PREVALENCE OF OBESITY AND TYPE 2 DIABETES WITH SEDENTARY BEHAVIORS AND THEIR ASSOCIATION ACROSS AGE GROUPS IN CANADA

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DEDICATION

This thesis is dedicated to the glory of the Almighty God, the alpha and the omega of my life. I will also like to dedicate this thesis to my parents, Mr. and Mrs. Oyewole Ajao. Thank you very much for your support, prayers, and encouragement. Your value for good education will stay with me forever.

ABSTRACT

This study examines the association between different sedentary behaviors and the prevalence of obesity and type 2 diabetes among adults in Canada. The purpose of the study is to understand the differential relationship between different types of sedentary behavior, obesity and type 2 diabetes across three main age group classifications. This study employs a quantitative research design using the Canadian Community Health Survey (CCHS) data with a collection period from January to December 2016. The analysis of the data was completed using univariate statistics, logistic regression, and generalized linear models in the Statistical Package for Social Sciences (SPSS) version 24.

Overall, the results revealed a relationship between different sedentary behaviors, obesity, and type 2 diabetes among Canadian adults. In addition, age moderates the relationship between sedentary behavior and obesity while older adults have higher odds of type 2 diabetes than young and middle-aged adults.

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CHAPTER 1: INTRODUCTION

Background of the Study

The detrimental effects of sedentary behaviors on health and the significance of adequate physical activity as essential for healthy living were recognized in the 5th century B. C. (Berryman, 1992). However, recent studies revealed that adults are still sedentary in their lifestyles (Alizadeh & Salehi, 2016; Dollman, Norton, & Norton, 2005). The high prevalence of sedentary behavior in the present generation might be due to technological advancements, as well as the influence of certain cultural and personal belief systems on lifestyles (Shehu, Abdullahi, & Adekeye, 2010). The World Health Organization (WHO, 2010) further noted that the chronic health outcomes of sedentary behaviors such as obesity, diabetes, cardiovascular diseases, and certain forms of cancer are related to several preventable deaths every year.

Interestingly, developed countries including Canada have recommended that the sedentary time should be reduced across all ages (WHO, 2010; The Canadian Society for Exercise Physiology, 2012). This is due to the chronic health outcomes of sedentary behavior which are usually independent of physical activity (Harvey, Chastin, & Skelton, 2015). Although studies have shown that sedentary time increases as age increases, chronic diseases affecting the present-day generation seem to not be age dependent (Booth, Gordon, Carlson, & Hamilton, 2000). This is due to the high prevalence of chronic diseases among young, middle-aged, and older adults.

This study focuses on the relationship between different sedentary behaviors such as computer use, reading, video game time, and television viewing; and total sedentary time with obesity and type 2 diabetes across three main adult age groups: young adults (18 - 39 years), middle adulthood (40 - 64 years), and older adults (65 years and above) in Canada.

Problem Statement

A sedentary behavior is defined as too much sitting, usually (less than 1.5 METs) independent of physical activity (Tremblay et al., 2017). Various activities can lead to too much sitting among adults which is usually influenced by economic advancement in western countries, including Canada. For instance, the majority of adults find it difficult to engage in activities such as walking and gardening. This is mainly because sedentary activities have displaced these more active options. Sedentary activities such as reading and watching television are more common across these different age groups.

Technology and recent innovations in this present generation have contributed enormously to the menace of sedentary behaviors. Adults manage to accomplish tasks just by sitting still and pressing buttons. Adults spend much less time visiting, due to the presence of mobile telecommunication. Learning, shopping, and many other activities are already simplified through the internet medium. In fact, the advent of technology has made virtually everything possible with just a touch of a button. Considering this high prevalence of sedentary behavior (Harvey, Chastin, & Skelton, 2013), it is expedient to discuss chronic diseases associated with this behavior.

Sedentary Behaviors and Associated Diseases

The negative impacts of sedentary behavior have been implicated in the disruption of some important physiological activities in the body (Bey & Hamilton, 2003), thereby resulting in the emergence of some chronic diseases. Obesity, which can be described as excess body fat, is closely associated with sedentary behavior (Dunstan et al., 2007), and is a risk factor for several chronic diseases such as type 2 diabetes (Reaven, 1995). In the US, the Centers for Disease Control and Prevention (CDC, 2003) noted that in “areas where obesity is higher than 30%, the prevalence of sedentary behavior is also higher than 30%.” Although sedentary behavior is an independent risk factor for chronic diseases (Celis-Morales et al., 2012), it is also a major contributor to obesity; hence, sedentary behavior and obesity are risk factors for many chronic diseases such as type-2 diabetes, cardiovascular diseases, and certain types of cancers, among others.

Purpose and Significance of the Study

The central purpose of this study is to understand the differential relationship between different types of sedentary behavior and their health outcomes such as obesity and type 2 diabetes across three main age group classifications. Also, the study examined the influence of socio-demographic factors such as educational levels, marital status, sex, and age in the prevalence of obesity and type 2 diabetes among adults. The findings provide clarity into whether the prevalence of chronic diseases is associated with different types of sedentary behavior.

Knowledge Gap

From a health promotion perspective, the prevention or management of chronic diseases can be approached in multi-faceted ways (Bandura, 1998). One way to prevent chronic diseases is to recognize the causative factors and its correlates (Bandura, 1998). Although, the relationship between sedentary behavior, obesity and type 2 diabetes has been well established in the literature, many studies focus only on television viewing time and its potential association with obesity and type 2 diabetes. Since there are other forms of sedentary behavior, it is important to assess their relationship with these chronic diseases (obesity and type 2 diabetes). In addition, it is important to establish how the prevalence of obesity and type 2 diabetes varies from one age group to another based on different sedentary behaviors. This information highlights the gap in the literature which this study answered using two research questions.

Research Questions

The following research questions were answered in the study;

a. How do different types of sedentary behavior (computer use, reading, television viewing, video game time and total sedentary behavior) relate to the prevalence of obesity and type 2 diabetes among adults in Canada?

b. How does age moderate the relationship between different types of sedentary behavior (computer use, reading, television viewing, video game time and total sedentary behavior), obesity, and type 2 diabetes across the three age groups?

Hypotheses are categorical statements used for prediction in research (Sivakumar & Singaravelu, 2016) and hence the need to state the hypothesis tested in this study.

Hypothesis

In this study, the following hypotheses were tested:

a. Different types of sedentary behavior are associated with the prevalence of chronic diseases (obesity and type 2 diabetes).

b. Age moderates the relationship between different types of sedentary behavior and the prevalence of chronic diseases (obesity and type 2 diabetes) across the three age groups.

Thesis Organization

This thesis is presented in five chapters. In chapter two, I thoroughly review the relevant literature, providing a description of available research on the association between sedentary behavior, obesity and type 2 diabetes as well as socio-ecological correlates of sedentary behaviors.

In chapter three, I present the research methodology including re-categorization of the variables and the statistical method used in analyzing the data. Chapter four consists of detailed discussion of results obtained in the analysis, while chapter five, presents the main findings of the study, strengths and limitations, implications, conclusions, as well as recommendations for future research.

CHAPTER 2: REVIEW OF LITERATURE

The leading cause of death in Canada is no longer infectious diseases (Statistics Canada, 2015). This breakthrough might be due to availability of effective antibiotics and efficient Medicare (Olshansky, Rudberg, & Carnes, 1991). This has drastically reduced the previous trend of death from infectious diseases in developed countries, including Canada. On the other hand, chronic conditions were reported to be the leading cause of death in Canada in the year 2011 (Statistics Canada, 2015). These chronic conditions include Alzheimer disease (2.6%), diabetes (3%), chronic respiratory diseases (4.6%), cardiovascular diseases (19.7%), and cancer (29.9%), among others.

