LONGITUDINAL ANALYSIS OF THE DIETARY INTAKE PATTERNS OF QUEBEC YOUTH

BY

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Abstract

In Canada, the problem of obesity in children and adolescents is particularly alarming, as it is advancing at a more rapid pace than among adults. The role played by the immediate environment in shaping the dietary behavior of youth is increasingly important, particularly in the context of obesity prevention. Due to the ease with which cross-sectional studies can be undertaken, there are numerous such studies showing the relationship between children and their dietary intake, especially how they are not meeting their nutrition recommendations. Little research has examined the changes in dietary intake in children as they age. This study examines the changes in eating patterns of children between the ages 8-10 years and 15-17 years and to describe potential determinants of dietary changes as children grow older including, initial BMI and sex of the child, maternal obesity, paternal obesity and supper with family as potential factors associated with this change. The study used a secondary data set which was collected using a longitudinal cohort design- the Quebec Adiposity and Lifestyle Investigation in Youth (QUALITY) cohort. An essential eligibility criterion included Caucasian children with at least one obese biological parent. Participants 8-10 through 15-17 years of age had their dietary assessments by means of three 24-hour recalls at two time-points approximately 7 years apart. Data were entered and verified using the CANDAT10 software which uses the Canadian Nutrient File (CNF), version 2010 as a database. Key nutrients and food groupings were examined using IBM SPSS Statistic 22.0 © 2012 Software. Descriptive analyses were performed to understand sample characteristics. Paired t-tests were used to the compare the changes in servings of fruits, vegetables, grains, meat and alternatives, and dairy and alternatives consumed at two time-points. Participants were stratified by gender and by their obesity status to learn more about the evolution of diet as the child grows older. The participants ($n = 365$), were on average 9.5±0.9y, 54.5% were male, the mean BMI z-score of the cohort was 0.61±1.0 at baseline. Dietary intakes were normalized to 1000 kcal consumed. Overall the number of fruit and dairy servings decreased from 1.5±0.9 to 1.3±1.0 ($p=0.004$) and 1.1±0.5 to 1.0±0.5 ($p<0.001$) respectively per day over time. In contrast servings of grains and meats and alternatives increased. These changes in food choices led to increases in protein ($p<0.01$), and a decrease in calcium ($p<0.01$), owing to the decreased dairy consumption. The girls showed no decline in fruit intake while the boys declined substantially showing a significant difference ($p<0.01$) between the sexes. The mean change score for the five food groups examined was not influenced by baseline bodyweight of children. No significant differences were observed in the mean change score of servings for food groups examined, between the healthy weight group and the overweight/obese group. However, on comparing the mean change score, the healthy weight group reported greater increases in energy intake than the overweight/obese group ($p<0.01$). The children of mothers who were obese reduced their fruit intake over time ($p<0.01$). But on comparing mean change scores, maternal obesity status had no significant associations on the change in food group consumption or energy intake of the individuals in the study. The children having a non-obese father reported greater increases in their energy intake over time as compared to those children with an obese father ($p<0.01$). The findings from this study

suggest that initiatives to increase fruit, vegetable and dairy intake with increasing age should be included in programs and interventions aimed to improve diet quality of individuals.

Résumé

Au Canada, le problème de l'obésité chez les enfants et les adolescents est particulièrement alarmant car il progresse à un rythme beaucoup plus rapide que celui observé chez les adultes. Le rôle joué par l'environnement immédiat dans l'élaboration du comportement alimentaire de la jeunesse est de plus en plus important, en particulier dans le contexte de prévention de l'obésité. En raison de la facilité avec laquelle des études transversales peuvent être entreprises, il existe de nombreuses études montrant la relation entre les enfants et les conséquences de ne pas atteindre les recommandations en matière de nutrition dans leur consommation alimentaire. Cependant, peu de recherches ont examiné l'effet du vieillissement dans l'apport alimentaire chez les enfants. L'objectif de cette étude est d'examiner le changement des habitudes alimentaires des enfants âgés de 8 à 10 ans et de 15 à 17 ans en décrivant les déterminants potentiels des changements alimentaires lorsque les enfants grandissent, parmi lesquels figurent l'indice de masse corporelle (IMC) initiale, le sexe de l'individu, l'obésité maternelle, l'obésité paternelle et le fait de souper en famille. Cette étude a exploité un ensemble de données secondaires qui ont été recueillies à l'aide d'une conception de cohorte longitudinale - la cohorte de l'Enquête sur le l'adiposité et le mode de vie chez les jeunes du Québec (QUALITY). Un critère d'éligibilité essentiel comprenait des enfants de race blanche avec au moins un parent biologique obèse. Les participants âgés de 8 à 10 et 15 à 17 ans ont eu leurs évaluations alimentaires au moyen de trois rappels de 24 heures à deux moments. Les données ont été saisies et vérifiées à l'aide du logiciel CANDAT10. CANDAT10 utilise la version 2010 du Fichier Canadien sur les Éléments Nutritifs (FCÉN) comme base de données. Les principaux éléments nutritifs et groupes d'aliments ont été examinés à l'aide du logiciel IBM SPSS Statistique 22.0 © 2012. Des analyses descriptives ont été effectuées pour comprendre les caractéristiques de l'échantillon. Des tests en t jumelés ont été utilisés pour comparer les changements des tailles de portions de fruits, végétales, grains, viande et alternatives, et de laitier et alternatives consommés à deux moments. Les participants ont été stratifiés par sexe et par leur état d'obésité pour en apprendre davantage sur l'évolution du régime alimentaire à mesure que l'enfant grandit. Les participants ($n = 365$) dont la moyenne d'âge était de 9,5 ± 0,9y, 54,5% étaient des mâles, et au départ le score z de l'IMC moyen de la cohorte était de 0,61 ± 1,0. Les apports alimentaires ont été normalisé a 1000 kcal consommé. A l'ensemble, le nombre de portions de fruits et de produits laitiers a diminué pendant un certain temps de 1,5 à 1,3 ($p=0.004$) et de 1,1 à 1,0 ($p<0.001$) respectivement. Par contre, les portions de céréales et de viandes et d'autres produits alternatifs ont augmenté. Ces changements dans les choix alimentaires ont entraîné une augmentation des protéines ($p <0.01$) et une diminution du calcium ($p <0.01$), en raison de la diminution de la consommation de produits laitiers. Les filles n'ont montré aucun déclin de la consommation de fruits alors que celle des garçons a diminué considérablement. Ceci pointe une différence significative ($p <0.01$) entre les sexes. La différence moyenne dans le score pour les cinq groupes d'aliments examinés n'a pas été influencé par le rapport du poids initial de l'enfant à la période de référence. Aucunes différences significatives entre le groupe de poids sains et le groupe des surpoids/obèses n'ont été observées dans les scores de changement moyen des portions pour les groupes d'aliments examinés. Cependant, en comparant le score de changement moyen, le groupe d'individus au poids sain a montré une augmentation plus importante de l'apport énergétique que le groupe en surpoids / obésité ($p <0.01$). Les enfants de mères obèses ont réduit leur consommation de fruits au fil du temps ($p <0.01$). Mais en comparant les scores moyens de changement, l'état d'obésité maternelle n'a pas de lien significatif avec le changement de la consommation de groupe alimentaire ou sur l'apport énergétique des individus de l'étude. Les enfants ayant un père non obèse ont signalé des augmentations plus importantes de leur consommation d'énergie au fil du temps par rapport aux enfants ayant un père obèse ($p <0.01$). Les résultats de cette étude suggèrent que les initiatives visant à accroître l'apport en fruits, légumes et produits laitiers avec la croissance d'âge devraient être incluses dans les programmes et les interventions visant à améliorer la qualité du régime alimentaire des individus.

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Contribution of Authors

As the first author of the manuscript, I was responsible for the conceptualization of research questions, submission of the research ethics application, data analysis, interpretation of findings, and for writing the manuscript. Dr. Katherine Gray-Donald provided the guidance and supervision through all the stages of research project, including conceptualizing the analysis and interpreting the results. Louise Johnson-Down provided continual help with the data, statistical tutoring and all the technical help for completing this project. Everyone associated with the QUALITY study and those at Sainte-Justine Hospital were responsible for collection of data. Luciano Germani and Kawnene Fidahoussen helped with French translation.

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BMI	Body Mass Index
BMR_{est}	Basal Metabolic Rate
CCHS	Canadian Community Health Survey
CDC	Centers for Disease Control and Prevention
CFG	Canada's Food Guide
CHU	Clinique du Centre Hospitalier Universitaire
CNF	Canadian Nutrient File
DBM	Double Burden of Malnutrition
EAT	Eating Among Teens
EI	Energy Intake
EPIC	European Investigation into Cancer and Nutrition
FAO	Food and Agriculture Organization of the United Nations
FV	Fruits and Vegetables
ICN	International Conference of Nutrition
INPES	Institut National de Prévention et d'éducation pour la Santé
NHS	Nurses' Health Study
NHS II	Nurses' Health Study II
NLHB	Norwegian Longitudinal Health Behaviour study
NPHS	National Population Health Survey
QUALITY	Quebec Adipose and Lifestyle Investigation in Youth
USDA	United States Department of Agriculture
WHO	World Health Organization
CSFII	Continuing Survey of Food Intakes by Individuals
(GUTS)	Growing Up Today Study
AMDR	Acceptable Macronutrient Distribution Range

CHAPTER I

DIETARY PATTERNS OF CHILDREN AND ADOLESCENTS -THE REVIEW

1.1 Introduction

The consumption of food is an integral part of our lives. Food is the primary source of energy for all living beings since time immemorial. Our earliest ancestors ate raw plants and eventually, with the discovery of fire, several cooking techniques came into existence. Trends of consumption patterns were different during the hunter-gatherer times, varied with the advent of agriculture, and they continue to evolve. These constantly changing patterns have consequences on human health and wellbeing in both developed countries and those undergoing development. One of the most common current health consequences of ways of eating is being overweight or obese.

The World Health Organization (WHO) has coined the term "Globesity" to address the global epidemic of obesity that is currently prevailing worldwide (Organization, 2000). As indicated by French and his colleagues (French et al., 2001) in his exploratory review, this multifactorial epidemic stems from several environmental factors including trends in the food supply, eating away from home, food pricing, food advertising, promotion, and education. Fundamentally, obesity can be described as a condition that occurs due to a chronic imbalance in the energy equation that occurs when the energy intake is greater than energy expenditure, categorizing it as a chronic condition which needs constant monitoring throughout one's lifetime. (Barlow & Dietz, 1998).

1.2 Critical Periods for Development of Adiposity

Developmental stages involving numerous physiological alterations which increase the risk of obesity later in life could be referred to as critical periods. Dietz in 1994, defined three critical periods for development of obesity: (1) fetal life, (2) the period of adiposity rebound between ages

4 and 6, and (3) the period of adolescence (Dietz, 1994). Adiposity rebound is a phenomenon that was first described by Rolland-Cachera. Adiposity rebound is defined as the second rise in adiposity, which is measured by BMI and is characterized in children between 3 and 7 years of age (Rolland-Cachera et al., 1984). While this exhibits a normal pattern of growth, excess weight gain during this period lays the origin of obesity later in adulthood. During this period, expression of food related activities and behaviours are developed, children become more autonomous and develop control of their food intake which might explain their energy imbalance (Johnson & Birch, 1994). Another aspect is that early rebound may reflect early maturation, which in turn is associated with increased adiposity in adulthood (Thompson & Smolak, 2001).

Adolescence is an essential phase in an individual's life that marks the transitional stage of physical and psychological development. The nutritional needs of an adolescent are higher than it is at any other time of their life cycle. Their dietary habit during this period has long-term health consequences (Neumark-Sztainer et al., 1999). Adolescence appears to represent a critical period for the entrainment of obesity-associated morbidity. One potential explanation of this could be the pattern of fat deposition that occurs during this phase. The pattern of depositing fat centrally and losing peripherally appears to be observed more in boys than in girls, as they mature. (Dietz, 1997). This also marks the start of independence, individuals try to fit into the society, establish independence and are undergoing several changes in their dietary and activity patterns which influence their lifestyle (Berkey et al., 2000). These critical periods serve as a window of opportunity to take preventive measures through changing dietary habits.

1.3 Defining Overweight and Obesity in Young Children

To assess the weight status in children and adolescents, body mass index (BMI) is most commonly used. BMI is a measure of (measured) weight adjusted for height which is calculated as weight in kilograms divided by the square of height in meters. Height and weight are simple, inexpensive, non-invasive measurements, easy to collect (Willet, 1998) and are most widely used in clinical and research settings for population-based applications. One of the limitations of using BMI as a measure is that it doesn't distinguish between excess fat mass from and high lean mass. However, BMI correlates well with direct measures of body fat in children. BMI also accounts for between-person differences in fatness (Pietrobelli et al., 1998) unless there is a change in the proportion of muscle mass, it is a good measure over time at the individual level (Anderson et al., 2006)

Among research studies that have been previously conducted, there is not a single straightforward definition of overweight and obesity that can be used for all age groups as healthy BMI ranges vary by age and sex with growth and maturation (Katzmarzyk & Tremblay, 2007; Wilkinson & McCargar, 2014). Cole and his colleagues determined the values of BMI using six nationally representative data sets drawn from surveys that define overweight in children (Cole et al., 2000). The Centers for Disease Control and Prevention (CDC) growth charts are used commonly to access the weight status of children and age and sex-specific percentile ranges are used as cut offs to define different categories, as shown below:

WEIGHT STATUS CATEGORY	**PERCENTILE RANGE**
Underweight	Less than 5^{th} percentile
Normal or Healthy Weight	5^{th} percentile to less than 85^{th} percentile
Overweight	85^{th} to less than the 95^{th} percentile
Obese	95^{th} percentile or greater

Table1.1 Source: Centers for Disease Control and Prevention

In the table above, the 85^{th} and the 95^{th} percentiles used, imply that 15% and 5% of children respectively are expected to weigh above the 85^{th} and the 95^{th} percentiles respectively, if the population under consideration is identical to the reference population. These standards are for a large sample of US children using weight data that precede the obesity epidemic. The World Health Organization has also drawn samples of children from 6 different regions of the world for children under 5 years and has slightly different cut points for overweight and obesity which lead to higher estimates at the same ages of children. Their reference data for older children is based on US data from older surveys.

