	.30	0.87 (0.46 -1.62)	.66
High (median = 1)	2.25 (0.73)	.01	0.01 (0.06)	.92	1.47 (0.82 - 2.63)	.14
P value for trend		<.001		.01		.38
Canadian HEI Score						
< 44	0[Reference]		0[Reference]		0[Reference]	
Low (median=50)	-1.29 (0.79)	.06	-0.02 (0.06)	.74	1.34 (0.72 - 2.48)	.35
Med (median=56)	-1.94 (0.75)	.005	-0.07 (0.06)	.31	1.14 (0.62 - 2.10)	.66
High (median=63)	-1.44 (0.78)	.03	-0.06 (0.06)	.37	1.52 (0.82 - 2.80)	.19
P value for trend		0.07		.20		.60

[1] Log of HOMA-IR.

Each category adjusted for age (years), sex and BMI

[6] DISCUSSION

Indigenous people in Canada are enduring rapid lifestyle transitions, which have been shown to have serious negative health effects; the Cree communities of James Bay are no exception. Based upon the prevalence of obesity and diabetes, The Cree are one of the most affected Canadian Indigenous Peoples with regards to the nutrition transition [8, 31]. Therefore, it is imperative for the health status of future Cree generations that effective measures are found to reverse trends in obesity and T2DM.

The focus of this thesis was largely the Cree's diet and physical activity habits; identifying how they are impacting the risk for obesity, insulin resistance and IFG. Traditional food has been shown to be a vital component in indigenous health, as it protects against the detrimental effects of nutrition transition [1, 56]. However, there was no significant association between traditional food intake and obesity, insulin resistance and IFG in the current study. Traditional food may have had a protective effect on the health status of the communities if it was not for the drastic drop in overall consumption reported by Torrie et al. [8]; this drop may have made any effects of low-level traditional food consumption undetectable.

The dietary guidelines assessed in this analysis raise questions regarding what constitutes a culturally acceptable guideline for Cree and other Indigenous Canadians. Health Canada developed a guideline for First Nation, Inuit, and Métis, which offers culturally appropriate suggestions for the 4 food groups, but may not be adequately addressing the food groups themselves. A closer look at how the food groups and their respected servings apply to the indigenous population should keep in mind that the Cree had survived with little health complications on a mostly traditional meat, fat, and foraged plant/fruit diet until recently [1, 3, 5]. As expected, the James Bay Cree adults did not meet the recommended servings for the vegetables and fruit or milk and alternatives categories as these items can be difficult to attain for many of the community members. In another example, the mean daily servings of vegetables and fruit in the James Bay Cree adults was just above 1, as compared to the recommended servings for adults at 7-10 [71]. In general the HEI scores for all the communities were quite low in comparison to the rest of the Canadian population, which ranges from 69-75 [67]. The low scores may again be a symptom of the guide, as it is adapted from the CFG; however, the overall HEI scores were an excellent indicator of weight status in the five communities as similarly demonstrated in Guo et al. [65].

Physical activity in the form of walking was also shown to be a positive behavioral habit for frequent walkers. The significant association between walking and BMI is consistent with results from a subset of this study in the community of Mistissini, where increased levels of walking were related to a lower BMI [20].

Low or non-vigorous activity, which includes walking, has previously been shown to improve insulin sensitivity in Mayer-Davis et al and Plasqui et al, and it did in this study as well [82, 84]. However, in Plasqui et al., non-vigorous activity included walking as well as other types of low intensity activities; therefore, walking was not separately evaluated. The multivariable results in this study indicate that the potential protective effect of walking on insulin resistance is mediated through a lower BMI among the regular walkers compared to non-regular walkers.

The primary limitation of this study is that it relied upon just one 24-hour recall for 80% of the participants. The 24 hour recall is effective in large samples sizes such as this one, however it most useful when there are at least 3 days of repeat recalls [104].

The dietary habits of the James Bay Cree do not generally fit the same pattern as non-indigenous Canadians making it difficult to compare an indigenous diet to guidelines such as the Canadian Food Guide (CFG) and the HEI.

The sample gathered from the five James Bay communities was an accurate representation of the Cree population within this area. As in previous research the results showed the deleterious effects of the nutrition transition on obesity [1-3, 5-6, 8, 106], as 64% of the James Bay Cree population was classified as obese. The lack of physical activity seen is also in accordance with recent literature which shows the nutrition transition leading to a less physically active lifestyle, and subsequent weight gain [1-3, 5-6, 8, 106].

It is evident from this study that daily walking and the cessation of high sugar drinks are two daily habits which combat specific behavioural health risks. Campaigns for greater awareness and strategies to contend with the obesity epidemic have already started in some of the Cree communities, for example posters which compare the sugar and kilocalorie content in pop to water. A focus on the health of the James Bay Cree has only recently begun, with the recent formation of the Cree Health Board and in depth projects from McGill's CINE, Laval, and McMaster.

As the Cree life starts to more closely resemble that of the rest of Canadians it has ultimately brought massive changes to their lifestyle. The first change is from a people of active hunting and basic survival of their communities; to a more sedentary lifestyle where activity is simply something one does for recreation. Thus, it should not be a surprise that recreational walking or physical activity is low in the Cree, as it is a fairly new phenomenon and not a common accepted practice. Those who are walking frequently are seeing the same results on their weight as all their ancestors would have seen through activity by means of survival. Secondly, the introduction of a multitude of easily accessible high energy food items in the Cree communities also provided a sudden paradigm shift, from uncertainty to mass availability, in less than a generation. Availability has most likely played a significant role in the increased high sugar drink and junk food consumption in indigenous populations, as it went from unavailable to an ultimately endless and cheap supply.