Chronic diseases are slow in terms of progression but with long-lasting effects (Hoffman, Rice, & Sung, 1996), and with a high prevalence in both developed and developing countries. Though chronic diseases are non-communicable, their epidemic incidence is often underestimated (Andersen & Gudnason, 2012).

The global prevalence of obesity in 2008 (BMI > 30kg/m^2) was 34.3% for both men and women with an average age of 20 years (Finucane et al., 2011). A trend analysis from 1980 to 2013 reveals that the prevalence of obesity and overweight increased from 28.8% to 36.9% for men and 29.8% to 38% for women (González, Fuentes, & Luis Márquez, 2017). Also, the worldwide prevalence of diabetes among adults in 1995 was 4.0% with a projected rise by 5.4% in the year 2025 (King, Aubert , & Herman, 1998).

Although genetic make-up and environmental influences have been implicated in the prevalence of chronic diseases, the majority of the incidence of chronic diseases can be ascribed to non-genetic, modifiable risk factors such as lifestyles and diet, among others (Danaei et al., 2011). This shows the importance of lifestyle modification and dietary adjustments in the management and prevention of these chronic diseases (type 2 diabetes, cardiovascular diseases and cancer) that are causing a high number of deaths in Canada.

It is noteworthy that the prevalence of sedentary behavior increases in both developed and developing countries with associated risk of chronic diseases (Aadahl et al., 2013). As early as the 20th century, public health researchers have observed that people who engage in occupations involving prolonged sitting had a two-fold increase in the risk of cardiovascular diseases compared to their counterparts whose occupations require physical activity (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Morris, Heady, Raffle, Roberts, and Parks (1953) observed a two-fold rise in myocardial infarction risk (cardiovascular event) in bus drivers (sedentary work) in London. This was compared with bus conductors whose jobs involved physical activity.

In Canada, a 12-year Longitudinal Fitness survey done by Katzmarzyk, Church, Craig, and Bouchard (2009) quantified the relationship between sitting time (used as a marker of sedentary behavior) and the risk of cardiovascular mortality among Canadians. Statistics show an increase from 22% to 54% in the risk of cardiovascular disease among participants who reported sitting for half of the time, three-quarters of the time, and almost all of the time compared to none of the time and one-quarter of the time. Hu, Li, Colditz, Willett, & Manson (2003) emphasized the need for reducing sedentary behaviors in addition to public health campaigns focusing on increased exercise in a bid to reduce the prevalence of obesity and type 2 diabetes. Researchers found that television viewing (sedentary behavior) is significantly associated with the high prevalence of obesity and type 2 diabetes among women in the United States and the risk is independent of exercise levels.

Obesity has been described as an independent risk factor for all-cause mortality (Kushi et al., 2012). The relationship between obesity and other chronic diseases such as type 2 diabetes, cancer, and sedentary behaviors are well-established in the literature.
A study conducted by Dunstan et al. (2012) in Australia among 19 obese or overweight participants ranging in age from 45 to 65 revealed the relationship between high body mass index and type 2 diabetes. Participants with higher sedentary time (television viewing time and reading time) had the highest concentration of blood glucose. This signifies a high risk of diabetes. The risk can further be classified based on the degree of obesity with mildly obese individuals having a two-fold risk, moderately obese individuals having a five-fold risk, and severely obese individuals having a ten-fold risk of diabetes compared to normal weight individuals (American Dietetic Association; South Suburban Dietetic Association (Ill.); Dietitians of Canada, 2000). In Canada, 75% of people living with diabetes are either obese or overweight (Public Health Agency of Canada, 2016).

The relationship between obesity and cancer is quite mixed. Some researchers believe further study is needed on the relationship between obesity and cancer particularly hormone mediated cancers such as breast, prostate, and endometrial cancers (WHO, 2015). Other researchers have found a relationship between obesity and cancer. It was documented that the relationship between obesity and cancer is linear with an increase of 5kg per m^2 BMI associated with esophageal, renal, thyroid and colon cancers (WHO, 2015).

Although pathological factors underlying how sedentary behavior leads to cancer are poorly understood, researchers have claimed that obesity, raised blood sugar levels, metabolic syndrome, and cardiovascular risk are risk factors for cancer. These risk factors are independently associated with sedentary behavior. Therefore, a sedentary behavior can be hypothesized to be implicated in the pathogenesis and the progression of cancer

(Wijndaele et al., 2009). Considering the direct relationship between sedentary behaviors and chronic diseases such as obesity, type 2 diabetes, cancers, and cardiovascular diseases among others, it is important to review the most appropriate marker of sedentary behavior across age groups.

Suitable Marker of Sedentary Behaviors across Age Groups

Sedentary behavior has been defined as activity that requires little or low energy expenditure, usually less than 1.5 Metabolic Equivalent Task (MET) (Hinkley, Salmon, Okely, & Trost, 2010). There are different forms of sedentary behaviors namely: reading, computer use, television viewing, and electronic or video game use, among others. These behaviors have been associated with different forms of negative health outcomes (Owen, Bauman, & Brown, 2009). However, television-viewing time has been described as the most predominant sedentary behavior that is associated with a number of negative health outcomes (Hinkley, Salmon, Okely, & Trost, 2010). A number of studies assessed sedentary behaviors using television-viewing time as the most suitable marker with different results (Biddle, Gorely, & Marshall, 2009).

In a similar vein, Kikuchi et al. (2013) studied the correlates of prolonged TV viewing time among older men and women in Japan. The results revealed that men who have lower education status and were not in full-time employment reported prolonged TV viewing. Also, women living in regional areas and who are overweight reported more prolonged TV viewing. Although TV viewing has been described as a suitable marker for sedentary behavior across age groups, the rate of television viewing is dependent on several factors, such as age.

Sugiyama, Healy, Dunstan, Salmon, and Owen (2008) conducted a study examining whether television-viewing time can be termed as a marker of a broader sedentary behavior among Australian adults aged between 20 years and 65 years. This study revealed that TV viewing could be a stronger marker among women than men with respect to sedentary behavior and the risk of type 2 diabetes. This is because TV viewing time displaces physical activity leisure time among women (negative association with physical activity) and promotes participation in other sedentary behaviors (positively associated with other sedentary behaviors). This association between TV viewing time and risk of type 2 diabetes was not found among men (Mattingly & Bianchi, 2003).

In Canada, the effect of income on the prevalence of TV viewing among Canadians was studied using the 2007 Canadian Community Health Survey data. It was reported that 22% of the participants in the high-income percentile were frequent TV viewers whereas 39% in the low-income percentile reported viewing TV more frequently (Shields & Tremblay, 2008).

Considering the effect of age, gender, and income on the prevalence of TV viewing, studies focusing on only TV viewing time as a marker of overall sedentary behavior across age groups might not give a holistic representation of the prevalence of sedentary behavior. This is because people who spend less time viewing TV might engage in other sedentary behaviors, hence the need to consider those different sedentary behaviors and their health outcomes.

In summary, Bertrais et al. (2005) examined the relationship between sedentary behaviors, physical activity, and metabolic syndrome among middle-aged adults in France with the recommendation to examine the effect of different indicators of sedentary behaviors on chronic diseases such as obesity and type 2 diabetes, among others.