1.3.1 Double Burden of Malnutrition

Energy imbalance is a key concept which is addressed while discussing obesity and undernutrition. Malnutrition was defined by World Health Organization (WHO) as the insufficient, excessive or imbalanced consumption of nutrients. The coexistence of both undernutrition, including micronutrient deficiencies, and over nutrition, including overweight and obesity, in the same population (within the same household, community, and the same country) across one's life course is termed as the Double Burden of Malnutrition (DBM). This term arose in an International Conference of Nutrition (ICN) held in 1992 by the Food and Agriculture Organisation (FAO) of the United Nations and the World Health Organization (WHO). The coexistence of energy over-nutrition and iron deficiency is a classic example of DBM seen at an individual level. Those individuals who are undernourished early in their life are more inclined to be overnourished in adulthood (Shrimpton & Rokx, 2013). In North America, the findings suggest the presence of the burden of under-nutrition within the burden of energy over nutrition (Ivana Kolčić, 2012).This is a major concern due to its consequences on health and well-being.

The field of nutritional epidemiology arose establishing and determining the possible associations between diet and occurrence of diseases (Willet, 1998). Dietary habits influence the risk of developing certain chronic conditions. Studying such patterns in children and adolescents will provide us with inputs on planning interventions aimed at attempting to reverse the current epidemic of obesity. These measures could be taken at an individual, household, institutional and/or community level.

1.4 Canadian Rates of Overweight and Obesity among Young Children

Childhood overweight and obesity have been rising steadily in Canada in recent decades and this concerning matter is declared to be a childhood obesity epidemic by the Public Health Agency of Canada. “More than one-in-four children and youth in Canada are overweight or obese” (Public Health Agency of Canada, 2012). In 1978/79, 12% of 2 to 17-year-old Canadians were overweight and 3% were obese. In 2004, the reports indicated that 18% of Canadian children and adolescents aged 2 to 17 years were overweight, and 8% were obese. Over the span of 25 years, the studies conducted revealed that the collective prevalence of overweight and obesity among 2 to 17-year-olds more than doubled, while the prevalence of obesity alone has tripled (Shields, 2006). This implies that a larger number of teens are overweight/obese suggesting a population shift in positive energy balance. Moreover, childhood overweight and obesity have both immediate and long-term health complications, such as metabolic syndrome and Type 2 diabetes, which were previously diagnosed almost exclusively among adults (Public Health Agency of Canada, 2012). Existing data predicts that by 2019, about 21% of the adult population of Canada will be obese. The dynamics of the trends observed in the study conducted in Canada to observe the prevalence of obesity in adults enable us to understand that over the years, the obesity rates will increase and there needs to be interventions to curb this growth. The present generation of obese and overweight children will become the next generation of adults (Twells et al., 2014).

Understanding the prevalent dietary patterns in a population group will enable us to discover a model to further explore the relationship between food consumption and increases in adiposity. There are strong associations between certain eating patterns and well-being, however, many such associations have yet not been defined as a cause and effect relationships. Although health is influenced by several factors including diet, lifestyle, and environment, an individual exerts a much greater control over their food consumption than many other factors (Schwerin et al., 1981).

1.5 Impact of Overweight and Obesity on the Health Care System

According to the Public Health Agency of Canada, surveys conducted by the Canadian Community Health Survey (CCHS), the National Population Health Survey (NPHS) and the Economic Burden of Illness in Canada investigated the economic burden of obesity between the year 2000 and 2008. The findings of this study suggest that the annual economic burden of obesity increased by $735 million. The influence of increasing obesity is negatively impacting both the direct costs to the health care system (i.e., hospital care, pharmaceuticals, physician care and institutional care) and the indirect costs to productivity (i.e., the value of economic output lost as a result of premature death and short- and long-term disability) (Public Health Agency of Canada, 2011).

1.6 Different Approaches to Studying the Antecedents of Obesity in Children

The best way of studying dietary patterns of children is by examining longitudinal studies, where data are gathered for the same individuals over a study period. A longitudinal study refers to the investigation where the possible exposures or treatments related to a participant are measured at several different follow-up times. This design yields multiple or “repeated” measurements on each subject. The data on food groups consumed and the participant's anthropometric measurements could be collected to characterize the evolution of diet quality in children.

This approach enables us to understand normal growth and aging, to assess if diets are changing over time and the factors contributing to its effect. Longitudinal studies involve a great amount of effort and resources. Due to the relative ease with which cross-sectional studies can be carried out, there are a lot of studies describing diets of a population at one time-point. Few of the research studies to date underline the change over time and very few of them have analyzed this aspect in children and adolescents.

1.6.1 Advantages of Using Longitudinal Analysis to Study the Antecedents of Obesity in Children:

To measure the occurrence of obesity in children, different body parameters such as height, weight, diet and physical activity status are recorded over time along with blood parameters. This information aids in investigating the timing of onset of obesity (based on BMI classification) which could be related to recent changes observed in the participant's lifestyle. The exposure status, for example diet, is recorded at baseline and during every follow-up. In this case, the participants being studied could be categorized in relation to adiposity based on their BMI and then the exploratory analysis of their observations will help discover patterns of systematic variation across groups. This is also beneficial in omitting recall bias. Individual change in outcomes is measured in a longitudinal design set-up. This is a distinguishing feature of performing longitudinal analysis as, it measures changes in outcomes and measures exposure at an individual level. Therefore, individual patterns of change in weight or height measures, diet trends, and various other factors can be observed.

The use of a longitudinal study design captures individual changes with time. This is possible because this study design is such that several measurements are obtained at different time points for the same individual ($t_1,t_2,t_3…tn$) which characterize multiple time scales. This is possible due to the ease of using covariates derived from the calendar time of visit, participant's birth year, the age of the participant (i) at the time (t_j) is $age_{ij} = (t_j – birth)$. Here every effect is clearly defined (Longitudinal Data Analysis Report).

1.6.2 Age Effect

An age effect is a change in a variable which occurs among the cohorts as these cohorts grow older, regardless of the time-period. When an event occurs as a function of your age independent of the year you were born it is known as an aging effect. One example of this effect would be studying energy needs in individuals as a function of age, regardless of which year of birth, as children grow older they require more energy (Longitudinal Data Analysis Report).

1.6.3 Period effect

The period effect is the change that occurs at a particular time and it may affect all age groups. For example, the Bogalusa Heart Study (Nicklas et al., 2003) investigated eating patterns and childhood obesity. Each year for a period of 21 years they recruited 10-year old boys and girls for a period of 21 years to understand what temporal changes in their eating pattern might be influencing the rise in obesity. Therefore, keeping the age groups being studied constant while studying the period effect, only the year in which these measurements are obtained changes.

1.6.4 Challenges Faced while Conducting Longitudinal Studies:

Longitudinal studies are reportedly time-consuming since they may require years to reach reliable inferences. There is a risk of attrition bias posed due to participant drop-out conducting such a study. Participants abandon the research for various reasons, mortality, moving off to another place, painful measurements required and disinterest in the ongoing study, to name a few. Longitudinal studies face other problems such as delayed results, achieving continuity in funding and research design (Farrington, 1991)

1.7 Aging Effect of Dietary Changes

As the face of global economy changes, populations become more urbanized and different nations enter different stages of nutrition transition (Drewnowski & Popkin, 1997). “Nutrition transition” refers to the shift occurring in dietary consumption and energy expenditure that is influenced by the economic, demographic and epidemiological changes. This shift is causing a larger population of teenagers and children to be obese and overweight (Popkin et al., 2012).

While there appears to be strong period effects where the diet of the whole population is shifting over time, it is important to study what is happening with children in terms of dietary changes as they age. This review attempts to evaluate the studies analyzing dietary changes as children age so as to understand how to prevent the adoption of obesogenic diets. The nature and predictors of change in food group consumption as they age have not been extensively investigated in children transitioning from childhood to adolescence. The complexity of the nature of human diet makes understanding the relationship between foods consumed and their impact on adiposity a challenging task.

The initial studies which examined changes in dietary intakes used the single nutrient-effect approach to understand the etiology of the overweight condition in children. Initially, only the macronutrients were studied. Identifying food groups along with nutrients in a diet is more complex than studying the single-nutrient model. Investigation of dietary patterns makes use of either of the two methods: (1) diet score or diet index is used with compliance to prevailing dietary guidelines. For instance, the Healthy Eating Index or the Dash diet index. (2) Factor or cluster analysis to derive dietary patterns. For example, grouping commonly consumed food groups or nutrients. Due to high rates of heterogeneity in respective studies applying these methods, no one has reached a conclusion as to which one method is the most suited (Kant, 2004). Another approach is to form food groups based largely on food guidance and examine the changes over time such as examining fruit consumption.

In addition, observational studies have been using “percentage energy from dietary fat” or “added sugar” to measure the diet quality which is too simplistic (Maffeis et al., 1998), (Berkey et al., 2000) and (Frary et al., 2004). The review conducted by P. Togo et al suggested that studying only the nutrient effect might not be the best approach to understand evolving diets. Even a single meal consumed is composed of several foods, which in turn constitutes several nutrients in varying amounts. Considering the public health perspective, it is highly recommended to analyze intake of foods or food groups that are immediately identifiable. (Togo et al., 2001).

Home availability of fruits and vegetables and taste preferences have been identified as the two strongest and consistent factors correlating with their intake in children and adolescents by the studies reviewed by Neumark-Sztainzer (Neumark-Sztainer et al., 2003). Interestingly, when the interaction of these two factors was evaluated, home availability emerged as the more influential factor among the two in determining the intake.

1.7.1 Dietary Patterns of Young Children

There are very few studies conducted for children and young adults that examine the relationship between patterns in dietary intake and their predictors. The Eating Healthy with Canada’s Food Guide (CFG) has outlined the daily recommendations for children as shown in Table 1.2.

Table 1.2 Recommended Number of Food Guide Servings per Day:

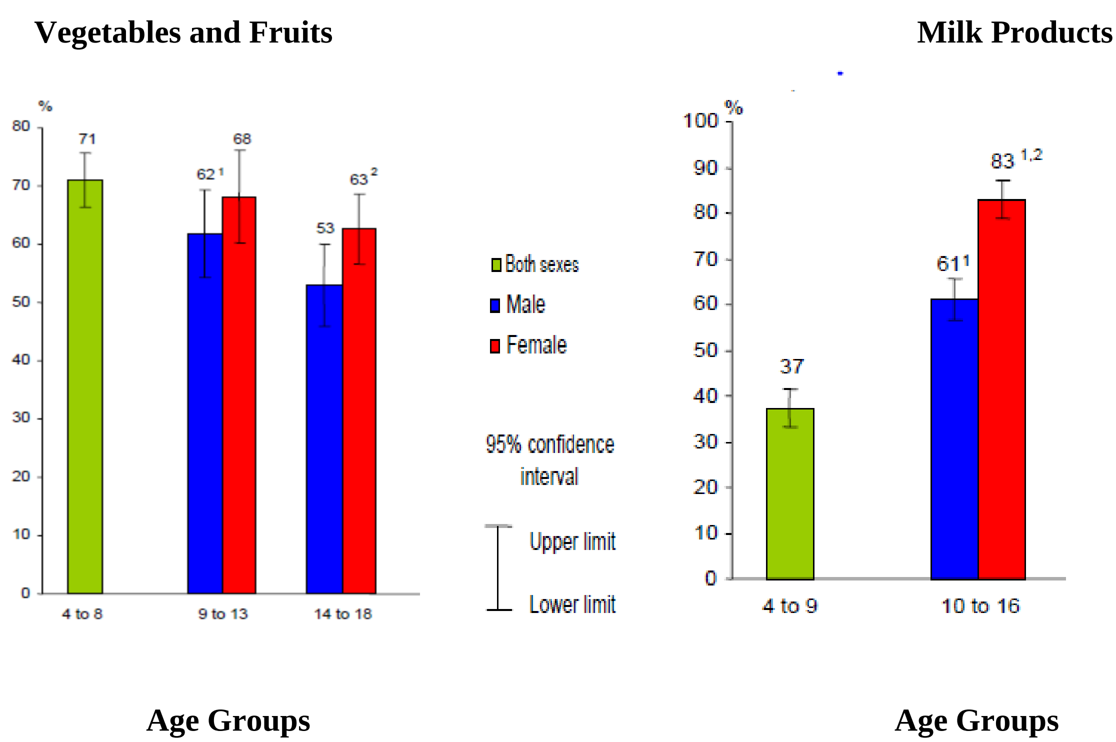
	Children			**Teens**	
	2-3	**4-8**	**9-13**	**14-18 years**	
	Girls and Boys			**Female**	**Male**
Vegetables and Fruits	4	5	6	7	8
Grain Products	3	4	6	6	7
Milk and Alternatives	2	2	3-4	3-4	3-4
Meat and alternatives	1	1	1-2	2	3

Source: Eating Well with Canada's Food Guide (CFG)

The overview conducted by (Garriguet, 2004) on the findings from the Canadian Community Health Survey (CCHS) in 2004 showed that seven out of ten children between the ages 4-8 years, do not meet the recommended allowance of consuming a minimum of five daily servings of fruits and vegetables. It was also observed that more than 37% of children, 4 to 9 years old do not consume the recommended servings of milk/milk products i.e. 2 daily servings. Figure 1.1 illustrates the percentage below the recommended minimum number of servings by age and sex of milk and FV. The findings suggest that children and teens are failing to meet their recommended daily servings of the milk products and FV. The 2004 CCHS presented findings which suggest that as the child ages, 4 years until 16 years, and a higher percentage of children are failing to meet the minimum number of servings as defined by CFG, i.e., 2-3 servings daily.

The fifth category specified in the Canada's food guide is "Other Foods" which is a broad group covering foods and beverages that are not part of the four major food groups. The foods included in this category are: fats and oils such as cooking oil and butter; foods that are mostly sugar such as jam, syrup, honey and candies; high-fat or high-salt foods and/or high-salt foods such as chips; beverages such as soft-drinks, tea, coffee and alcohol; and herbs and condiments.