Even though the nutrition transition in the James Bay has been narrowed down to two factors in this study, it is important to keep in mind the complexity of that which is the nutrition transition. Equally, in order to move forward in the James Bay communities a sense of urgency must be brought towards the importance of extensive educational health and programming providing positive change. Changes that need to be met can be specific and immediate as we have seen in the two examples presented in this study, as well as broader and sustainable programs in the long term. Optimistically, results from this study provide further documentation to strengthen public health campaigns, which can ultimately lead to an improvement in the current health trends seen in the Cree.

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APPENDICES

Table 6. Means and Standard Deviations (SD) for HEI Component and Total Scores by BMI and Sex among Five Communities of James Bay Cree Adults: 2009.

	Male		Female	
Component (maximum score)	**BMI<30 (n=96)**	**BMI≥30 (n=117)**	**BMI<30 (n=79)**	**BMI≥30 (n=187)**
Intake of grain products (10)	6.7 (2.4)	6.5 (2.4)	6.7 (2.2)	6.5 (2.7)
Intake of vegetables and fruit (20)	2.9 (1.9)	2.8 (1.9)	3.1 (2.4)	3.0 (2.4)
Intake of milk products (10)	3.7 (1.3)	3.9 (1.1)	3.9 (1.0)	3.6 (1.3)
Intake of meat products (10)	9.0 (2.4)	9.3 (1.9)	9.4 (1.6)	9.3 (2.2)
Total fat intake (10)	6.0 (2.2)	5.2 (2.5)***	6.0 (2.3)	5.5 (2.0)*
Saturated fat intake (10)	6.8 (2.1)	6.3 (2.3)*	7.3 (2.0)	6.9 (2.0)*
Cholesterol intake (10)	3.9 (4.5)	3.2 (4.1)	5.7 (4.5)	5.4 (4.4)
Sodium intake (10)	8.0 (2.6)	6.7 (3.4)***	7.7 (2.8)	7.7 (2.8)
Dietary Variety (10)	6.4 (1.44)	6.8 (3.3)	6.6 (1.5)	6.3 (1.7)
Total HEI Score (100)	53.5 (8.4)	50.4 (8.0)**	56.4 (7.0)	54.3 (8.5)*

Student's t-test used to generate P-value between BMI categories by Sex. *P<0.1, **P<0.05, ***P<0.01

Table 7. Means and Standard Deviations (SD) of Servings from the CFG by BMI and Sex among Five Communities of James Bay Cree Adults: 2009

CFG Category	Male		Female	
	BMI<30 (n=96)	BMI≥30 (n=117)	BMI<30 (n=79)	BMI≥30 (n=187)
Servings of F&V	1.9 (0.9)	1.2 (0.8)	1.3 (1.1)	1.3 (1.0)
Servings of Grains	5.2 (2.1)	5.0 (2.3)	5.0 (1.9)	5.0 (2.3)
Servings of milk products	0.7 (0.3)	0.7 (0.2)	0.8 (0.2)	0.7 (0.3)
Servings of meat & alternatives	3.1 (1.4)	3.4 (1.4)	3.1 (1.0)	3.4 (1.5)*

Student's t-test used to generate P-value between BMI categories by sex. *P<0.1, **P<0.05, ***P<0.01

Table 8. Means and Standard Deviations (SD) of Age, Sex, BMI and HOMA-IR by Total MET, Moderate MET, and Vigorous MET Quartiles among Five Communities of James Bay Cree Adults: 2009

	MET mean (range)	Age	% Males	BMI	HOMA-IR
Total MET					
1 (n=119)	1156 (34 - 2147)	37.8 (16.0)	47.1	33.0 (6.5)	3.01 (2.34)
2 (n=119)	3365 (2160 - 4632)	35.9 (13.0)	40.3	32.8 (6.3)	2.75 (1.91)
3 (n=119)	6235 (4712 - 8105)	34.9 (13.6)	41.2	32.0 (6.1)	2.53 (1.34)
4 (n=119)	11706 (8106-19278)	36.5 (13.2)	49.6	31.5 (5.8)*	2.45 (1.47)**
Moderate MET					
1 (n=125)	373 (60 - 720)	35.3 (14.2)	60	31.8 (6.0)	2.82 (2.59)
2 (n=123)	1306 (840 - 1680)	34.8 (12.2)	35	33.8 (6.5)	2.83 (1.55)
3 (n= 90)	2920 (1920 - 3360)	37.0 (13.6)	33.3	32.0 (6.0)	2.61 (1.40)
4 (n= 99)	4778 (3600 - 5040)	37.0 (14.1)	40.4***	31.6 (6.0)	2.42 (1.17)
Vigorous MET					
1 (n= 92)	516 (82-960)	34.8 (12.2)	39.1	33.2 (6.6)	2.63 (1.41)
2 (n=78)	1767 (1080-2400)	35.6 (11.8)	56.4	32.6 (5.9)	2.49 (1.42)
3 (n=70)	3575 (2520-4872)	35.0 (12.1	50	31.8 (5.8)	2.31 (1.25)
4 (n=80)	8238 (5760-10080)	37.2 (13.6)	58.8**	31.3 (5.3)*	2.50 (1.56)

- METs represent minutes/week

- Trend test across ordered groups used to generate P-value across Total, Moderate, and Vigorous MET quartiles for Age, %Males, BMI, HOMA-IR.

- *P<0.1, **P<0.05, ***P<0.01