Socio-Ecological Correlates of Sedentary Behavior among Adults

Several factors influence sedentary behavior at the individual level. These factors include behavioral, biological, and psychological (Rhodes, Mark, & Temmel, 2012). However, these are not independent factors, therefore addressing them alone will not result in significant changes in sedentary behavior; hence the need to approach the correlates of sedentary behavior using the socio-ecological model (Owen et al., 2011). The socio-ecological model focuses on individual adult's behavior (places the individual at the center) and acknowledges the effect of other multi-level influential factors such as policy, environmental and social factors (Glass & McAtee, 2006).

Age and gender have been described as intrapersonal factors that are correlates of sedentary behavior (Rhodes, Mark, & Temmel, 2012). Older adults are more sedentary regarding leisure time and total time. High income men reported more time in sedentary activities such as transportation. Older females with high sedentary time reported less time in physical activity, and have a high body mass index (Sugiyama et al., 2012).

Socioeconomic status has been described as one of the most consistent correlates of sedentary behaviors among adults (Van Dyck et al., 2012). Occupation, education and income are examples of measures of socioeconomic status which are correlates of sedentary behavior. Educational attainment is positively correlated with self-reported sedentary time. Adults with higher education are more likely to hold a professional job that is more sedentary in nature (Ding et al., 2012).

Interpersonal factors such as marital status, living with common law partners and number of children are inconsistent correlates of sedentary behavior (O'Donoghue et al., 2016). This shows that other environmental or individual factors might influence the relationship. Although interpersonal factors such as interactions with friends, colleagues, and peers are correlated with unhealthy behaviors (Trost, Owen, Bauman, Sallis, & Brown, 2002), these factors do not have any influence on the sedentary behavior (Van Holle et al., 2014).

Policy has been correlated with sedentary behavior (Crespo, Sallis, Conway, Saelens, & Frank, 2011). Programs promoting healthy living lead to an increase in physical activity level and reduce time spent in sedentary behaviors.

Built environment is one of the correlates of sedentary behavior and its effect cannot be over emphasized. There is an inverse relationship between self-reported sedentary behavior and neighborhood walkability (Kozo et al., 2012). However, the reverse is true for association between objectively measured sedentary time and neighborhood walkabilty (Kozo et al., 2012).

In conclusion, the socio-ecological correlates of sedentary behavior include policy, built environment, intrapersonal, interpersonal, and socioeconomic factors. The factors in conjuction with health education will reduce the rate of sedentary behaviors among adults.

Prevalence of Obesity and Type 2 Diabetes in Canada

Bray, Kim, and Wilding (2017) define obesity from the epidemiological model as a progressive, relapsing chronic disease which affects the host and results in a disease. Although the developmental mechanism of obesity is poorly understood, it is believed that obesity results from an imbalance between energy intake and energy expenditure (more energy intake and less energy expenditure) (Dehghan, Akhtar-Danesh, & Merchant, 2005). Obesity has been rated second to smoking on the risk factor list with respect to the prevalence of chronic diseases in Canada and the United States (Lim et al., 2012). Sadly, the growing rate of obesity in Canada is alarming (Gotay et al., 2013).

A trend analysis on the current and predicted prevalence of obesity in Canada conducted by Twells, Gregory, Reddigan, and Midodzi (2014) reveals an increase from 6.1% to 18.3% between the year 1985 and 2011. In terms of the individual classes of obesity, it was reported that the prevalence of class I (BMI of 30 – 34.9 kg/m^2), class II (BMI of 35 – 39.9 kg/m^2) and class III (BMI of $\geq$ 40 kg/m^2) obesity increased from 5.1%, 0.8%, and 0.3% to 13.1%, 3.6%, and 1.6% respectively within this period. Prospectively, researchers predicted that by the year 2019, the prevalence would have reached 14.8%, 4.4%, and 2.0% for class I, class II, and class III obesity respectively and generally, 21% of Canadian adults would be obese by the year 2019.

In the various provinces in Canada, the prevalence of obesity has been documented. Using data from Canadian Community Health Survey (CCHS) between 2001 and 2011, researchers reported that 18.3% of Canadian adults were obese in the year 2011 with provinces like Newfoundland and Labrador having the highest figure of 27.7% compared to the rest of the provinces. Provinces like Alberta, British Columbia, Ontario, and Quebec have a lower rate of obesity compared to the remaining six provinces (Twells, Gregory, Reddigan, & Midodzi, 2014).

In Canada, the prevalence of obesity also differs based on ethnicity. The prevalence of obesity is highest among Canadians with Aboriginal ethnic background compared to other ethnic groups such as Caucasians, Latin Americans, and Africans (Valera, Sohani, Rana, Poirier, & Anand, 2015)

Considering this high prevalence of obesity, Mandl and Jason (2000) emphasized the large contribution of sedentary behaviors to the prevalence of obesity with the encouragement to reduce sedentary behavior in a bid to reduce the prevalence of obesity. Other researchers have highlighted measures that can help in reducing the prevalence of obesity. Rolls and Bell (2000) emphasized the importance of caloric restriction in the management of obesity. A reduction of 1000 – 1200 kilocalorie per day resulted in an average loss of 8% in the body mass index after 3 to 12 months. However, Dietitians of Canada (2000) published in their book "Manual of Clinical Dietetics" the long term effects of eating 1000 Kcal or less per day to include decrease in metabolic rate, reduction in essential nutrients and vitamins necessary to stay healthy, reversal of weight loss upon cessation of diet restriction, among other negative effects. Although there is no significant difference in the management of obesity regardless of whether the restriction is either proteins, carbohydrates, or a low fat diet (any of the diet restrictions resulted in reduction in the BMI) (Sacks et al., 2009), long term compliance is difficult to achieve.

Moreover, the long-term effectiveness of diet restriction has been examined. Dietary intervention (carbohydrate, protein or fat) in obesity management resulted in only 5 to 10% loss in BMI and this is often reversed after 3 years, calling into question, the appropriateness of dietary intervention as the sole measure in obesity management.

Physical activity is another measure used in the management of obesity. Exercise is effective in reducing obesity, glucose intolerance, and it improves over-all well-being (Ross, Hudson, Stotz, & Lam, 2015). A randomized trial was conducted among 300 abdominally obese participants in Canada. After the longitudinal study conducted from 2009 to 2013, the participants randomized to the exercise group had a greater reduction in BMI than the participants in the control group (no exercise) (Ross et al., 2015). Although the reduction in the BMI is independent of the intensity of exercise (physical activity) (Ross et al., 2015), physical activity as a measure in reducing the prevalence of obesity is more effective when combined with caloric restriction (Lau et al., 2007).

In conclusion, the effective approach in the management of obesity is the multimodal approach which includes a reduction in sedentary behavior, increased physical activity and diet therapy (Kumanyika et al., 2008).

The prevalence of diabetes worldwide has reached an alarming figure. This shows that type 2 diabetes has become a public health epidemic and is fast becoming a global health menace. With this highly disturbing prevalence, research has shown that the majority of people with type 2 diabetes have high sedentary behavior and low physical activity level (Katzmarzyk, 2010). This behavior has become a challenge in the medical management of type 2 diabetes. Although the imbalance in the biological system in the body plays a role on the pathological pathway of type 2 diabetes (onset and progression), the impact of inappropriate diet and sedentary behavior cannot be overemphasized (Hu, 2011). Thus, human activities have been described as the main etiology of diabetes and it is essential to approach these activities in a proper way in an attempt to therapeutically manage the condition (Ferzacca, 2012). In terms of complications in onset of diabetes, it has been shown that the age of onset is partly responsible for complications in conjunction with inappropriate management. A cross-sectional study among the Chinese living with type 2 diabetes mellitus revealed that the development of diabetes retinopathy (complication of diabetes) is increased with diabetes onset between 31 and 45 years (Zou et al., 2016). Therefore, there is a need to review the economic burden of obesity and type 2 diabetes.