1.1 Figure 1.1 Percentage of the children and young adults that reportedly consume less than the recommended number of servings of milk and vegetables & fruits per day (CCHS 2004)



1. Significantly different from estimate for previous age group of same sex ($p < 0.05$)
2. Significantly different from estimate for males in same age group ($p < 0.05$)

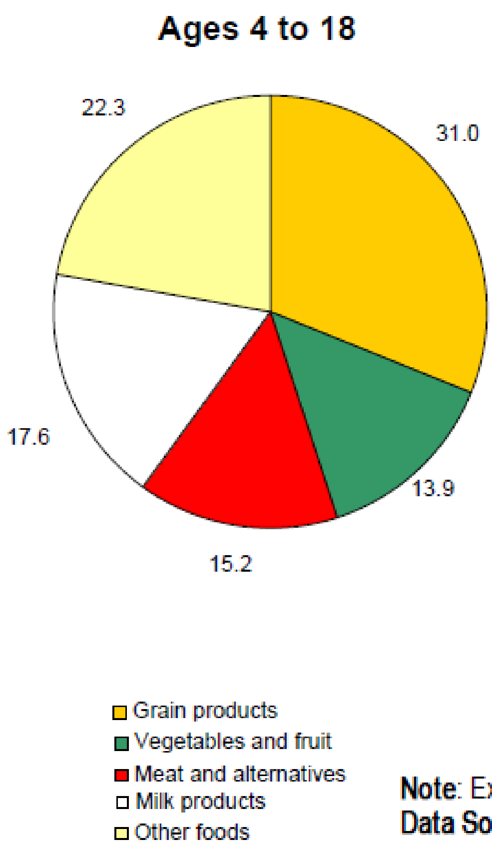
Notes: Based on usual consumption. Age groups are based on Canada's Food Guide to Heathy Eating for People Four Years Old and Over, which recommends a minimum of two servings a day for children aged 4 to 9 and adults aged 17 or older, and three servings a day for 10- to 16-year-olds. Excludes women who were pregnant or breastfeeding.

Data source: 2004 Canadian Community Health Survey: Nutrition

The findings from CCHS 2004 found that for adolescents aged 14 to 18, 22.3% of all their calories consumed came from “other foods”. Furthermore, findings suggested that individuals between the ages of 4 to 18 years in Quebec, derived 21.5% of their calories from “other foods”. Although a wide range of foods and beverages comprise this category of food group, relatively small number of specific foods account for most consumption. In fact, two-thirds of the calories derived from this category is accounted for by only the ten most commonly consumed “other foods”. Soft drinks rank first, followed by salad dressing, sugar/syrups/preserves, beer, and oils/fats (Figure 1.2).

Thus, implying that children and young adults derive a great proportion of their calories consumed from the “other foods” category (Garriguet, 2004).

Figure 1.2 Percentage distribution of sources of calories, by food group, household population aged 4 to 18 years, Canada excluding territories, 2004



Foods and drinks accounting for most calories from "other foods," household population aged 4 or older, Canada excluding territories, 2004

Food/Drink	% of "other food" calories
Soft drinks	11.3
Salad dressing	9.4
Sugars, syrups, preserves	8.7
Beer	8.2
Fruit drinks	6.1
Vegetable oil, animal fats, shortening	5.8
Margarine	5.3
Chocolate bars	4.8
Potato chips	4.7
Butter	3.9

Note: Excludes women who were pregnant or breastfeeding
Data Source: 2004 Canadian Community Health Survey: Nutrition

1.7.2 Food Group Consumption Patterns in Adults:

Over the past decade, nutritional epidemiology has experienced a shift from investigations at the level of individual nutrients to the level of foods and dietary patterns. This shift has been driven by several practical considerations. Dietary patterns are known to represent a broader picture of the food and nutrient consumption. These patterns are more predictive of risk factors associated with a condition than it would have been by studying individual nutrients and foods. Nutrients and foods are often highly correlated which makes accurately determining their individual effects with traditional statistical approaches a difficult task (Hu, 2002). Conceptually, by using food groups to analyze dietary patterns it is easier to promote a public health message.

Most of the prospective studies that examined food group intake over time (baseline and follow-up), assessed the mean effects of frequency of consumption of specific food groups with advancing age (Lien, Lytle, & Klepp, 2001), or investigated the influence of fruit and vegetable consumption on body weight changes (Buijsse et al., 2009; Neumark-Sztainer et al., 2003; Quatromani, et al., 2002). Some studies have shown an association between consumption of specific food groups and body weight changes. One of the largest adult prospective health studies, the European Investigation into Cancer and Nutrition (EPIC), reported a lower weight gain of 14 g/year per difference in every 100 g intake of fruit and vegetables consumed (Buijsse et al., 2009). Increasing consumption of fruits and vegetables reduced the risk of weight gain, persons who stopped smoking benefitted more from fruit and vegetable consumption than those who did not. Thereby, suggesting some weak inverse association between consumption of fruits and vegetables and weight gain. These results were consistent with the study conducted by Drapeau and colleagues in Quebec. It reported that an increase in consumption of fruit group or a decrease in consumption of fat group (from the food-based questionnaire) predicted lower increases in body weight and adiposity indicators over time (Drapeau et al., 2004). Those individuals consuming higher amounts of fruits and vegetables reported a reduction in consumption of other food groups (mainly fattening foods), which were associated with smaller gains in BMI and waist circumference (Newby et al., 2003).

Longitudinal observational studies addressing the relationship between food group consumption and body weight changes often yielded an association (Table 1.3). Whereas cross-sectional studies identified no consistent associations between BMI or obesity and food intake pattern, which were derived from diet index scores, factor analysis or cluster analysis (Togo et al., 2001).

Table 1.3.A review of studies on diet as a predictor of weight change: -

Author, Date	**Location**	**Study Design**	**Objective**	**Year (Follow-up)**	**Age-Group**	**Findings**
Buijsse et al, 2009	Europe	Longitudinal (n = 89,432)	F & V intake & weight change	1992-1998 - Country specific FFQ	50-60 y	F & V intake inversely associated with weight change.
Drapeau et al, 2004	Montreal, Quebec	Longitudinal (n = 248)	Changes in diet patterns and weight change	1989-2000 3-day diet record	18-35 y	Consumption of less fat/fatty foods showed lower increase in weight and percent body fat compared to those eating more fat.
Newby et al, 2003	Baltimore, USA	Ongoing Longitudinal Study	Dietary patterns and its impact	1963-ongoing	27-88 y	Increased consumption of F & V, associated

		(n = 459)		-7-day dietary record		with decreased consumption of fatty foods.
Quatromani et al, 2002	Framingham	Longitudinal (n = 737)	Diet patterns and development of overweight	1971 (follow-up every 4 years) -FFQ	45 years	Healthy heart diet associated with lower incidence of overweight/obesity than empty calorie diet.

1.7.3 Food Group Consumption Patterns in Young Children:

There are very few observational studies investigating the effects of food group consumption over time in children. The study conducted by Lien et al, 2001, is one of the first longitudinal studies conducted to investigate the stability in consumption of fruits and vegetables in a cohort transitioning from early adolescence to adulthood. A longitudinal study titled the Norwegian Longitudinal Health Behaviour (NLHB) (Lien et al., 2001), consisting of a cohort of 924 13-year old students randomly selected from 22 schools followed children from 13 to 21 years of age. The NLHB study reported the frequency of consumption of fruits and vegetables decreased over the tenure of the study (7 years) while a rise in the frequency of consumption of soft drinks occurred (Figure 1.3). This study was conducted keeping in mind the stability in dietary behavior during the transitional phase from adolescence to early adulthood and its implications on lifestyle related health consequences but did not measure its impact on weight change.

Prevalence of Daily Consumers (%) and Frequency of Consumption (Times per Week ± 95% Confidence Interval (CI) of Fruit, Vegetables, Sweets/Chocolate, and Soft Drinks for Boys and Girls from Age 14 to Age 21 (*N*—See Table 1)

	Boys		Girls	
Food item and age (years)	% daily	Times per week (95% CI)	% daily	Times per week (95% CI)
Fruit				
14	53	6.0 (5.8–6.3)	59	6.2 (5.9–6.5)
15	49	5.7 (5.4–6.0)	48	5.7 (5.4–6.0)
16	34	4.7 (4.4–5.0)	42*	5.3 (4.9–5.6)*
18	30	4.2 (3.8–4.5)	32	4.6 (4.2–4.9)
19	22	3.3 (3.0–3.7)	34***	4.4 (4.0–4.8)***
21	20	3.3 (3.0–3.7)	29*	4.2 (3.8–4.6)***
Vegetables				
14	43	5.1 (4.8–5.3)	39	4.8 (4.5–5.1)
15	35	4.6 (4.3–4.8)	39	4.8 (4.5–5.1)
16	30	4.0 (3.7–4.3)	32	4.2 (3.9–4.5)
18	26	3.9 (3.6–4.2)	29	4.1 (3.8–4.4)
19	27	3.9 (3.6–4.2)	28	3.8 (3.5–4.1)
21	22	3.6 (3.3–4.0)	22	3.9 (3.5–4.2)
Sweets/chocolate				
14	6	2.6 (2.4–2.7)	3*	2.4 (2.2–2.6)
15	8	2.6 (2.4–2.8)	4*	2.5 (2.3–2.7)
16	11	3.0 (2.8–3.2)	9	2.9 (2.7–3.1)
18	11	3.0 (2.8–3.2)	9	3.0 (2.8–3.2)
19	10	3.0 (2.8–3.3)	8	2.8 (2.6–3.0)
21	10	3.0 (2.7–3.2)	8	2.8 (2.6–3.0)
Sugar-containing soft drinks				
14	9	2.8 (2.6–3.0)	3**	2.0 (1.8–2.1)***
15	12	3.1 (2.9–3.3)	3***	2.0 (1.8–2.1)***
16	25	4.1 (3.8–4.4)	12***	2.8 (2.5–3.1)***
18	30	4.6 (4.2–4.9)	14***	3.0 (2.7–3.3)***
19	29	4.4 (4.0–4.7)	13***	3.0 (2.6–3.3)***
21	30	4.3 (3.9–4.7)	15***	2.8 (2.4–3.1)***

* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$ for difference between boys and girls.

Fig. 1.3. Source: Lien, Lytle, and Klepp, 2001

Figure 1.3 shows the frequency of consumption of four broad categories of food items: Fruits, vegetables, sweets and soft drinks. The important changes in the "times per week" can be clearly perceived as it demonstrates modifications in the same child's eating pattern over a period of 10 years in Norway. Table 1.4 consists of studies conducted in children and young adults to investigate the direction of consumption of fruits and vegetables as the child or youth ages.

Table 1.4. Studies conducted on dietary intake patterns in children and young adults:

	Lien et al, 2001	**Larson et al, 2007**	**Pabayo et al, 2012**
Country	Norway	U.S. A	Canada
Study Design	Longitudinal	Longitudinal	Cross-sectional
Year of Methodology	1990-2000	1999-2004	2005 and 2007

Age-groups	14 years followed up to 21 years of age	11 years followed up to the age of 18	4 and 5 years old
Findings	Mean weekly consumption of F & V decreased by 1-2.5 times/week. In boys, fruit intake decreased by 33% in 10 years	Longitudinal decrease in consumption of F & V	65% of the children in the study met with their fruit intake whereas only 15%, their vegetable intake

Pabayo et al, 2012 analyzed the food consumption patterns in children (from Edmonton region in Canada) aged 4 and 5years. It was not a nationally representative sample; however, it enables us to understand the most recent trends in consumption. The findings revealed that only 29.1% and 29.6% of children in the study aged 4 and 5 years respectively, met the daily recommendations. (Pabayo et al., 2012).

Table 1.5 Proportion of preschool children who met the recommended servings of foods based on the Canada Food guide

	Age	**Fruits**	**Vegetables**	**Fruits & Vegetables**	**Grains**	**Milk and alternatives**	**Meat and alternatives**
Canada Food Guide – Servings	4-8 years	-	-	5	4	2	1
	4 years (n=643)	65.0%	15.1%	29.1%	21.4%	92.1%	94.2%

Pabayo et al, 2012	5 years (n=651)	65.1%	15.1%	29.6%	25.5%	89.6%	94.1%

There has been significant research to examine the relationship between fruit and vegetable intake and body weight in adults. However, only two of the studies described below were conducted with the primary objective to understand this relationship solely in children within large populations (greater than 3,000) as summarized by Tohill and colleagues (Table 1.6). The first one was conducted by researchers with USDA's Economic Research Services. When controlled for age, sex and ethnicity/race, a cross-sectional analysis of 3064 children and adolescents (5-18 years) participating in the Continuing Survey of Food Intakes by Individuals (CSFII) indicated that overweight boys ate less total vegetables, fruits, and white potatoes. While overweight and at-risk-of-overweight girls ate fewer fruits. Overall, fruit consumption emerged to be a better predictor of BMI than vegetable consumption. The weak correlation between vegetable consumption and BMI was explained by the way Americans prepare vegetable dishes: deep fried, topped with high-fat dressings or sour cream or including it in high-fat mixtures (Lin and Morrison, 2002). The other study that examined the relationship between FV intake and body weight in children, Field et al 2003, is a part of the Growing Up Today Study (GUTS). This prospective cohort study included children aged 9-14 years found no association between change in-age- and sex-specific z scores of BMI and total fruit and vegetable intake, fruit intake (without juice), and fruit juice intake in either boys or girls during 3 years of follow-up. These analyses were controlled for age, age squared, Tanner stage of development, activity, inactivity, age- and sex-specific z score of baseline BMI, and height change during follow-up. The lack of association could be explained by controlling for certain factors such as baseline BMI, age and activity levels which are known predictors of change in weight and BMI. (Field et al, 2003, Tohill et al, 2004).

Table 1.6 Studies reporting the relationship between fruit and vegetable intake and body weight in children

	Field et al, 2003	**Lin and Morrison, 2002**
Study Design	Prospective cohort study	Cross-sectional analysis
Year of Methodology	1996-1998	1994-1996,1998
Age-groups	9-14 years with 3-year follow-up period	5 to 18 years old
Findings	Among boys, vegetable intake was inversely related to changes in BMI z score, attenuated after controlling for energy intake. No relationship was reported among girls.	Overweight boys ate less total vegetables, fruit, and white potatoes. Overweight and at-risk-of-overweight girls ate fewer fruits

1.8 Misreporting in Nutritional Studies

Misreporting of dietary intake is a serious problem concerning studies of nutrition and health. Obese individuals are more likely to misreport their dietary intake compared to individuals of normal weight (Livingstone and Black, 2003). By far, consistently females are at a greater risk for implausible underreporting (Klesges et al., 1995). To assess the validity of the reported energy intake, comparisons were made to the energy expenditure values obtained using the doubly labelled water technique (Burrows et al., 2010). However, this technique is difficult to administer in large epidemiological studies. Thereby, cut-off points representing limits of energy needs for free-living persons came into existence. The ratio of energy intake to the expected BMR (EI: BMR_{est}) could be compared to the expected ratio of energy expenditure. Assuming there is no weight loss, estimates of energy intakes below the pre-defined cut-off points would indicate suspected under-reporting.

Based on the review of the literature we have established the changing trends of consumption patterns of fruits, vegetables and other major food groups in children. Recently the issue concerning industry-funded medical research has been in focus of scrutiny. Vartanian and his colleagues (2007) conducted analyses which revealed a considerable difference in the overall patterns of results when they compared soft drink studies that are funded by the food industry versus those studies that are not. The overall effect size for studies that are funded is significantly smaller than the average effect size for non-funded studies. (Vartanian et al., 2007). None of the studies included in this review had any such conflict of interest.

1.9 Concluding Remarks

In summary, the rising epidemic of obesity is a significant global concern. In Canada, the problem of obesity in children and adolescents is particularly alarming, as it is advancing at a more rapid pace than among adults. There are a wide variety of factors contributing to the increasing rates of childhood obesity, including diet, lifestyle and food and activity environments. Due to the ease with which some cross-sectional studies can be undertaken, there are a lot of pre-existing cross-sectional studies establishing trends among major food groups and its association with BMI and weight status in children. Very few studies examine the aging effect of dietary intake as a child grows older. A better understanding of this relationship may eventually lead to the development and implementation of more effective and sustainable intervention programs.

CHAPTER 2: GENERAL METHODOLOGY

2.1 Research Design

A secondary analysis of data which were collected using a longitudinal cohort design- the Quebec Adiposity and Lifestyle Investigation in Youth (QUALITY) Cohort was undertaken. The cohort comprised children aged 8-10 years at baseline (Visit 1) which were recruited between September 2005 and December 2008. The first follow-up, when the youth were 10-12 years of age (Visit 2), which was completed between September 2008 and March 2011. And the Visit 3 was completed when they youth were 15-17 years of age from 2012 until 2016.

2.2 Sample Selection

The QUALITY cohort recruited children using school-based sampling strategy to identify the potential participants. About 400,000 recruitment flyers were distributed over 3 consecutive years to parents of children in Grades 2–5, in 1040 primary schools (89% of schools approached) including 44 private schools situated within 75 km of Montreal, Quebec City and Sherbrooke in the province of Quebec, Canada. Eligibility criteria included children aged 8-10 years old with at least one obese biological parent (i.e. the body mass index (BMI) $\geq$ 30 kg/m^2 or waist circumference >102 cm in men and >88 cm in women, this was based on self-reported measurements of height, weight, and waist circumference). Only Caucasian families were recruited, to reduce genetic admixtures in this cohort. An essential criterion was also that both the biological parents needed to be available to participate in the baseline assessment. Families were not eligible to participate if the mother was pregnant or breastfeeding at the baseline evaluation, or if the family had pending plans of moving out of the province. Children were excluded if they had any of the following conditions: (1) a previous diagnosis of type 1 or 2 diabetes; (2) a serious illness, psychological condition or cognitive disorder that would hinder participation in some or all study components; (3) treatment with anti-hypertensive medication or steroids (except if administered topically or through inhalation); and (4) following a very restricted diet (<600 kcal/day).

2.3 Overall Study Aim

The overall objective of this study is to study the transition observed in eating patterns of children aged 8-10 years old to when they are 15-17years of age and to describe potential predictors of the change in diet over time.

2.3.1 Study Objectives

The objectives of this study are:

- To investigate the change in eating patterns of children between the ages 8-10 and 15-17 years
- To examine predictors of this change in diet, including, initial body weight, sex, eating supper with family, and maternal and paternal obesity status at baseline.

2.4 Data Collected

The families were followed up every 2-3 years at a full-day visit at the Unite de researché Clinique du Centre Hospitalier Universitaire (CHU) Sainte-Justine in Montreal and Hôspital Laval in Quebec City. Table 2.1 provides a list of the variables assessed in children by interview-administered questionnaires at Visits 1, 2 and 3. There were self-administered questionnaires for the parents, as well as biological and physiological measurements of both, the parents and their biological children. At each study visit, anthropometric measurements were taken based on standardized protocols. Within 8-12 weeks of Visit 1 and Visit 3, three 24-hour recalls on non-consecutive days including one weekend day were administered over the telephone by a dietitian. A small disposable kit of food portion models (ex- graduated cup, bowls) was provided to the participants at the clinic visit, this was done in conjunction with a short training and practice session to enhance the collection of dietary data. At the time of writing the thesis, the dietary data were available for analysis for Visits 1 and 3 but data on weight at Visit 3 was not available.

Table 2.1 Variables assessed in children by interview-administered questionnaires at Visits 1, 2 and 3

VARIABLES	VISIT 1	VISIT 2	VISIT 3
General Information			
Age	✓	✓	✓
Sex	✓		
School Grade	✓	✓	✓
School Environment & academic achievements			✓
Part-time paid work			✓

Lifestyle behaviours			
Dietary habits	✓	✓	✓
Mode of transportation to and from school	✓	✓	✓
Sedentary behaviors (screen-time, homework, etc.)	✓	✓	✓
Level of physical activity	✓	✓	✓
Mother's, father's and friends' support/ role-modelling For physical activity	✓	✓	✓
Self-efficacy for physical activity	✓	✓	✓
Beliefs/attitudes about physical activity	✓	✓	✓
Barriers to physical activity	✓	✓	✓
Neighborhood resources and facilities available for physical activities	✓	✓	✓
Alcohol consumption	✓	✓	✓
Cigarette smoking	✓	✓	✓
Use of illicit drugs			✓
Health			
General health	✓	✓	✓
Chronic health problems			✓
Acute health problems			✓
Use of medications			✓
Oral health	✓	✓	✓
Weight-related perceptions	✓	✓	✓
Date of first menses (girls)	✓	✓	✓
Anxiety symptoms	✓	✓	✓
Depression symptoms	✓	✓	✓
Sleep duration and quality		✓	✓
Stress (life events, perceived daily)	✓	✓	✓

2.5 Data Analysis

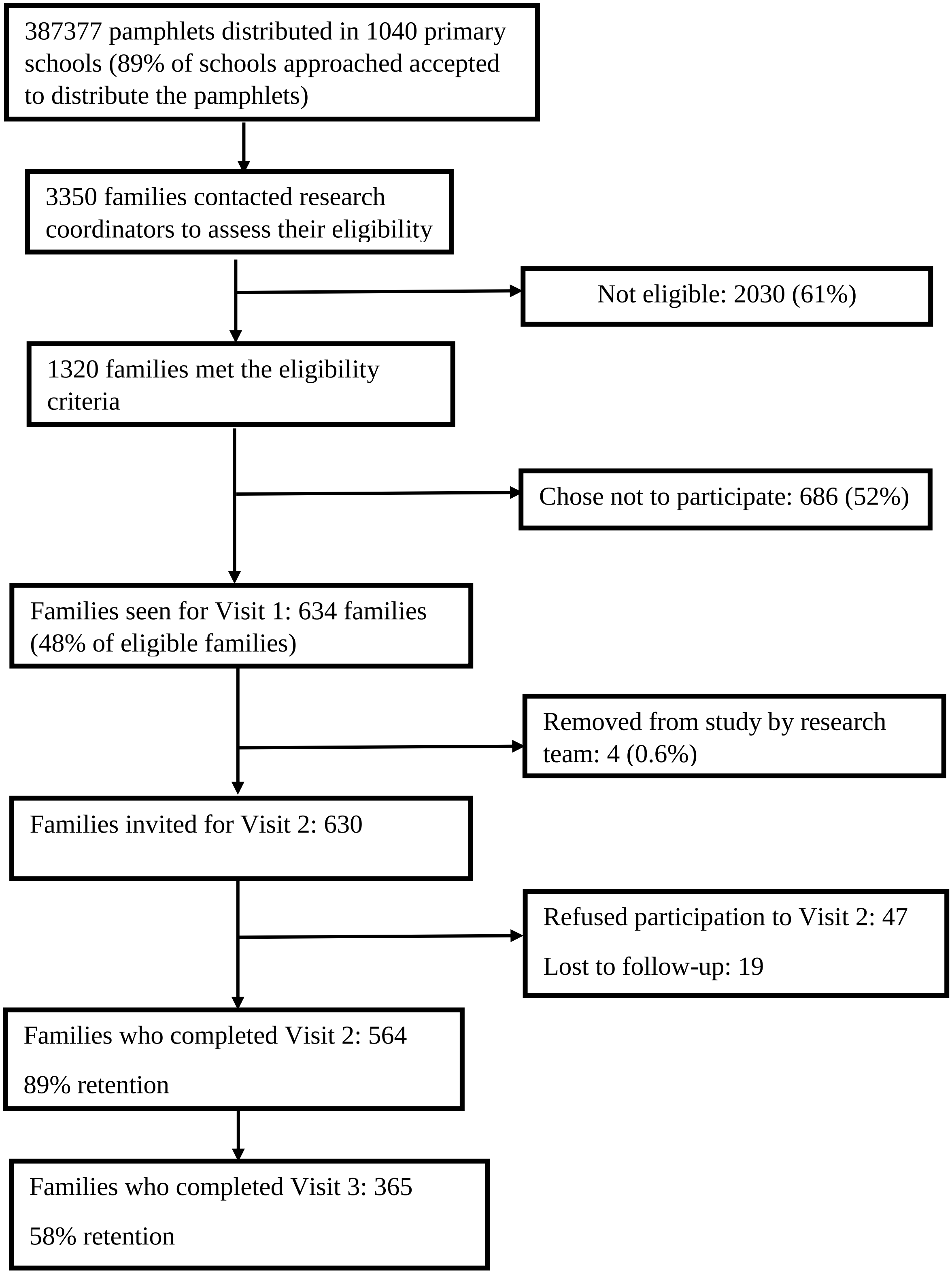
Assessments of serving sizes was conducted using the Canadian Nutrient File (CNF) 2010. Canadian Nutrient File is a computerized, bilingual food composition database containing average values for nutrients in foods available in Canada. Much of the data in the CNF have been derived from the comprehensive United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference (Verdier et al., 1984). The data was then analyzed using IBM SPSS Statistic 22.0 © 2012 Software.

Descriptive analyses were performed to find the means, standard deviations, and ranges for continuous variables and frequency distributions were generated for categorical variables. Although 634 families visited the research clinic at baseline, only 611 provided their complete dietary data at baseline. Therefore, participants who provided their entire dietary data at baseline (T1) included 611 participants and those at follow-up (T3) included 365 participants. Only the participants with dietary data for both T1 at T3 were included in the final analysis (n=365). Figure 2.1 provides recruitment and screening process of the participants at Visits 1, 2 and 3.

As the children grew older, there was an expected increase in energy intake. This increase invariably reflected by an increase in servings of food groups consumed. In order to compare changes in the diet quality intakes were adjusted by 1000 kcal consumed. The values obtained were henceforth referred to as “energy adjusted”. CDC reference values were used to devise the BMI z-score for each child at baseline. Categorical variables were analyzed using Chi-square tests.

Dietary data of three days is used to reduce intra-subject variation. Statistical significance was set at <0.01 for all analyses. The significance was set to strengthen induction by limiting the probability of discovering significant effects between subgroups of the cohort when none actually exist.

Figure 2.1 Recruitment and full dietary data available in the QUALITY Cohort



2.6 Sample Characteristics and Descriptive analyses

Since the rate of attrition was high in this sample, an independent samples t-test was run to compare the differences in sample characteristics between those who remained in the cohort (referred to as "Cohort" group) (n =365) and those who dropped out of the study (n= 246). The factors that were compared between those who remained in the cohort and those who dropped out, included mean age of the participants, mean BMI percentile, percentage of males, and percent obese individuals present in both the groups.

Dependent samples paired t-tests were used to compare mean servings of food groups consumed at the two time-points. The mean for absolute values and the adjusted values of food servings were compared along with protein and calcium levels. The entire sample was stratified into subgroups based on their BMI z-score. The cut point was set at BMI z-score of 1.036 which is equivalent to the 85th percentile. The cut-offs values were obtained from CDC to form the subgroups, all the children below the BMI z-score of 1.036 were classified as healthy weight children (n= 227) and those above as overweight and obese children (n= 138). This was done to see if a relationship exists between BMI and change in diet among the children as they aged. Furthermore, stratification aided in higher statistical precision by lowering the variability within the subgroups. To compare the change in diet over the years, paired t-test was performed on the five food groups with their absolute and adjusted for calories values at two time-points. Independent t-test of the mean change scores between the subgroups was performed to test if differences existed between diets of the subgroups.

The data were classified into subgroups by sex to test if there were statistically significant differences between eating patterns of boys (n= 199) and girls (n = 166) within the cohort.

Independent t-tests tested the hypothesis that there were no significant differences in change in the number of portions adjusted for age between the boys and the girls.

To test additional determinants of changing diets over the years, three factors were examined:

- Eating supper with family at baseline,
- Maternal obesity status, and
- Paternal Obesity status.

1. **Eating supper with family**: The impact of having supper with family was examined to predict the change of diet over time in the cohort. Three random days of the week were chosen to determine on an average if the children ate with their family at baseline. They were asked to select among the following options. On those three specified days, if they had supper: (1) with one parent, (2) with a sibling, (3) alone, (4) with other than family, and (5) does not apply. Those who had supper with either a parent or a sibling were grouped into the "Yes" category. The rest formed the "No" category. A paired t-test was conducted to compare baseline diets between those who ate supper with family (Yes) and the rest (No) at baseline. Similarly, the test was conducted to see if eating with family had an influence on the change in diet. To measure the change in diet, a new variable was computed which was obtained by subtracting food servings, for all the five food groups in the study, at follow-up (T3) from that at baseline (T1). The new variable obtained was labelled as "T3-T1".