Economic Burden of Obesity and Type 2 Diabetes

There are various studies done on the economic burden of obesity which provide statistics on the prevalence and impact of obesity to decision and policy makers (Tremmel, Gerdtham, Nilsson, & Saha, 2017).

In the year 2014, the impact of obesity on the global economy was estimated at US $2.0 trillion (equivalent to 2.8 times Gross Domestic Product (GDP)) on health care expenditures from over 2.1 billion people (approximately 30% of the global population) affected with a 5% death rate attributed to the menace. Unfortunately, the global prevalence of obesity is predicted to reach half of the world's population by 2030, if the rate of growth is not controlled (Dobbs et al., 2014).

Apart from this humongous cost, obesity is indirectly responsible for low work productivity, some deformities (e.g. osteoarthritis), a high number of work days lost, and a high rate of mortality (Tremmel, Gerdtham, Nilsson, & Saha, 2017).

In Canada the total cost of overweight individuals (BMI of 25 – 29.9) and obesity in 2012 was estimated at $19 billion with obesity having an estimated cost of $11.5 billion and overweight accounting for the remaining $7.5 billion. This estimated value includes the direct costs such as pharmaceuticals, physicians, hospital care, and long-term care and also the indirect costs such as low work productivity, premature death, and permanent disability (Krueger, Turner, Krueger, & Ready, 2014).

In 2010, the global health cost of diabetes accounted for $376 billion (12%) of the health expenditure and the projected estimate by 2030 is $490 billion (Zhang et al., 2010).

The global economic estimate for diabetes for 2015 was $US 3.1 trillion (Bommer et al., 2017). The estimate was calculated from the economic data and epidemiological prevalence of 184 countries as regards any type of diabetes. The analysis revealed that North American countries were most affected with respect to GDP, and thus contributed most to the global cost.

Bommer et al. (2018) estimated the global economic burden of diabetes from the year 2015 through 2030. The researchers predicted that even if the WHO Global Action

Plan for the Prevention and Control of Non-communicable Diseases 2013 – 2020 and the Sustainable Development Goals (SDG) are met, the economic burden of diabetes will increase the cost of care from 1.8% (1.7 – 1.9) in 2015 to 2.2% (2.1 – 2.2) by 2030. The increasing prevalence of diabetes and its associated cost is almost equal to the economic gains of most developing countries of the world (Hu, 2011).

Considering this increment in the economic burden of diabetes, governments and policy makers are advised to make appropriate public health policy to mitigate the prevalence of diabetes. The next sections review the prevalence of obesity and type 2 diabetes among young, middle-aged, and older adults respectively.

Obesity and Type 2 Diabetes among Young Adults

Since childhood obesity can lead to obesity in adulthood (Laitinen, Power, & Jarvelin, 2001), it is essential to consider the impact of childhood obesity to young adulthood. Researchers have argued that obesity is strongly linked to genetic make-up (Apovian et al., 2015); however, the impact of environmental factors regarding food intake and physical activity play a great role in the genetic expression of obesity. In Canada, the prevalence of childhood obesity among children aged 7 to 13 years tripled (from 5% to 15%) between 1981 and 1996 (Tremblay & Willms, 2000). Considering the huge growth in obesity within this time frame, Tremblay and Willms (2003) studied the potential causes and concluded that the high prevalence of obesity is mostly due to environmental factors and not genetic make-up. The contribution of genetic factors to the prevalence of obesity has been quantitatively estimated. Statistically, a child of non-obese parents only has a 9% risk of being obese. If one of the parents is obese, the risk of obesity in the child increases to 50% and the rate further increases to 80% if both parents are obese (Price et al., 1987).

In conclusion, genetic and environmental factors both contribute significantly to the prevalence of obesity with environmental factors playing a key role. Childhood obesity and parental obesity are also described as risk factors for obesity among young adults (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997).

Although chronic complications usually manifest during adulthood, diabetes is the most prevalent metabolic disorder among young adults (Dyck, Osgood, Gao, & Stang, 2012). In the past, the majority of diabetes cases among young adults were attributed to type 1 diabetes; however, changes in lifestyles and a higher incidence of obesity among children have led to an enormous increase in the prevalence of type 2 diabetes among this age group (Shields, 2006; Fagot-Campagna et al., 2000).

In Canada, the prevalence of diabetes is higher among First Nations young adults compared to non-First Nation young adults (Dyck, Osgood, Gao, & Stang, 2012). Research conducted by Dyck et al. (2012) among three hundred and twenty First Nations and two thousand one hundred and thirty six non-First Nations in Saskatchewan revealed the diabetes pandemic affects female First Nations young adults disproportionately. The age-adjusted study used data from 1980 to 2005 with participants aged between 0 and 19 years and the result showed that the prevalence of diabetes is similar between First Nations males and non-First Nations females. Diabetes occurrence for non-First Nations males was approximately 30 out of 100 000, but the average for First-Nations females was 46.3 out of 100 000 in the early 1980s. The prevalence of diabetes increased between 2003 and 2005 with First Nations females having a figure of 260 out of 100 000; non-First Nations females, 205 out of 100 000; First Nations males; 232 out of 100 000; and non-First Nations males 256 out of 100 000. Generally, the prevalence of diabetes among young adults requires urgent public health attention to stop the trend. Considering the high prevalence of diabetes, the lifestyles of young adults needs appropriate modification.

Research has shown a high prevalence of sedentary behaviors among young adults. In North America including Canada, the majority of children and youth spend most of their waking hours (40% to 60%) in sedentary activities such as prolonged sitting, television viewing, playing video games, among others (Saunders & Chaput, 2014). These activities have been associated with a rise in cardio-metabolic diseases such as diabetes and the adverse effects of these activities have been found to be independent of factors such as physical activity and obesity among this age group. (Sardinha, Andersen, & Anderssen, 2008).

Although there is a limited number of reviews that investigate the effect of sedentary behaviors on the health of children, Canada has established guidelines for sedentary behaviors among children and youth (Tremblay et al., 2011). These guidelines are different from the physical activity guidelines and recommend youth and children not accumulate more than two hours of recreational screen time daily and also to limit their prolonged sitting hours and motorized transportation (Tremblay et al., 2011).

Obesity and Type 2 Diabetes among Middle-aged Adults

Sedentary behavior has been described as one of the most relevant modifiable risk factors for chronic diseases such as obesity and type 2 diabetes, among others (Guthold, Ono, Strong, Chatterji, & Morabia, 2008). Sadly, studies have shown that middle-aged adults are more sedentary in their lifestyles compared to young adults (Burton et al., 2009). Bertrais et al. (2005) reported that the high prevalence of obesity among middle-aged adults is due to sedentary behavior.