1. **Maternal and paternal obesity status**: The participants were first stratified into subgroups based on their parents' obesity status at baseline. The subgrouping to define obesity in this study is based only by using the BMI values of the parents. CDC defines an adult as obese if a person's weight in kilograms divided by the square of height in meters

is higher than 30 kg/m^2. BMI values were used to define obesity in parents of the participants in this study. This was because the parents' height and weight measurements were readily available and research has shown that BMI is strongly correlated with the gold-standard methods for measuring body fat (Gallagher et al, 1996). The groups formed were labeled as "Obese" and "Healthy/Overweight" for each of the parents separately. Paired t-tests were used to examine changes in their children's diet from baseline to follow-up. Independent t-tests compared the mean change score of servings for the five food groups between participants with an obese mother and those with a non-obese mother. Similarly, independent t-tests compared the changes in diet between children having an obese father and those with a non-obese father. Independent t-tests were also used to compare the changes in diet between children with both parents obese and those with only one parent obese. The associated significance level was set at <0.01 for all tests. Children with both parents obese

2.7 Ethical Consideration

There were minimal risks involved with this project undertaken since secondary data was utilized for analysis. The data were denominalized. The Research Ethics Board of the Faculty of Agriculture and Environmental Sciences at McGill University reviewed and approved this project and all the study's procedures were conducted in accordance with the McGill University Policy on the Ethical Conduct of Research Involving Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

CHAPTER 3: MANUSCRIPT

Longitudinal Analysis of Dietary Intake Patterns of Quebec Youth

3.1 Abstract

Introduction: The rising epidemic of obesity is a significant global concern. The more alarming problem is obesity in children and adolescents in Canada, which is advancing at a pace much more rapid than it is among adults. There is a wide variety of factors contributing to this problem, including diet, lifestyle, and environment.

Objectives: The objective of this study is to examine the change in eating patterns of children between the ages 8-10 years and 15-17 years and to describe potential determinants of dietary changes as children grow older including, initial body weight and sex of the child, maternal obesity, paternal obesity and supper with family as potential factors associated with this change

Method: A secondary analysis of data which was collected using a longitudinal cohort design- the Quebec Adiposity and Lifestyle Investigation in Youth (QUALITY) cohort was undertaken. Participants 8-10 through 15-17 years of age had dietary assessments by means of three 24-hour recalls at two time-points, baseline, and final measure. Data were entered and verified using the CANDAT software. Key nutrients and food groupings (fruits, vegetable, grains, dairy & alternative, and meat & alternatives) were examined using IBM SPSS Statistic 22.0 © 2012 Software. Paired t-tests were used to the compare the changes in food groups consumed at two time-points. Independent t-tests were conducted to identify group differences in change in diet. The groups compared were defined by child overweight, sex, maternal and paternal obesity, and eating supper with family at baseline.

Results: The participants ($n = 365$), were on average 9.5±0.9y, 54.5% were male, the mean BMI z-score of the cohort was 0.61±1.0 at baseline. Dietary intakes were normalized to 1000 kcal consumed. Overall the number of fruit and dairy servings decreased from 1.5±0.9 to 1.3±1.0 ($p=0.004$) and 1.1±0.5 to 1.0±0.5 ($p<0.001$) respectively per day over time. In contrast servings of grains and meats and alternatives increased. These changes in food choices led to increases in protein ($p<0.01$), and a decrease in calcium ($p<0.01$), owing to the decreased dairy consumption. On comparing the mean change scores of food groups consumption, boys significantly reduced their fruit intake ($p<0.001$) and increased their energy intake ($p<0.001$) more than girls. The mean change serving score for the five food groups examined were not influenced by childhood overweight. No significant differences were observed in the mean change score of servings for food groups examined between the healthy weight group and the overweight/obese group. However, on comparing the mean change score, the healthy weight group reported greater increases in energy intake than the overweight/obese group ($p<0.01$). The children of mothers who were obese reduced their fruit intake over time ($p<0.01$). But on comparing mean change scores, maternal obesity status had no significant associations on the change in food group consumption or energy intake of the individuals in the study. The children having a non-obese father reported greater increases in their energy intake over time as compared to those children with an obese father ($p<0.01$). Having supper with family did not influence dietary intake of children as they grew to become adolescents. The findings from this study suggest that initiatives to increase fruit, vegetable and dairy intake with increasing age should be included in programs and interventions aimed to improve diet quality of individuals.

Keywords: Dietary patterns, food groups, children, adiposity

3.2 Introduction

Food is an integral part of each of our lives and the transitions in food consumption patterns have been observed since the hunter-gatherer times until the agricultural time and continue to do so. The nutrition transition is described as the shift occurring in dietary consumption and energy expenditure that is influenced by the economic, demographic and epidemiological changes (Drewnowski & Popkin, 1997). The structure of dietary intake has been shifting rapidly in recent times and has repercussions on changes in body weight and rise in obesity among children and adolescents. (Popkin et al., 2012).

In 1978/79, 12% of 2 to 17-year-old Canadians were overweight and 3% were obese. In 2004, the reports indicated that 18% of Canadian children and adolescents aged 2 to 17 years were overweight, and 8% were obese. Over the span of 25 years, the studies conducted revealed that the collective prevalence of overweight and obesity among 2 to 17-year-olds more than doubled, while the prevalence of obesity alone has tripled (Shields, 2006). The more alarming problem is obesity that in children and adolescents in Canada is advancing at a pace much more rapid than it is among adults. This is a concerning matter since previously conducted research suggests that the present generation of overweight and obese children become the next generation of adults (Reilly et al., 2003). In Canada, approximately 25% of children are overweight or obese (Public Health Agency of Canada, 2012). Due to the ease with which some cross-sectional studies can be undertaken, there are many cross-sectional studies establishing trends among major food groups and their association with BMI and weight status in children. Much research has been done to describe food consumption on BMI at one given time-point. However, very few examine how dietary intake changes as a child grows older.

The nature and predictors of change in food group consumption over time have not been extensively investigated in children transitioning from childhood to adolescence. Most of the studies evaluating food group consumption either focus on the correlates of fruits and vegetables as a food group, the entire diet (Buijsse et al., 2009) (Neumark-Sztainer et al., 2003) or on the dairy intake. Since foods are not consumed in isolation it is ideal for research objectives to focus on dietary patterns based on the natural eating behavior of an individual. Some studies that evaluate the intake of all food groups investigate if the cohort is meeting their nutrition recommendations or the eating patterns (Lien et al., 2001) and very few examine the impact it has on body weight (Drapeau et al., 2004) (Buijsse et al., 2009).

This study is based on an underlying premise that an individual's long-term dietary intake pattern might have an impact on the development of adiposity. Evaluating a person's diet is a challenge since diet has a myriad of dietary components, most of the times all the factors are correlated to one another. Some dietary components may increase the prevalence of the condition whereas others may have a protective effect. This complicates the process of understanding these dietary trends. It is a well-established concept that dietary and behavioral interventions constitute the foundation of obesity treatment and or prevention. Based on this theory, the main aim of this study is to describe the changes in diets of children aged 8-10 years over 7 years and to determine the predictors of their dietary change.

This project is a secondary data analysis. It uses a longitudinal design, meaning data were gathered for the same subjects repeatedly over a period of time. In this study, the dietary data were collected at two time-points. The data obtained were transcribed in CANDAT10, a software program used to enter nutrition data, which could then be exported to a statistical analysis software program. CANDAT10 uses the Canadian Nutrient File (CNF), version 2010 as a database (containing 5807 foods and 150 nutrients). The data were then analyzed using IBM SPSS Statistic 22.0 © 2012 Software.

3.3 Methodology

3.3.1 Study Population

The Quebec Adipose and Lifestyle Investigation among Youth (QUALITY) is a cohort study which was designed to investigate the determinants and consequences of metabolic syndrome in children (Lambert et al., 2011). Baseline data were collected when the youth were aged 8-10years (Visit 1) between September 2005 and December 2008. The final follow-up was completed when the youth were 15-17 years of age between 2012-2015 (Visit 3). The QUALITY cohort recruited children using a school-based sampling strategy. Eligibility criteria included children aged 8-10 years old with at least one obese biological parent (i.e. the body mass index (BMI) $\geq$ 30 kg/m^2 or waist circumference >102 cm in men and >88cm in women, based on self-reported measurements of height, weight, and waist circumference). An essential criterion was also that both the biological parents were available to participate in the baseline assessment. Families were not eligible to participate if the mother was pregnant or breastfeeding at the baseline evaluation, or if the family had pending plans of moving out of the province. To reduce genetic admixtures in this cohort, only Caucasian families were recruited. The children with the following excluded: (1) a previous diagnosis of type 1 or 2 diabetes; (2) a serious illness, psychological condition or cognitive disorder that would hinder participation in some or all study components; (3) treatment with anti-hypertensive medication or steroids (except if administered topically or through inhalation); and (4) following a very restricted diet (<600 kcal/day). The cohort was not intended to be representative of all Quebec families. Parents provided informed written consent and children provided verbal assent. The study was approved by the Center Hospitalier Universitaire Sainte-

Justine ethics committee and by the Research Ethics Board of the Faculty of Agriculture and Environmental Sciences McGill University.

3.3.2 Data Collection

Data collection included interviewer-administered questionnaires for children, self-administered questionnaires for parents, and biological and physiological measurements for both children and parents. The anthropometric measurements of the children were taken according to standardized protocols with children and parents dressed in light indoor clothing without shoes, using a stadiometer for height, an electronic scale for weight, a standard measurement tape for waist circumference (mid-distance between the last floating rib and the iliac crest at the end of a normal expiration).

To measure dietary intake, families were given a set of disposable containers (i.e., bowl, plate, and glass with measure indicators) and a ruler to help estimate portion sizes and were instructed on their use. Telephone-administered 24-hour diet recalls were conducted by a trained registered dietitian on three non-consecutive days (2 weekdays and 1 weekend day) with the child to assess his or her dietary intake. Additional details concerning the food preparation and methods were obtained from a parent where warranted. Data were entered and verified using the CANDAT software (Godin and Associates) by trained data entry staff.

The mean of the three dietary recalls was used. Data for the portions of five mutually exclusive food groups (dairy products, fruits, vegetables, milk and alternatives, and meat and alternatives) were derived. All the foods having the same weight for one serving as defined by CFG were grouped together. The food groups formed were technically defined by their food codes on the CANDAT software. As foods were grouped by density, grams of food for each food group, was divided by a standard food portion size for that food grouping. This was developed with a methodological purpose of grouping foods together that could be described and quantified similarly. The amounts of all the foods in a food sub group with similar densities were divided by their weight per portion. For example, 37g of each, broccoli and cabbage, are defined as one food serving size by the CFG. They would fall in the same subgroup while vegetables like carrot and yam, weighing 75g each as one food serving, would be placed in another subgroup. Subgroups were developed on a similar basis for all the food groups. Canada's food guide has recommendations for four food groups (the vegetable and fruit group is treated as an individual entity). However, in this study, vegetables and fruits have been treated as separate entities as the participants exhibited varying consumption patterns of vegetables and fruits, which wouldn't have been detectable if they were grouped together.

The impact of having supper with family and biological parents' BMI were examined to predict the change of diet over time in the cohort. Three random days of the week were chosen to determine on an average if the children ate supper with their family. They were asked to select among the following options. On those three specified days, if they had supper: (1) with one parent, (2) with a sibling, (3) alone, (4) with other than family, and (5) does not apply. Those who had supper with either a parent or a sibling were considered as the "Yes" category. The rest formed the "No" category.

3.4 Statistical Analysis

3.4.1 Sample Characteristics and Descriptive Analysis

Descriptive analyses were performed to find the means, standard deviations, and ranges for continuous variables and frequency distributions were generated for categorical variables. Only the participants present for both T1 at T3 were included in the final analysis (n=365). As the children grew older, there was an expected increase in energy intake. This increase would invariably be reflected by an increase in servings of food groups consumed. In order to compare changes in the diet quality intakes were normalized to 1000 kcal consumed. The values obtained were referred to as “energy adjusted” variable.

As the rate of attrition was relatively high in this sample, an independent samples t-test was run to determine the differences in sample characteristics between those who remained in the cohort (referred to as “Cohort” group) (n =365) and those who dropped out of the study or did not provide dietary data at follow-up (n= 246).

Dependent samples paired t-tests were used to compare mean servings of food groups consumed at the two time-points. The mean for absolute values and the adjusted values of food servings were compared along with protein and calcium levels. To measure the change in diet, a new variable was computed which was obtained by subtracting food servings, for all the five food groups in the study at baseline (T1) from that at follow-up (T3). The new variable obtained was labeled as “T3-T1”.

Independent samples t-test were used to compare diet at baseline and the change in diet (T3-T1) between those who ate supper with family as compared to those who did not. The test was conducted to see if eating with family had an influence on the change in diet.

3.4.2 Grouping of data

The sample was stratified into subgroups based on BMI z-score to analyze various relationships:

1. Firstly, the participants were classified into two groups, those who were overweight and those who were not, and this was examined as a predictor of dietary change. This was done by using the cut-off point set at BMI z-score (baseline values) of 1.036 which is equivalent to the 85th percentile. The cut-off values were obtained from the CDC to form the

subgroups, all the children below the BMI z-score of 1.036 were classified as healthy weight children (n= 227) and those above as overweight and obese children (n= 138). This was done to see if a relationship exists between BMI at baseline and the change in dietary intake in children. To compare the change in diet over the years, paired t-tests were performed on the five food groups with their change in absolute and adjusted for calories values at two time-points. This t-test tested the hypothesis that there is no difference in the diets between the healthy weight and overweight subgroups at two time-points. Independent t-tests were used to compare the mean change scores of servings for the five food groups between the obese (> 85^{th} percentile) and non-obese (< 85^{th} percentile) individuals in the cohort. The associated significance level was set at <0.01 for all tests. The significance level was set so to strengthen induction by limiting the probability of discovering significant effects between subgroups of the cohort when none actually exist since the tests involved several comparisons having several outcomes.

2. Secondly, the data were analyzed by sex to test the diet changes of boys over time separately from that of the girls in the cohort. The paired t-test analyzed if significant differences existed between eating patterns of boys (n= 199) over time. Similar tests were performed to examine the dietary changes in girls (n = 166) as they grew older. Independent t-tests were used to compare the mean change scores of servings for the five food groups between boys and girls in the cohort. Statistical significance was set at <0.01 for all sets.

3. The participants were categorized into subgroups based on their parents' obesity status. These values were used to define obesity in parents of the participants. The groups formed

were labeled as “Obese” ($\geq$30 kg/m^2) and “Healthy/Overweight” (<30 kg/m^2) for both the parents. The subgrouping to define obesity in this study is based only by using the BMI values of the parents. This was because the parents’ height and weight measurements were readily available and research has shown that BMI is strongly correlated with the gold-standard methods for measuring body fat (Gallagher et al, 1996). Paired t-tests were used to compare the dietary patterns at baseline and the change in diet over the years (T3-T1) between participants with were an obese mother and those participants who had healthy weight/overweight mother. Similar tests were performed to evaluate the influence of paternal obesity status on the change in dietary patterns over the years (T3-T1). The tests were run separately for evaluating the effect of both, the maternal obesity status and paternal obesity status, on the change in diet over time. Independent t-tests were used to compare the mean change score of servings for the five food groups between participants with obese mother and those with a non-obese mother. Similar tests compared the changes in diet between children having an obese father and those with a non-obese father. Independent t-tests were used to compare the changes in diet between children with both parents obese (n=67) and those with only one parent obese (n=297). The associated significance level was set at <0.01 for all tests.

4. Paired t-tests were conducted to compare baseline diets between those who ate supper with family (Yes) and the rest (No) at baseline. Similarly, the test was conducted to see if eating with family had an influence on the change in diet. To measure the change in diet, a new variable was computed which was obtained by subtracting food servings, for all the five food groups in the study, at baseline (T1) from that at follow-up (T3). The new variable

obtained was labeled as “T3-T1”. Paired t-tests were used to compare the change in food group consumption based on family meals consumed at baseline. The associated significance level was set at <0.01 for all tests.

5. Underreporting of total energy intake among our cohort was addressed by computing a ratio of energy intake (EI) to the estimated basal metabolic rate (BMR_{est}). The estimated BMR was calculated using body weight, height, age and sex by standard equations devised by Schofield (Rodriguez et al, 2002). An independent t-test was used to test for differences in energy intake and EI: BMR_{est} between boys and girls. EI/BMR ratio $\leq$ 1.14 was established as a cut-off limit, and the individuals whose energy intake levels were below this were defined as under-reporters (Goldberg et al., 1991). The ratio was calculated for the participants belonging to different BMI categories. T-tests were used to test differences for the EI: BMR_{est} ratio between girls and boys. To compute the BMI categories the cut point was set at BMI z-score of 1.036 which is equivalent to the 85^{th} percentile. The cut-offs values were obtained from CDC to form the subgroups, all the children below the BMI z-score of 1.036 were grouped together (n= 227) and the rest in other (n= 138).

3.5 Results

3.5.1 Sample Characteristics

The mean follow-up period was 7 years. The age of participants ranged from 8-10 years at baseline to 15-17 years at follow-up. Of these, at baseline, 21% (n=77) were overweight and a further 16.7% (n=61) were obese. With a total of 611 participants enrolled at baseline, 40% (n=246) of the participants dropped out or did not provide their dietary data at follow-up. **(Table 3.1)** There was a higher number of obese individuals in the drop-out group (31.3%) as compared to those who remained in the cohort (16.7%) (p<0.01).

3.5.2 Dietary Intake of Food Groups and Nutrients

Changes in food intake over the follow-up period from ages 8-10 years to 15-17 years for the entire sample indicated an expected higher energy intake in the older youth ($p<0.001$). In order to compare changes in the diet quality, intakes were normalized to 1000 kcal consumed. We found that the number of fruit servings per 1000 kcal per day decreased from 1.5±0.9 to 1.3±1.0 servings ($p=0.004$) (**Table 3.2**). Similarly, servings of dairy & alternatives decreased significantly ($p<0.001$). In contrast, servings of grains ($p=0.006$) and meat & alternatives ($p<0.001$) increased. These changes in food choices led to increases in protein ($p<0.001$), presumably from the meat and alternates group and a decrease in calcium ($p<0.01$), which is explained by the decreased dairy consumption.

3.5.3 Dietary Change Based on BMI Differences

On comparing the dietary patterns of the overweight (and obese) participants to that of the healthy weight participants at baseline, findings revealed that there were no significant differences between the two subgroups in consumption of energy ($p=0.78$), fruits ($p=0.53$), vegetables ($p=0.76$), grains ($p=0.02$), dairy & alternatives ($p=0.04$) and meat & alternatives ($p=0.02$). Similarly, for the energy adjusted changes between baseline and follow-up, there were no significant differences in consumption of fruits ($p=0.10$), vegetables ($p=0.10$), grains ($p=0.09$), dairy & alternatives ($p=0.56$) and meat & alternatives ($p=0.10$) between the overweight (and obese) participants and the healthy weight participants at follow-up.

A summary of absolute and energy-adjusted mean intakes at baseline and follow-up dietary intake of food groups by differences in BMI percentiles of the participants is presented in **Appendix A**. There were significant increases in consumption of meat & alternatives by both, the healthy weight group ($p<0.001$) and overweight group ($p<0.001$), over the follow-up period. The healthy weight participants reported significant increases in energy intake ($p<0.001$). In contrast, the overweight/obese individuals showed no significant increases in energy intake ($p=0.097$) over the years.

On comparing the mean change in energy intakes between the overweight (and obese) group and the healthy weight group by an independent t-test, no significant differences were observed in the food group consumption by these two groups. However, on comparing the mean change score, the healthy weight group reported greater increases in energy intake than the overweight/obese group ($p<0.01$) (data not shown in tables).

3.5.4 Dietary Change Based on Sex Differences

Boys and girls reported no significant differences in consumption of fruits ($p=0.55$), vegetables ($p=0.19$), grains ($p=0.74$), dairy ($p= 0.68$) and meat (0.06) at baseline (**Appendix B**). The boys reported significant increases in energy intake ($p<0.001$) and consumption of meat & alternatives ($p<0.001$) but reported significant decreases in consumption of fruits ($p<0.001$) over the course of the study period. In boys, the mean daily servings of fruits decreased from 1.5 ± 0.9 to 1.1 ± 0.9 servings per 1000 kcal consumed. Similarly, in boys, the mean dairy intake decreased significantly ($p<0.001$); from 1.1 ± 0.5 to 0.9 ± 0.4 servings per day per 1000 kcal consumed. There was no significant difference in the energy consumption by the female participants over the years. The self-reported intakes by girls remained unchanged at the two time-points for consumption of energy ($p=0.31$), vegetables ($p=0.02$), fruits ($p=0.57$), grains ($p=0.02$), dairy & alternatives ($p=0.02$), and meat consumption ($p=0.02$).

On comparing the mean change score of servings for the five food groups by means of an independent t-test, the results reported that the girls showed no decline in fruit intake while the boys declined their already low intake by half a serving ($p<0.01$) (data not shown in tables), showing a significant difference between the sexes. For the rest of the food groups, no statistical differences were obtained in terms of change in diet among the boys vs. girls. In summary, the boys deteriorated in terms of their diet quality (deceased fruit intake) more than that of girls ($p<0.01$). The significance level was set at <0.01 for these analyses to limit the probability of finding significant effects between subgroups of the cohort when none actually exist.

3.5.5 Dietary Change and Family Meals

The impact of the variables having supper with family and the biological parents' BMI were examined to predict the change in diet over time. About 88-90% of the parents reported that their child ate evening meals together with family (either with them or with a sibling). Of these, 286 participants ate supper with their family on all three days that they were interviewed (**Table 3.3**). No significant differences were observed in the diet at baseline or the change in diet (T3-T1) between those who ate supper with family as compared to those who did not (**Table 3.4**).

3.5.6 Dietary Change and Parents' Obesity Status

More than 40% of the children had a mother who was obese, and almost 1 in 15 had a mother with a BMI ≥ 40 kg/m^2 (n=23). Dietary patterns at baseline and the change in diet over the years (T3-T1) indicate that overall the decline in food quality is similar in the children with obese and non-obese mothers. The findings revealed that both, maternal and paternal obesity status, had a significant impact on the change in servings of meat ($p<0.001$) and dairy ($p<0.001$) consumed over the years. The children of mothers who were obese reduced their fruit intake over time ($p<0.01$) (**Table 3.5**). Those with non-obese parents reduced their intake of dairy and alternatives ($p<0.001$) as they grew older (**Table 3.6**). However, on comparing the mean change score of servings for the five food groups and energy intake using an independent t-test, no significant differences were observed between those having obese mother and those with a non-obese mother (data not shown in the tables). Similar tests, when conducted among individuals with an obese father and those with a non-obese father showed that no statistical differences existed between mean change servings of food groups. The children having a non-obese father reported greater increases in their energy intake over time as compared to those children with an obese father ($p<0.01$). The maternal obesity status had no significant associations on the change in food group consumption and energy intake of the individuals in the study. Paternal obesity status had a significant influence on the reported energy intake of the individuals in the study. The children having both parents obese (n=67, 18.4%) did not report significant differences in the mean change score of servings for the five food groups and energy intake ($p=0.44$) when compared to the children with only one parent obese (n=297, 81.6%).

3.5.7 Dietary Change and Underreporting

The reported energy intake was evaluated against presumed energy requirements. The suspected proportion of underreporting in our study was 24% of all participants (n=88) (EI/BMR ratio < 1.14). The proportion of overweight/obese participants (above the 85th percentile) (67%; n= 59) who were classified as under-reporters were not significantly different than that of the normal weight individuals (33%; n=29) ($p=0.48$). The under-reporters in the normal weight category comprised 17 girls and 12 boys. When evaluated further, the percentage of female under-reporters constituted 53.4% (n=47) while male under-reporters made up 46.6% (n= 41) of the total under-reporters in this study. The number of female under-reporters were not significantly different ($p= 0.89$) than the number of male under-reporters in this study (**Appendix D**).

3.6 Discussion

To elucidate the evolution of dietary intake as a child grows older, we compared the diets of children when they were 8-10 years old and when they grew up to 15-17 years. This study had three main findings pertaining to the food group consumption patterns and its association with initial body weight, sex, and parental obesity and eating meals together. Firstly, as a child moved into adolescence, they significantly decreased their consumption of fruit and dairy & alternatives and increased their consumption of meat & alternatives. Secondly, on average, the food group consumption patterns in overweight and obese individuals were not significantly different to that of the healthy weight participants. Healthy weight group reported greater increases in energy intake than the overweight/obese group. This could be explained by increases in physical activity by the healthy weight individuals as compared to their overweight/ obese counterparts, thereby, accounting for variations in their energy requirements. Past research shows that increases in body fatness leads to inactivity which is why healthy weight individuals are reportedly more physically active than their overweight/ obese counterparts (Metcalf et al, 2011). Physical activity is a modifiable risk factor and evaluating its influence along with the dietary intake patterns in the participants would help understand the results better. However, since the data was not available for all the participants it was excluded from this study. Lastly, the boys reported a decrease in mean consumption of fruits and significant increases in energy intake as compared to the girls. No significant difference in energy intake reported over the years by the girls could be explained in part by the high prevalence of implausible reporting of dietary intake. This was observed not just among overweight girls (n=29) but also among healthy weight girls as well (n=17). However, the number of female under-reporters was not significantly different than the male under-reporters in this study (p=0.89).

Our findings based on the mean change serving score suggest that boys consume diets which decline more in fruits as compared to girls, as they age. These results are consistent with previous studies that have found that girls consume greater quantities of fruits and vegetables than boys (Fernandez et al., 2016; Lien et al., 2001; Rasmussen et al., 2006). Findings from our study provide evidence of no strong associations between family meals and its association with dietary patterns in children. These findings are not consistent with cross-sectional studies that have found positive associations between frequency of family meals positively correlated with fruit and vegetable intake among children and adolescents (Neumark-Stainzer et al, 2003 and Gillman et al, 2000). One possible explanation for inconsistency could be the age criterion of the participants in these studies, where they have included children and adolescents (11 to 18 years and 9 to 14 years respectively) while our study has observed this characteristic in children when they were 8-10 years old and followed their changes over time. Our sample also recruited children at high risk of obesity. The absence of association of change in dietary intake patterns with family meals could also be that the proportion of participants not eating supper with family (21.4%) was very small, thus precluding from not seeing any association.

Maternal obesity status had no significant association with the changes in dietary intake of the children within our cohort. The children having a non-obese father reported greater increases in their energy intake over time as compared to those children with an obese father ($p<0.01$). Thus, suggesting that paternal obesity status has a significant influence on the reported energy intake of the individuals in the study. However, recent reports assert that because of energy underreporting, self-reported data suffer from measurement error (Subar et al, 2015). Self-reported energy intakes can not be entirely trusted and do not serve as a measure of energy intake. These errors are sometimes so great that they must be interpreted with caution.

The dietary intake of this cohort reflects that the food consumption patterns are in the direction opposite to that of the Health Canada recommendations. Within our cohort, the fruit and vegetable intakes are low at baseline and they decline further as the children grow older. These findings are parallel with the findings by CCHS, 2004 that children are failing to meet their recommended number of servings for F & V per day. At ages 9 to 13 in 2004, the figures are 62% for girls and

68% for boys that do not meet the five-serving minimum (Garriguet, 2004). Similarly, consumption of milk & alternatives declined further within our cohort. There were increases observed in the consumption of grains and meat & alternatives over time. The Acceptable Macronutrient Distribution Range (AMDR) for protein is 10 to 30% of calories in children and adolescents. According to the results of the CCHS 2004, the average for children and adolescents aged 4 to 18 is 14.7% of total calories. Thereby, suggesting that children meet their daily protein recommendations and increases in meat consumption might not be useful. Overall, the children within our cohort reported changes in their dietary intake that were in a less healthful direction.

Longitudinal studies are prone to be subject to missing data due to dropouts. The study's descriptive findings indicated that the number of obese children that discontinue participating in the study was almost twice as many as those who remained in the cohort. Unfortunately, this may limit the ability to generalize the results for this subgroup if those obese children who dropped out are different from those remaining in the cohort. In this study, the findings revealed that given the power of 0.8 and the standard deviation for the absolute change in fruits and a sample size of each 166 girls and boys, a difference of 0.54 servings could be picked up for the change in consumption of fruits between boys and girls. Similarly, a difference of 0.42 servings was observed for the change in consumption of vegetables. Thus, implying that due to the variability in intake of the individuals in this study, the tests might fail to pick up statistically significant differences when they actually exist.