In Canada, middle-aged adults between 45 and 64 years old reported the highest rate of obesity and overweight in 2011 (Wang et al., 2015). This might be responsible for a high rate of mortality among middle-aged adults. A longitudinal study conducted in Canada with the majority of participants below the age of 45 years (comprising young and middle-aged adults) found a statistically significant increase in mortality among participants in the underweight and class II+ obesity (Orpana et al., 2010)

In the United States of America (USA), 13% to 15% of all deaths that occurred between 1991 and 2000 were attributed to obesity among middle-aged adults (Mokdad, Marks, Stroup, & Gerberding, 2005). Moreover, Flegal et al. (2005) found that 5% of deaths among middle-aged adults were attributed to obesity (BMI $>30kg/m^2$) in the year 2000 in USA.

Individuals with type 2 diabetes at a younger age are more prone to long-term complications of diabetes (e.g. retinopathy, neuropathy, nephropathy) when the young adults reach age 40 and above (middle-age) (Pinhas-Hamiel & Zeitler, 2007). Hence the need for prevention or adequate management of diabetes in middle-aged adults.

Ebrahimi, Emamian, Hashemi, and Fotouhi (2016) conducted a longitudinal study to determine the prevalence of type 2 diabetes among middle-aged adults in Iran. Results showed a high prevalence of diabetes among men (20.19%) and women (26.45%) with the total prevalence at 23.89%.

Wilson et al. (2007) predicted the 7-year odds of type 2 diabetes among 3140 middle-aged men and women with oral glucose intolerance at baseline. The regression results revealed that obesity, metabolic syndrome, and parental diabetes predicts the onset of type 2 diabetes effectively.

Furthermore, a study conducted in Nigeria revealed that the prevalence of type 2 diabetes is higher among men than women who are in their middle-age. Ejim, et al. (2011) conducted a study among 858 participants with a mean age of 59.8 ± 9.9 years. Statistically, the study showed a higher prevalence of type 2 diabetes (4.4%) and hypertension (46.4%) among the male participants.

Sedentary behavior has been described to be prevalent among the middle-aged adults, partly due to lifestyles and the kind of jobs they do. Pereira, Ki, and Power (2012) conducted a study on the relationship between television viewing/sitting, work and cardio-metabolic diseases among the sedentary middle-aged adults. The results showed that television viewing time is associated with markers for type 2 diabetes, but time spent at work were not positive markers for chronic diseases.

Obesity and Type 2 Diabetes among Older Adults

The evidence to support the accuracy of BMI among adults 65 years and above is inconclusive (Douketis, 2005). This inaccuracy might be due to the instability of weight and height among these groups. Nonetheless, obesity increases the risk of disability and also recovery from disability among older adults (Samper-Ternent & Al Snih, 2012). Compared to the USA, the rate of obesity in Canada was lower in the mid-1990s (Zamboni et al., 2005). However, during the late 1990s, findings revealed a steady rise in the prevalence of obesity with 35% of men and 27% of women being obese in the ten provinces of Canada.

About 642 million of the global population have been projected to have diabetes by 2040, with one third of these people falling into the older adult age group (65 to 79 years) (Bommer et al., 2018). However, it is crucial that Canada takes proactive measures in approaching the prevalence of diabetes considering 3.7 million Canadians have been projected to be living with diabetes by 2019 (Adam, O'Connor, & Garcia, 2017).

In Ontario, a longitudinal study conducted between 1995 and 2005 showed a 69% increase in the prevalence of diabetes with a higher prevalence in participants aged 50 and above (Lipscombe & Hux, 2007). Although there is an increase in the prevalence of diabetes, the mortality rate from diabetes dropped by 25% between the period of 1995 and 2005 (Lipscombe & Hux, 2007). This decrease in mortality might be due to better diabetic management and improved care for patients living with diabetes.

Effect of Sedentary Lifestyles on the Prevention and Management of Diabetes

In the clinical management of diabetes, researchers have proposed that it is better to avoid prolonged sitting (Owen, Bauman, & Brown, 2009). This can be achieved by intermittently involving energy demanding activities such as brisk walking, jogging or bicycling every 25 to 30 minutes during prolonged sitting (Sigal et al., 2018).

Although there is no clinically validated preventive measures for the prevention of type 1 diabetes, lifestyle modifications resulting in loss of approximately 5% body weight can prevent the progression from pre-diabetes to type 2 diabetes (Prebtani, Bajaj, Goldenberg, & Mullan, 2018). It has been shown that metformin (oral anti-diabetic drug) reduces the risk of progression from pre-diabetes to type 2 by approximately 30% with effects lasting more than 10 years after stopping the pharmacologic therapy. On the other hand, lifestyle modification (diet and reduction in sedentary behavior) resulting in significant weight loss (approximately 5%) can reduce the risk of progression from pre-diabetes to type 2 diabetes by 60% with effects lasting for more than 20 years when initiated early in the progression of pre-diabetes to diabetes (Prebtani, Bajaj, Goldenberg, & Mullan, 2018). These two interventions can be combined for either the prevention or management of type 2 diabetes if significant results are not obtained with either of the two options.

There is a high prevalence of chronic diseases such as type 2 diabetes, hypertension among older adults (Celidoni, Dal Bianco, & Weber, 2017). This might partly be due to age and sedentary behaviors, and hence the need to review retirement and health among older adults.

Retirement and Health

Retirement on its own has some possible negative health outcomes (such as cognitive dysfunction) that accompany it (Celidoni, Dal Bianco, & Weber, 2017); therefore, sedentary behavior during retirement is a disaster. This has made the study of sedentary behaviors among older adults an important public health concern. Moreover, there is always deterioration in health as people get older, although there may be social inequalities that increase the deterioration of health with increasing age (Chandola, Ferrie, Sacker, & Marmot, 2007).

Although retirement has been shown to be a transition that affects health, it is also possible for ill health to be a progenitor of early retirement. In a study done on Australian retirees, Cai (2010) observed that the health of an individual contributes significantly to their decision to retire. This observation is supported by data given by the Australia Bureau of Statistics in 2014, which revealed the percentage of older adults that retire from active work due to ill health to be 30.5% for men and 23% for women. Therefore, retirement can predispose adults to chronic conditions partly due to sedentary behaviors and chronic conditions can also predispose to early retirement.

The Socio-Economic Impact of Old Age

The number of older adults in the population is expected to increase rapidly from 2007 through 2026 (Donna & Pedro, 2007). Most countries will experience the number of people aged 65+ doubled, and this will mean a higher demand for health care (Rapoport, Jacobs, Bell, & Klarenbach, 2004). This rapid change in the population of older adults will increase government expenditure on the healthcare of older adults in both developed and developing countries (Butterworth et al., 2006). In 2005, the medical expenditure survey in the United States gave an analysis that the amount of money spent on healthcare of older adults (average age 65 years and above) is five times more than the cost of taking care of people below 65, irrespective of their health condition. This might be partly due to the cost of palliative treatment for older adults with chronic diseases. Moreover, the Centers for Disease Control and Prevention (CDC, 2003) gave statistical evidence that verifies the presence of co-morbidities among older adults. It was documented that 80% of older adults reported a minimum of one chronic health condition, while 50% reported two or more chronic health conditions.

In a similar vein, retirement among older adults is usually accompanied by lower income (Cai, Giles, & Meng, 2006). The pension given to retirees in developing countries is not enough to maintain them. This has given rise to a loss of social status in the society, and by inference has led to depression which often results in sedentary behavior among retirees (Amune, Aidenojie, & Obinyan, 2015). Considering the economic cost of maintaining the health of older adults and the projected increase in their population, coupled with the loss of social status, it is expedient to know more about the moderating effect of age on the prevalence of the sedentary behavior among older adult (retirees).