Strengths of this study include the longitudinal study design with a high prevalence of overweight and obese parents and children. Both the biological parents were involved in the assessments. This study was unique and novel, as there have been no previous studies conducted in Canada to analyze food group consumption of children as they transition into adolescence. Data collection and management was done by the same person at baseline and at every follow-up over a period of 7 years. This assures consistencies in the methodology used for compiling data at both time points. Another essential strength of this study was that the data assessment included three 24-hour diet recalls decreasing the variability in intake within individuals but despite this, the variability in intake is quite high. Thus, adding to the challenge of picking up small differences.

There are limitations that should be noted. Although the generalizability of this study may be restricted to Caucasian children with a parental history of obesity, this group comprises a large segment of the population. Underreporting of food intake is a major limitation and a recurrent challenge in nutritional studies. Exclusion of physical activity status of the participants is a limitation in this study. Dietary intake and physical activity status are the two most essential modifiable risk factors in chronic conditions. The QUALITY study was developed with an objective to describe the natural history of obesity and its metabolic and cardiovascular consequences. Therefore, the eligibility criterion to define obesity for parents in the QUALITY study was based on either the BMI or the waist circumference measure. However, the subgrouping to define obesity in this study is based only by using the BMI values of the parents. This was because the parents' height and weight measurements were readily available. Future studies could examine the change in dietary intake patterns and their predictors by the addition of waist circumference to BMI since it predicts greater variance in health risk than does BMI alone (Janssen et al, 2004).

3.7 Conclusions

In summary, this study attempted to also understand the relationship between family meals at the age of 8-10 years and child overweight, sex, and parental obesity status on change in dietary intake. There was no significant association between change in dietary intake patterns and family meals in this study. Children with non-obese fathers significantly increased their energy intake over time as compared to those having an obese father. There is an overall decline in the dietary quality of children even after considering the differences in personal factors (such as BMI and sex), thereby suggesting that the child's environment may change as they age. The presence of vending machines in schools and colleges, decreasing government involvement in school food services, fast food outlets being readily available (by either increasing their operating hours, delivery options, or stationing at convenient locations near schools) could be a few examples of the changing food environment around children. Initiatives to promote consumption of fruit and vegetables with careful consideration of variety and diversity in healthful foods should be included in programs and interventions aimed at improving dietary quality in children.

3.8 Tables

Table 3.1. Characteristics of the cohort: Comparing those at baseline vs the dropouts

	Cohort (n=365)	Drop-Outs (n=246)	p-value
Age (Mean)	9.5±0.9	9.7±0.9	**0.06**
Sex % (Male)	45.7%	54.1%	**0.91**
Mean BMI Percentile	66.7±27.5	71.5±29.9	**0.05**
Mean BMI (kg/m2)	18.9±3.7	20.4±4.9	<**0.01**
% Obese	16.7% (n=61)	31.3% (n=77)	**<0.01**

Table 3.2. Absolute and energy-adjusted mean intakes of baseline and follow-up dietary intake of food groups and nutrients (n= 365): -

	Baseline* (absolute)	Baseline* (per 1000 kcal)	Follow-Up* (absolute)	Follow-Up* (per 1000 kcal)	Absolute Intakes (p-value)	Per 1000 kcal (p-value)
ENERGY (Kcal)	**1721±404**	**-**	**1953±679**	**-**	**<0.001**	**-**
FRUITS (Servings)	**2.5 ±1.7**	**1.5 ±0.9**	**2.4 ±1.9**	**1.3 ±1.0**	**0.398**	**0.004**
VEGETABLES (Servings)	**2.0 ±1.2**	**1.2 ±0.8**	**2.2 ±1.5**	**1.2 ±0.9**	**0.002**	**0.390**
GRAINS (Servings)	**4.8 ±1.6**	**2.8 ±0.8**	**5.7 ±2.6**	**3.0 ±1.0**	**<0.001**	**0.006**
DAIRY (Servings)	**1.9 ±1.0**	**1.1 ±0.5**	**1.8 ±1.1**	**1.0 ±0.5**	**0.211**	**<0.001**
MEAT (g)	**1.9 ±0.9**	**1.1 ±0.4**	**2.6 ±1.5**	**1.4 ±0.6**	**<0.001**	**<0.001**
Protein (g)	**68.6±19**	**40.1±7.7**	**83.6±30.4**	**43.6±10.3**	**<0.001**	**<0.001**
Calcium (g)	**890±326**	**518±149.7**	**951±418**	**490±147.5**	**0.008**	**0.008**

***All values indicated are Mean±SD**

Table 3.3. Descriptive statistics of those who had supper with family

		Frequency (n)	Percentage (%)
Day 1	With Family	330	90.4
Day 2	With Family	323	88.5
Day 3	With Family	323	88.5

Table 3.4. Influence of family supper on baseline diet and change in diet

	Family Meals	n	Baseline	p*	T3-T1	p**
	Yes	286	1.5±0.9		-0.2±1.2	
	No	78	1.5±1.0		-0.2±1.0	
	Yes	286	1.2±0.8		-0.02±1.0	
	No	78	1.1±0.6		0.3±1.0	
	Yes	286	2.8±0.8		0.2±1.2	
	No	78	2.8±0.9		0.1±1.1	
	Yes	286	1.1±0.5		-0.2±0.6	
	No	78	1.0±0.5		-0.1±0.7	
	Yes	286	1.1±0.4		0.2±0.7	
	No	78	1.1±0.5		0.3±0.7	

* p value for the family meals (yes and no) category at baseline

** p value for the change in food group consumption based on family meals consumed at baseline

Table 3.5. Food group consumption over time in children having obese mother

OBESE MOTHER		BASELINE	FOLLOW-UP	
FOOD GROUPS (Servings)	**n**	**Mean±SD**	**Mean±SD**	**p**
Fruits	155	1.5±1.0	1.2±1.0	0.003
Vegetables	155	1.1±0.7	1.2±0.8	0.177
Grains	155	2.8±0.8	3.0±1.0	0.016
Dairy	155	1.1±0.5	1.0±0.5	0.004
Meat	155	1.1±0.4	1.4±0.7	<0.001

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Food group consumption over time in children having non-obese mother

HEALTHY/ OV WT. MOTHER		BASELINE	FOLLOW-UP	
FOOD GROUPS (Servings)	**n**	**Mean±SD**	**Mean±SD**	**p**
Fruits	209	1.5±0.9	1.4±1	0.270
Vegetables	209	1.2±0.8	1.2±0.9	0.982
Grains	209	2.8±0.8	2.9±1.0	0.145
Dairy	209	1.1±0.5	0.9±0.5	<0.001
Meat	209	1.1±0.4	1.3±0.6	<0.001

Table 3.6. Food group consumption over time in children having obese father

OBESE FATHER		BASELINE	FOLLOW-UP	
FOOD GROUPS (Servings)	**n**	**Mean±SD**	**Mean±SD**	**p**
Fruits	182	1.4±0.9	1.3±1.0	0.050
Vegetables	182	1.2±0.8	1.3±0.9	0.229
Grains	182	2.9±0.8	3.1±1.0	0.077
Dairy	182	1.0±0.5	1.0±0.5	0.052
Meat	182	1.1±0.5	1.3±0.6	<0.001

Food group consumption over time in children having non-obese father

HEALTHY/OV WT. FATHER		BASELINE	FOLLOW-UP	
FOOD GROUPS (Servings)	**n**	**Mean±SD**	**Mean±SD**	**p**
Fruits	183	1.5±0.9	1.4±1.0	0.031
Vegetables	183	1.2±0.7	1.2±0.8	0.954
Grains	183	2.7±0.8	2.9±0.9	0.037
Dairy	183	1.2±0.5	0.9±0.5	<0.001
Meat	183	1.1±0.4	1.4±0.6	<0.001

CHAPTER 4: FINAL CONCLUSIONS

This study highlights the change in dietary intake patterns of children with increasing age having at the least one clinically obese parent. It also attempts to evaluate some risk factors contributing to it and confirms previous literature measuring food group consumption patterns with increasing age. The current study identifies diet declining in terms of quality, almost equally between obese and healthy weight individuals with a parental history of obesity. The study however does only include families with at least one obese parent so this does not say there are no differences among families with and without parental obesity. This study enriches the current body of knowledge by showing that changes in food group consumption in children transitioning from childhood to adolescence are progressing in a less healthful direction over time in these children.

The original purpose of this longitudinal study which was set up in 2005, was to investigate the natural course of obesity among Quebec Caucasian children and the health consequences of risk factors including diet, exercise and energy balance. The study was designed in a way that the dietary assessment was carried out by means of three telephone-administered 24-hour dietary recalls which were preceded by a training session to estimate portion sizes. Amongst all the known dietary assessment methods and tools, 24-hour diet recall is the most reliable measure (long term intake). Telephone-administered 24-hour dietary recall method when validated produced acceptable estimates of mean and distributions of nutrient intakes among groups of individuals (Posner et al., 1982). This method has proved the operational feasibility by markedly reducing the cost, time, logistical and personal constraints which are associated with longitudinal studies.

In recent times, a lot of attention is paid to the consumption patterns of sweetened beverages, snacks, fast foods, etc. and very little is known about the dietary intake of fruits and vegetables in children. This is one of the novel studies in Canada investigating the consumption patterns of children. As the children in this study progressed to adolescence, they significantly decreased their consumption of fruit and dairy & alternatives and increased their consumption of meat & alternatives. This finding is of paramount interest since it underscores the importance of looking for contemporaneous changes occurring in the environment around children as they grow older. Food environment plays a key role in determining a child's dietary intake. This factor was presumably reflected in the findings of this study since children having obese mother reduced their fruit intake over the years. The findings of this study suggest that the deterioration of diet quality was more pronounced in boys than that in girls on adjusting for the energy intake. The girls reported no changes in either energy intake or changes in food group consumption over the years. This may be since the energy requirement for girls when they are 8-10 years old is much more as compared to that when they are 15-17 years old.

This study provided interesting results but was not devoid of limitations, thereby the results must be interpreted with caution. As a part of a larger study, the study population included only Caucasian children, thereby, restricting the generalizability to other races. A major limitation of our study was identified to be misreporting of dietary intake. Misreporting usually in the direction of underreporting was observed among females (53.4%) and males (46.6%) (p=0.89). The number of overweight/obese under-reporters (67.1%) were not significantly different than normal weight under-reporters (32.9%) (p=0.49). To examine the validity of the reported dietary intake of the members in this study, energy expenditure values defined by Goldberg and his colleagues in their study (Goldberg et al., 1991) using data from the doubly labeled water method was used. This method is considered as a highest quality level reference of energy expenditure for assessing dietary intake (Burrows, Martin, & Collins, 2010).

Despite these limitations, this study had important strengths. A key strength of this study is the large sample of children who are at a high risk of being obese because of their parental history of obesity, who were followed for 7 years, which enabled the relationship between dietary intake and aging effect to be explored in detail in this high-risk population. Data collection and management was done by the same person over the years, thus assuring consistencies in methodology used for compiling data at both time points. This observational study provides insight into changes in dietary patterns with age and within this cohort of children at a high risk of obesity there were few consistent patterns of eating that differed by subject characteristics. Future research should explore the dietary patterns of those children who ceased to be clinically obese as they transitioned into adolescence, and how different their diet was from the children who continued to be obese. Physical activity level of the children must be taken into consideration. The findings from this study suggest that initiatives to increase fruit, vegetable and dairy intake with increasing age should be included in programs and interventions aimed to improve diet quality of children as they transition into adulthood. It would be important as well to see how the eating habits change over time in a household with at least one obese parent compared with households with no obesity among parents.

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APPENDIX A

Based on BMI z-score stratification > 1.036 (>85th percentile) (n=138)

	T1 (Absolute) Mean±SD	T1 (per 1000 kcal) Mean±SD	T3 (Absolute) Mean±SD	T3 (per 1000 kcal) Mean±SD	T1&T3 p Mean±SD	T1&T3 (per 1000 kcal) p Mean±SD
ENERGY (Kcal)	**1730±433**	**-**	1821±601	**-**	**-**	**0.097**
FRUITS (Servings)	**2.5**±1.7	**1.4**±0.9	**2.1**±1.7	**1.2**±1.0	**0.039**	**0.021**
VEGETABLES (Servings)	2.0±1.2	**1.2**±0.8	**2.3**±1.6	**1.3**±1.0	**0.039**	**0.156**
GRAINS (Servings)	**5.0**±1.7	**2.9**±0.8	**5.5**±2.3	3.1±1.0	**0.021**	**0.120**
DAIRY (Servings)	1.8±0.9	**1.0**±0.5	**1.7**±0.9	0.9±0.5	**0.170**	**0.026**
MEAT (Servings)	**2.0**±0.9	**1.2**±0.5	**2.6**±1.5	**1.4**±0.6	**<0.001**	**<0.001**

Significance level set at <0.01

Based on BMI z-score stratification ≤1.036 (≤ 85th percentile) (n=227)

	T1 (Absolute) Mean±SD	T1 (per 1000 kcal) Mean±SD	T3 (Absolute) Mean±SD	T3 (per 1000 kcal) Mean±SD	T1&T3 p Mean±SD	T1&T3 (per 1000 kcal) p Mean±SD
ENERGY (Kcal)	**1716±387**	**-**	2034±711	-	**<0.001**	**-**
FRUITS (Servings)	**2.6**±1.6	**1.5**±0.9	**2.7**±2.0	**1.4**±1.0	**0.522**	**0.065**
VEGETABLES (Servings)	2.0±1.2	**1.2**±0.8	**2.2**±1.4	**1.2**±0.8	**0.025**	**0.934**
GRAINS (Servings)	4.6±1.6	2.7±0.8	**5.8**±2.7	2.9±1.0	**<0.001**	**0.025**
DAIRY (Servings)	2.0±1.0	**1.2**±0.5	**1.9**±1.2	1.0±0.5	**0.599**	**<0.001**
MEAT (Servings)	1.8±0.8	**1.1**±0.4	**2.6**±1.6	**1.3**±0.6	**<0.001**	**<0.001**

Significance level set at <0.01

APPENDIX B

Stratified by Gender: Boys (n= 199)

	T1 (Absolute) Mean±SD	T1 (per 1000 kcal) Mean±SD	T3 (Absolute) Mean±SD	T3 (per 1000 kcal) Mean±SD	T1&T3 p Mean±SD	T1&T3 (per 1000 kcal) p Mean±SD
ENERGY (Kcal)	**1814±426**	**-**	2206±753	**-**	**<0.001**	**<0.001**
FRUITS (Servings)	**2.6**±1.6	1.5±0.9	**2.4**±2.0	**1.1**±0.9	**0.129**	**<0.001**
VEGETABLES (Servings)	2.0±1.3	**1.2**±0.8	**2.2**±1.5	**1.1**±0.8	**0.061**	**0.280**
GRAINS (Servings)	5.1±1.7	**3.0**±0.8	**6.4**±3.0	**3.2**±1.1	**<0.001**	**0.137**
DAIRY (Servings)	2.0±1.0	**1.1**±0.5	2.0±1.2	0.9±0.4	**0.690**	**<0.001**
MEAT (Servings)	2.1±0.9	**1.2**±0.4	3.2±1.8	**1.3**±0.6	**<0.001**	**<0.001**

Stratified by Gender: Girls (n= 166)

	T1 (Absolute) Mean±SD	T1 (per 1000 kcal) Mean±SD	T3 (Absolute) Mean±SD	T3 (per 1000 kcal) Mean±SD	T1&T3 p Mean±SD	T1&T3 (per 1000 kcal) p Mean±SD
ENERGY (Kcal)	**1610±345**	**1.6**±0.3	1649±408	**1.6**±0.4	**0.313**	**0.313**
FRUITS (Servings)	**2.5**±1.7	**1.5**±0.9	**2.5**±1.8	**1.6**±1.0	**0.633**	**0.573**
VEGETABLES (Servings)	1.9±1.2	**1.2**±0.7	**2.3**±1.5	**1.4**±1.0	**0.015**	**0.022**
GRAINS (Servings)	**4.4**±1.4	**2.8**±0.8	**4.9**±1.8	**3.0**±1.0	**0.005**	**0.016**
DAIRY (Servings)	1.8±1.0	**1.1**±0.5	**1.6**±0.9	1.0±0.5	**0.026**	**0.018**
MEAT (Servings)	**1.7**±0.7	**1.1**±0.4	**2.0**±0.9	**1.2**±0.5	**0.010**	**0.020**

Significance level set at <0.01

APPENDIX C

Mean energy intakes/ estimates basal metabolic rate (EI/BMR_{est}) in Quality cohort according to sex and BMI categories at baseline

			RATIO (EI: BMR_{EST})			BMI Z-SCORE> 95^{TH} PERCENTILE			BMI Z-SCORE< 95^{TH} PERCENTILE		
	Age	Energy Intake	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
All	9.5±0.9	1721±404	365	1.40	(0.4)	61	1.13	(0.3)	304	1.45	(0.3)*
Boys	9.6±1.0	1814±426	199	1.44	(0.4)	31	1.16	(0.3)	168	1.49	(0.4)*
Girls	9.5±0.9	1610±347	166	1.35	(0.3)	30	1.11	(0.3)	136	1.40	(0.3)*

Significant differences in EI/BMR_{est} between BMI categories within each sex (rows):

*, P<0.001;

APPENDIX D

Classification of under-reporters based on age and BMI categories

Classification	Cut-off	Frequency		Total	Percent	p
		Boys	Girls			
Normal weight	<85th percentile	12	17	29	32.9	0.48
Overweight	85-95th percentile	12	11	23	26.1	
Obese	>95th percentile	17	19	36	41.0	

APPENDIX E

What is a Food Guide Serving of…

Grain Products

Whole Grain

Bagel, whole grain	½ bagel, 45 g
Barley	125 mL, ½ cup – cooked
Bread, pumpernickel or rye	1 slice, 35 g
Bread, whole grain	1 slice, 35 g
Bulgur	125 mL, ½ cup – cooked
Cereal, cold, whole grain	30 g
Cereal, hot, whole grain (example: oatmeal)	150 g, 175 mL, ¾ cup – cooked
Couscous, whole wheat	125 mL, ½ cup – cooked
Crackers, rye	30 g
Crackers, whole grain	30 g
English muffin, whole grain	½ muffin, 35 g
Muffin, whole grain	½ muffin, 35 g
Pasta/noodles, whole grain	125 mL, ½ cup – cooked
Pita, whole grain	35 g, ½ pita
Popcorn, plain	500 mL, 2 cups
Quinoa	125 mL, ½ cup – cooked
Rice, brown	125 mL, ½ cup – cooked
Rice, wild	125 mL, ½ cup – cooked
Roll, whole wheat	1 roll, 35 g
Tortilla, whole wheat	½ piece, 35 g
Waffle, whole wheat	1 small, 35 g

What is a Food Guide Serving of…

Milk and Alternatives

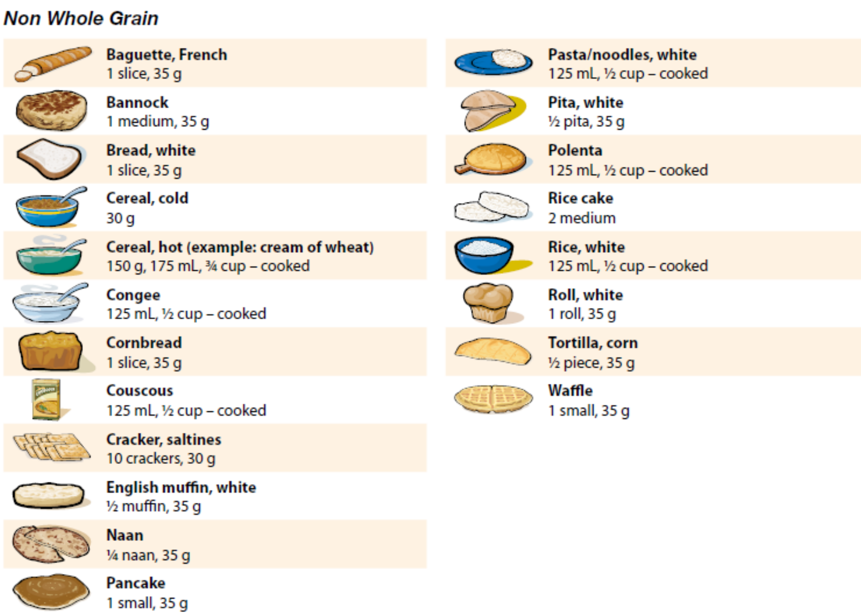
Milk

Milk, skim, 1%, 2%	250 mL, 1 cup
Milk, chocolate	250 mL, 1 cup
Milk, evaporated, canned	125 mL, ½ cup – undiluted
Milk, goat, enriched	250 mL, 1 cup
Milk, lactose reduced	250 mL, 1 cup
Milk, powdered	25 g, 75 mL, ⅓ cup
Milk, powdered	250 mL, 1 cup – reconstituted
Milk, whole	250 mL, 1 cup

Alternatives

* Fortified soy beverages are an option for people who do not drink milk.

Buttermilk	250 mL, 1 cup
Cheese, block (example: cheddar, Mozzarella, Swiss, feta)	50 g, 1 ½ oz
Cheese, cottage or quark	250 mL, 1 cup
Cheese, goat	50 g, 1 ½ oz
Fortified soy beverage	250 mL, 1 cup
Kefir	175 g, 175 mL, ¾ cup
Paneer	50 g, 1 ½ oz
Pudding/custard (made with milk)	125 mL, ½ cup
Yogurt (plain and flavoured)	175 g, 175 mL, ¾ cup
Yogurt drinks	200 mL



Non Whole Grain

Baguette, French	1 slice, 35 g
Bannock	1 medium, 35 g
Bread, white	1 slice, 35 g
Cereal, cold	30 g
Cereal, hot (example: cream of wheat)	150 g, 175 mL, ¾ cup – cooked
Congee	125 mL, ½ cup – cooked
Cornbread	1 slice, 35 g
Couscous	125 mL, ½ cup – cooked
Cracker, saltines	10 crackers, 30 g
English muffin, white	½ muffin, 35 g
Naan	¼ naan, 35 g
Pancake	1 small, 35 g
Pasta/noodles, white	125 mL, ½ cup – cooked
Pita, white	½ pita, 35 g
Polenta	125 mL, ½ cup – cooked
Rice cake	2 medium
Rice, white	125 mL, ½ cup – cooked
Roll, white	1 roll, 35 g
Tortilla, corn	½ piece, 35 g
Waffle	1 small, 35 g

What is a Food Guide Serving of...

Vegetables and Fruit

Dark Green and Orange Vegetables

Asparagus	125 mL, ½ cup, 6 spears
Beans, green	125 mL, ½ cup
Bok choy/Chinese cabbage (Choi sum)	125 mL, ½ cup – cooked
Broccoli	125 mL, ½ cup
Brussels sprouts	125 mL, ½ cup, 4 sprouts
Carrots	125 mL, ½ cup, 1 large
Chard	125 mL, ½ cup
Dandelion greens	250 mL, 1 cup – raw
Edamame (soy beans)	125 mL, ½ cup
Endive	250 mL, 1 cup
Fiddleheads	125 mL, ½ cup
Kale/collards	250 mL, 1 cup – raw
Leeks	125 mL, ½ cup, ½ leek
Lettuce, romaine	250 mL, 1 cup – raw
Mesclun mix	250 mL, 1 cup – raw
Mustard greens	250 mL, 1 cup – raw
Okra	125 mL, ½ cup
Peas	125 mL, ½ cup
Pepper, sweet, green	125 mL, ½ cup, ½ medium
Pumpkin	125 mL, ½ cup
Seaweed	125 mL, ½ cup
Snow peas	125 mL, ½ cup
Spinach	250 mL, 1 cup – raw
Squash	125 mL, ½ cup
Sweet potato	125 mL, ½ cup
Yam	125 mL, ½ cup
Zucchini	125 mL, ½ cup

More Vegetables and Fruits

Some orange coloured fruit can be substituted for an orange vegetable. See the fruit marked with an asterisks (*)

Apple 1 medium	**Eggplant** 125 mL, ½ cup	**Pear** 1 medium
Apricot, fresh* 3 fruits	**Fig, fresh** 2 medium	**Peppers, bell** 125 mL, ½ cup, ½ medium
Avocado ½ fruit	**Fruit juice** 125 mL, ½ cup	**Pineapple** 125 mL, ½ cup, 1 slice
Bamboo shoots 125 mL, ½ cup	**Grapefruit** ½ fruit	**Plantain** 125 mL, ½ cup
Banana 1 medium	**Grapes** 20 fruits	**Plum** 1 fruit
Beans, yellow 125 mL, ½ cup	**Guava** 125 mL, ½ cup, 1 fruit	**Potato** 125 mL, ½ cup, ½ medium
Beets 125 mL, ½ cup	**Honeydew** 125 mL, ½ cup	**Radishes** 125 mL, ½ cup
Berries 125 mL, ½ cup	**Kiwi** 1 large fruit	**Rhubarb** 125 mL, ½ cup
Bitter melon 125 mL, ½ cup, ½ pod	**Kohlrabi** 125 mL, ½ cup	**Tomato** 125 mL, ½ cup
Cabbage 125 mL, ½ cup	**Lettuce (example: iceberg or butterhead)** 250 mL, 1 cup – raw	**Tomato sauce** 125 mL, ½ cup
Cantaloupe* 125 mL, ½ cup	**Lychee** 10 fruits	**Turnip** 125 mL, ½ cup
Cauliflower 125 mL, ½ cup, 4 flowerets	**Mango*** 125 mL, ½ cup, ½ fruit	**Vegetable juice** 125 mL, ½ cup
Celery 1 medium stalk	**Mixed vegetables** 125 mL, ½ cup	**Watermelon** 125 mL, ½ cup
Chayote 125 mL, ½ cup	**Mushrooms** 125 mL, ½ cup	
Cherries 20	**Nectarine*** 1 fruit	
Corn 1 ear, 125 mL, ½ cup	**Orange** 1 medium	
Cucumber 125 mL, ½ cup	**Papaya*** ½ fruit	
Dried fruit 60 mL, 1/4 cup	**Peach*** 1 medium	

What is a Food Guide Serving of…

Meat and Alternatives

Meat, fish, poultry and shellfish

All Food Guide Servings of meat, fish, poultry and shellfish are represented as cooked.

Food	Food Guide Serving
Beef	75 g (2 ½ oz) / 125 mL (½ cup)
Bison/Buffalo	75 g (2 ½ oz) / 125 mL (½ cup)
Chicken	75 g (2 ½ oz) / 125 mL (½ cup)
Deli meat, low-fat, low-salt	75 g (2 ½ oz) / 125 mL (½ cup)
Duck	75 g (2 ½ oz) / 125 mL (½ cup)
Fish and shellfish, canned (example: crab, salmon, tuna)	75 g (2 ½ oz) / 125 mL (½ cup)
Fish, fresh or frozen (example: herring, mackerel, trout, salmon, sardines, squid, tuna)	75 g (2 ½ oz) / 125 mL (½ cup)
Game birds (example: ptarmigan, partridge, grouse, goose)	75 g (2 ½ oz) / 125 mL (½ cup)
Game meats (example: deer, moose, caribou, elk)	75 g (2 ½ oz) / 125 mL (½ cup)
Goat	75 g (2 ½ oz) / 125 mL (½ cup)
Ham	75 g (2 ½ oz) / 125 mL (½ cup)
Lamb	75 g (2 ½ oz) / 125 mL (½ cup)
Organ meat (example: liver, kidney)	75 g (2 ½ oz) / 125 mL (½ cup)
Pork	75 g (2 ½ oz) / 125 mL (½ cup)
Rabbit /Hare	75 g (2 ½ oz) / 125 mL (½ cup)
Shellfish, fresh or frozen (example: clams, crab, lobster, mussels, scallops, shrimp, prawns)	75 g (2 ½ oz) / 125 mL (½ cup)
Turkey	75 g (2 ½ oz) / 125 mL (½ cup)
Veal	75 g (2 ½ oz) / 125 mL (½ cup)

Meat alternatives

Food	Food Guide Serving
Beans, cooked and canned	175 mL, ¾ cup
Egg	2
Hummus	175 mL, ¾ cup
Lentils	175 mL, ¾ cup
Nuts, shelled	60 mL, ¼ cup
Peanut butter or nut butters	30 mL, 2 Tbsp
Seeds, shelled	60 mL, ¼ cup
Tofu	150 g, 175 mL, ¾ cup