Age has been described as one of the main determinants of sedentary behavior (Van Cauwenberg et al., 2014). Generally, the literature shows that older adults are more sedentary in lifestyle than any other age group (Harvey, Chastin, & Skelton, 2013). Harvey, Chastin, and Skelton (2015) also did a systematic review of studies among older adults from 10 different countries, showing that older adults lead sedentary lifestyles with a mean of 9.4 hours per day spent sedentary. Also, Condello et al. (2017) reported that sedentary activities (reading and internet use), and composite sedentary behavior are negatively correlated with physical activity; hence the need to review the physical activities and sedentary lifestyles profiles among older adults.

Physical Activities Profile among Older Adults

Physical activity increases energy expenditure above the rest level (Caspersen, Powell, & Christenson, 1985). In present-day medicine, attention has shifted from curative care to preventive care (Ifeanyichukwu & Ubong, 2012), and physical activity is one of the effective preventive measures against non-communicable, age-related diseases that affect older adults. The World Health Organization (WHO, 2010) recommended that "older adults should engage in at least 30 minutes of moderate to vigorous physical activities for a minimum of 5 days in a week". These physical activities include gardening, dancing, swimming, walking, hiking, cycling, sports, or any planned exercise.

Slingerland et al. (2007) examined the level of participation of older adults and employed workers (middle-aged adults) in physical activity in the Netherlands. The researchers followed up 971 participants who were employed in 1991, with their ages ranging from 40 to 65, for a period of 13 years after which 684 participants had retired and 287 participants were still employed. The results show that the older adults hardly spend time on work-related physical activities (with a proportional growth in sedentary time from

55% to 90%). It was further reported that those who were employed increased their participation in sporting activities, but the older adults did not. Another study conducted by Berger, Der, and Mutrie (2005) involved 699 workers who were about to retire (older adults) in West Scotland, and was followed up for 5 years after retirement. The result reveals qualitatively that a sizeable number of physical activities were lost after they retired, and these activities were not compensated for during their leisure time.

Furthermore, Chung, Domino, Stearns, and Popkin (2009) conducted a study on retirement and physical activity in the USA and the data was analyzed using the wealth and the occupations of the participants. The longitudinal research involved 9,935 participants with an average age of 60, and the study was conducted from 1996 to 2002. The percentage of the population who engaged in sedentary jobs while in active service was 54%, and 48% of them retired from a physically active job. The analysis of the self-reported data revealed that physical activities decreased by 7.5% after retirement for people engaged in jobs that were physically demanding, while physical activities increased by 4% for older adults who engaged in sedentary jobs while active in the work force. All the above reviewed literature concluded that older adults increase their sedentary activities as soon as they approach the age of 65 years; hence there is a need to review sedentary lifestyle profiles among the older adults.

Sedentary Behavior Profiles among Older Adults

Zaman, Mian, and Butt (2018) reported that research on a sedentary behavior is crucial because some people believe there is no time for physical activity. However, older adults are susceptible to sedentary behavior, partly because they have left active service, and have less activity to perform. This shows that time is not the reason for the prevalence of sedentary behavior. It can be argued that people do not reduce their sedentary activities and decide to be sedentary due to preferences (Dergance et al., 2003).

Moreover, according to Leandro, Mauricio, Juan, Victor, and Olinda (2014), older adults (retirees) spent most of their waking time engaging in sedentary activities. They further explained that despite the health risk associated with this behavior, there is no considerable difference in the sedentary behavior among older adults. Although the recommendation for physical activity is participation in a minimum of 30 minutes of moderate physical activity five days in a week, Owen, Healy, Matthews, and Dunstan, (2010) reported that it is possible to meet the requirement for physical activity and still be sedentary in lifestyle.

Summary of Physical Activity and Sedentary Behavior Profiles of Older Adults

Critically, considering the physical activity and sedentary behavior profile among older adults, it can be concluded that the majority of older adults spend a greater proportion of their awake time being sedentary in lifestyle without engaging in any compensatory physical activity in their leisure time; hence, one might conclude that the prevalence of chronic diseases is partly due to their sedentary lifestyles.

Determinants of a Sedentary Behavior

A sedentary behavior has been linked to negative health outcomes as explained in previous sections; however, there are factors that moderate engagement in this behavior across age groups. Van Der Berg et al. (2014) described a sedentary behavior as a health behavior with a distinct characteristic different from physical activity; therefore, proper identification of these moderating factors will help in developing interventions necessary to improve the lifestyle.

Several studies examined this concept and the literature give a holistic view to this subject matter. The factors will be captured under the following subheadings; Individual factors (age, gender, and marital status, nature of retirement, education attainment, income, and health), Interpersonal factors, and Environmental factors.

Individual factors

- ***Age.*** Van Cauwenberg et al. (2014) observed a decrease in self-reported sedentary behavior after 65 years among older adults in Belgium. The study involved 50,986 participants and the marker of sedentary behavior used was television viewing time. The result showed that there is a decrease of 30 seconds per day for every year in the rate of viewing television as participants' advances in age above 65 years old. However, in the USA, Shiroma, Freedson, Trost, and Lee (2013) used an accelerometer to measure sedentary behavior among 8,373 senior women who wore the instrument for 7 days only during waking hours. The result showed that sedentary time increased by 5% after the age of 65. There is a conflicting result from the two studies discussed above, which shows the subjectivity of age as a factor predisposing adults to a sedentary lifestyle. Moreover, since there are other media through which adults are involved in sedentary activities (such as reading, driving, among others; apart from viewing, and these activities, most of the time occur concurrently), the result given by the use of an accelerometer is likely to give a better overview of the behavior with an increasing age. Therefore, it can be said that sedentary behavior increases with age (Dogra et al., 2017).
- ***Gender.*** Males and females are different with respect to participation in sedentary activities. This can be seen in their post-transition lifestyle (e.g. retirement)

adjustment which makes one gender more prone to sedentary behavior than the other. Also, gender has been shown to have pronounced effects on the organization of work life and corresponding transition experiences (Gall, Evans, & Howard, 1997; Van Solinge, 2007).

In a study conducted by Arnardottir et al. (2013); an accelerometer was used to measure sedentary behavior among 579 adults between 73 and 98 years old. The result shows that male participants were more sedentary compared to the females. Also, Kikuchi et al. (2013) reported that Japanese men are more sedentary than women by 21% using television viewing time as a marker of sedentary behavior among 1,665 older adults. Conversely, Lord et al. (2011) reported no significant association between sedentary behavior and gender.

In summary, there is inconclusive evidence regarding gender differences in sedentary time.

- ***Marital status.*** The effect of a married companion or the loss of a spouse on sedentary behavior is worth reviewing. According to research done by Van Der Berg et al. (2014), single older adults who have never been married, reported more sedentary behavior than their married age mates. This is further corroborated by Van Cauwenberg et al. (2014) who revealed that sedentary behavior is more prevalent among widows, widowers, and divorcees when compared to their counterparts who have partners. This might be due to encouragement on the need to reduce sedentariness on the part of both partners involved; further, the loss of a spouse might bring depression which might make a widow or widower be more sedentary in their behavior.

- ***Nature of retirement***. One of the factors considered to contribute significantly to a sedentary behavior is the form of retirement. Retirement can occur through three main forms namely: voluntary, involuntary, or mandatory. Adequate preparation is generally made towards a voluntary or mandatory form of retirement; hence, there may be a positive healthy behavior after retirement. This behavior may reduce the risk of being sedentary. The involuntary form occurs with no preparation and the employee has no control over this form of retirement. It is usually determined by the employer due to certain reasons such as economic recession, lack of productivity on the side of the employee, among many other factors. An adult after an involuntary retirement may experience smoking, alcoholism, and other unhealthy lifestyles (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Also, depression, anxiety, and physical illness may set in. These outcomes always result in sedentary behavior (Teychenne, Ball, & Salmon, 2010).

  In addition, an involuntary retiree usually retires at an age lower than the recommended retirement age. Dave, Rashad, and Spasojevic (2008) observed a decline in mental health if retirement is involuntary and occurs at an earlier age. It was reported after analyzing longitudinally the health and retirement study data (HRS) in the USA that a significant value of 6% to 9% decline in mental health occurred during involuntary retirement compared to the sample mean.

  In another study conducted among British and Australian men that retired before the recommended retirement age, participants had a higher rate of significant mental disorder compared to their counterparts who were still working (Melzer, Buxton, & Villamil, 2004). The negative health outcomes that follow involuntary retirement might pre-dispose the retiree to a sedentary behavior. Also, an involuntary retiree might be more prone to a sedentary behavior compared to voluntary or mandatory retiree due to inadequate planning. This is because life transitions like retirement are subject to certain norms and timing to prevent unforeseen circumstances (Settersten, 1998; Settersten & Hagestad, 1996). Therefore, the circumstances or the nature of retirement determines the kind of behavior whether sedentary or healthy (physically active), that a retiree will live after disengaging from work.

- ***Education attainment*.** The level of education attained in most cases determines the status one will occupy in his/her career. The lesser educated person might get a lower status job which might be more physically strenuous while the most educated people might get managerial work (most likely less strenuous). The level of experience can also determine the position held in the place of work. The literature pertaining to the relationship between sedentary behavior and level of education attained were conflicting in terms of the direction of moderation. Van Cauwenberg et al. (2014) observed that the more educated adults view television 42 minutes less than their lower educated counterparts on a daily basis. Moreover, Kikuchi et al. (2013) analyzed the sedentary behavior among older Japanese men and women. It was reported that the most educated older adults viewed television by 37% more, compared to their lower educated counterparts.

  Critical analysis of the reports given by Van Cauwenberg et al. (2014) and Kikuchi et al. (2013), reveal that television viewing is just one of several common sedentary behaviors that exist among adults. In fact, the more educated older adults might engage in reading more than viewing television.

  ***Health*.** The outcome of sedentary behavior is a negative health status, but it is also possible to be sedentary because of poor health. Although the sedentary behavior is a condition that affects health; a psychological or functional imbalance in health can be a precursor of the sedentary behavior. Ku, Fox, Chen, and Chou (2011) in a study conducted through telephone interview of 1,450 Taiwanese with an average age of 62.1 years, found an inverse relationship between self-reported well-being and sedentary behavior. Arnardottir et al. (2013) measured physical activity objectively using accelerometers and found that adults who are obese are more sedentary in lifestyle compared to their non-obese colleagues in Iceland.

The association between cardiovascular disease and sedentary behavior among older adults was examined by Van Der Berg et al. (2014) and the report showed 7% risk of a cardiovascular disease among sedentary older adults. Therefore, one may conclude that there is a relationship between the sedentary behavior and health; hence, sedentary behavior can lead to negative health outcomes, and a negative health outcome can lead to a sedentary behavior.

- ***Income.*** The level of income of an adult is an important factor that moderates a sedentary lifestyle. The amount of income that a retiree is entitled to as pension on a monthly basis is lower than the amount received during active service, and the wages of young adult and middle aged adults vary based on kind of job and position held. The highly placed employee usually earns more than the lower placed employee. According to a Gray report (Grimm, 2011) released by the public health department of the University of North Carolina, Americans who earn less than $15,000 per year have a higher rate (39.5%) of being sedentary in their lifestyle and also have a greater percentage (82.4%) of being at risk for health related problems due to sedentary behavior, while Americans who earn more than $50,000 per annum have a lower rate (13.2%) of being sedentary in their lifestyle and possess a lower percentage (74.4%) of being at risk of health related problems due to a sedentary lifestyle.

Anderson, Currie, and Copeland (2016) conducted a study using 2010 Canadian Community Health Survey (CCHS) data. Results revealed that television viewing time (sedentary behavior) was more common among adults with lower household income compared to households with higher income.

Interpersonal factors. Loneliness has been ascribed as a reason why some adults live a sedentary lifestyle. This is captured in the view of Van Cauwenberg et al. (2014) when they observed that 2 minutes of television viewing on a daily basis is attributable to loneliness among Belgian adults. Kikuchi et al. (2013) reported similar results among older Japanese men and women adults. In a comparison study done between adults who live in a shared apartment and those who live alone, they observed that there is 26% increase in television viewing time in those who lived singly. Therefore, a lonely adult might have a higher tendency to be sedentary in behavior compared to an adult that stays in a shared apartment.

Environmental factors. The availability of recreational, tourist, and relaxation centers may influence sedentary time. Chastin, Fitzpatrick, Andrews, and DiCroce (2014) conducted qualitative research analysis and found that lack of recreational centers promotes sedentary behavior among adults. In a similar vein, Kikuchi et al. (2013) observed quantitatively that adults in rural areas have a higher rate of television viewing (48%) compared to their counterparts in urban centers due to inadequate recreational facilities. However, in most developing countries like Nigeria, there is a good inter-relationship among both youths and elders in rural communities which make them do many things together and even live together. This relationship has made adults reduce their sedentary activities despite the absence of basic amenities and recreational centers. Therefore, the impact of environmental factors on sedentary behavior among adults will depend on geographical location.

Summary of the Determinants of Sedentary Lifestyle

The likelihood of being sedentary increases with age. Sedentary behavior is also high among individuals who are single, possess a high level of education or low-level income. Also, health, nature of retirement, and interpersonal or environmental factors moderate the extent of the sedentary behavior. The literature reviewed reveals that one of the causes of chronic diseases in adults in developing and developed countries might be sedentary behavior. The literature clearly linked sedentary behavior with some common chronic diseases such as cardiovascular disease, obesity, type 2 diabetes, and certain types of cancer. There is overwhelming evidence in the literature that shows the beneficial effect of reduced sedentary activities to prevent and manage chronic diseases such as obesity and type 2 diabetes. However, most adults persist in sedentary behavior.

In addition, attention has shifted from curative medicine to preventive medicine. A reduction in sedentary activities is recommended to prevent non-communicable chronic diseases (Ifeanyichukwu & Ubong, 2012). However, sedentary behavior has been shown to contribute to co-morbidity experienced by adults (CDC, 2003). Even though sedentary behavior has been scientifically proven to have negative health consequences, the culture of healthy behavior is gradually fading away among adults. Only a minority of adults comply with the minimum 150 minutes of recommended moderate physical activity per week, but most engage in sedentary behavior during their leisure time (Hamilton & Zderic, 2007). This is a call for additional research into sedentary behavior and its socioecological correlates among adults in developed countries such as Canada.

Moreover, the level of sedentary behavior varies with factors such as age, gender, and level of education among others. Therefore, the study of relationships between sedentary behavior and associated disease among adults in developed countries such as Canada is an important public health concern.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

The research design used in examining the relationship between sedentary behavior, obesity, and type 2 diabetes across age groups in Canada is the cross-sectional research design. A cross-sectional research design is a subset of the quantitative research design and it entails the collection of quantifiable data in a bid to find an association between two or more variables (Zheng, 2015). The cross-sectional research design has its own strengths and limitations, and these will be discussed with reference to the text titled "Epidemiology in Medicine", written by Buring (1987). The strength of the cross-sectional research design includes ease of conducting research. The cross-sectional study needs no follow-up thereby making it easier to conduct compared to a longitudinal study.

The design is less costly than other types of quantitative research designs, such as the experimental design. Also, the design is good for descriptive analysis and it helps in generating hypotheses. These hypotheses can be confirmed or rejected using statistical analysis. Conversely, in a cross-sectional research design, it is impossible to determine cause and effect relationships. For example it is difficult to state emphatically that sedentary behavior is the cause of obesity or type 2 diabetes. Considering the strengths and limitations of the cross-sectional research design and its appropriateness to my study it is expedient to discuss the source of data used for the analysis.

Data Source

The data used for this study is secondary data obtained from the Canadian Community Health Survey (CCHS). The version of the data used is the 2016 cycle with a collection period between January and December 2016. The participants voluntarily responded to the survey.

Sampling and Data Collection

A simple random sampling method was used to select study participants. The data consists of 130,000 respondents with 120,000 of the respondents aged 18 years and above and the remaining 10,000 respondents aged between 12 to 17 years. This provides a reliable estimate for each health region. Also, two different frames were used in the collection of the CCHS data, namely the Area frame and the Canadian Child Tax Benefit (CCTB) frame. The area frame was used in collecting data from participants aged 18 years and above. In this collection method, all members of a household (dwelling) were catalogued according to their age and persons aged 18years and over were randomly selected. For respondents aged 12 to 17, the CCTB was used to sample respondents with one of the children pre-selected to complete the survey. Data was collected from participants using telephone interview software and a computer assisted personal device. The participants completed the interview in either English or French.

Sample Size

Although the participants sampled are aged 12 and above, the study only focuses on adults 18 years and above. There are 55,690 respondents (18 years and above) out of 120,000 participants who answered questions related to sedentary behaviors, type 2 diabetes and obesity and the response rate was 61.3%.

Measures

Variables can be defined as quantifiable factors obtained through operationalization (Kaur, Rana, & Gainder, 2013). Variables convert abstract ideas into a more understandable and empirically measurable concepts. The variables in this study include:

Independent variable. In this study, the independent variable is self-reported leisure sedentary time over the past 7 days. It excludes occupational sedentary time, so it is leisure sedentary time. The sedentary time is "a waking behavior that involves low energy expenditure, usually ≤ 1.5 metabolic equivalent task (MET) while in a reclining, sitting or lying posture" (Tremblay et al., 2017). This variable is further divided into the following subgroups

- ***Reading time*.** This represents the number of hours in the past seven days that participants spent reading books, magazines, or newspapers including electronic format. It includes time spent reading as part of homework, but it does not include time spent reading at work, during class time, during transportation, or while exercising. The variable was measured as a continuous variable with scores ranging from 0 to 95 hours per week. The mean reading time was 6.7 hours (standard deviation, SD = 7.96). For the purposes of this study, reading time was re-categorized as low reading time (the reading time less or equal to the mean value) and high reading time (the reading time above the mean value). The variable was then recoded as a nominal variable with high and low reading time.
- ***Television viewing time*.** This represents the number of hours in the past seven days that participants spent viewing television, digital versatile disc (DVD), movies, or internet videos. It does not include time spent viewing screens while exercising. The variable was measured as a scale variable with responses ranging from 0 to 95 hours per seven days. The mean of television viewing time was 13.6 hours (SD = 11.18). In this study, the variable was re-categorized as low television viewing time (the television viewing time less or equal to the mean value) and high television

viewing time (the television viewing time above the mean value). The variable was then recoded as a nominal variable with high and low television viewing time.

- ***Video game time.*** This represents the quantity of time spent playing video or computer games as reported by participants in the last seven days. It includes games played on consoles, computer, or hand held electronic devices such as smart phones and tablets. The variable was measured as a continuous variable with scores ranging from 0 to 95 hours per week. The mean of the video game time was 2.1 hours (SD = 5.79). For the purposes of this study, the variable was re-categorized as low video game time (less or equal to the mean value) and high video game time (above the mean value). The variable was then recoded as a nominal variable with high and low video game time.
- ***Computer time.*** This represents the amount of leisure time (in hours) participants spent working on computer, smart phones, or tablets in the past seven days. It also includes activities such as emailing, surfing the internet, doing homework, or using social media such as Facebook. It does not include time spent on computer, tablets, or smart phone at work, during transportation, or while in class. The variable was measured as a continuous variable with minimum score of 0 hours and maximum score of 95 hours per week. The mean of the computer time was 7.1 hours (SD = 9.81). The variable was re-categorized as low computer time (less or equal to the mean value) and high computer time (above the mean value). The variable was then recoded as a nominal variable with high and low computer time.
- ***Total sedentary behavior.*** This variable represents the total time spent in sedentary behavior such as reading, television viewing, computer use, and playing video

games. Total hours spent in these activities per week were calculated with participants classified in one of ten categories, beginning with < 5 hours of leisure sedentary time and increasing in five-hour increments to a maximum of ≥ 45 hours per week. For the purposes of this study, the variable was re-categorized based on the median category as low total sedentary time (the total sedentary time less or equal to 25 hours per week) and high total sedentary time (the total sedentary time above 25 hours per week). The variable was then recoded as a nominal variable with high and low total sedentary time.

Dependent variable. This is the outcome variable. In this study, the outcome variables are obesity and diabetes.

- ***Obesity.*** This variable is the measure of self reported body mass index adjusted (BMI). It is a nominal variable that consists of six different sub-groups namely: underweight, normal weight, overweight, obese class I, obese class II, and obese class III. The three obese classes were combined to form the obese category while sub-groups like underweight and overweight were excluded. This is because the study focuses only on obese participants. The normal weight and obese (combined category) were then used for the new BMI Groups adjusted variable. This new variable was used as a measure of obesity.
- ***Diabetes*.** This variable represents participants' response to the question of whether they have diabetes or not. It is a dichotomous nominal variable with the name "Has Diabetes" in the analysis.

Moderating variable. A moderating variable measures the changes to the direction or strength in the relationship between the independent and dependent variable. In this study, Age was the moderating variable. The variable age is a scale variable and it represents the age of participants in the study. This variable was re-categorized into three different age categories such as Young adults (age 18 – 39), Middle-aged adults (age 40 – 64) and Older adults (age 65 and above).

Covariates. A covariate (also known as a control variable) is a variable that may predict the dependent variable under study (obesity and diabetes), thus the need to control for these variables. The following variables were controlled for in this study:

- ***Education level*.** This variable is an ordinal variable with eight different categories. These categories include grade 8 and lower, grade 9 – 10, grade 11 – 13, secondary school graduate, trade certificate/diploma, certificate/diploma, university certificate or diploma below bachelor's degree, and bachelor's degree. In this study, the education level variable was recoded into three distinct categories which include the following

  i. High school and other lower educational qualifications: These qualifications include grade 8 or lower, grade 9 -10, grade 11 – 13, and secondary school graduation.

  ii. Certificate below bachelor's degree: The educational qualification under this category includes trade certificate or diploma, certificate/diploma and university certificate or diploma below bachelor's degree

  iii. University degree: This educational qualification includes bachelor's degree and other university qualification above bachelor's degree

- ***Marital status***. The marital status of each of the participants as it affects the outcome variable (obesity and type 2 diabetes) was also controlled for in this study.

In the data, the variable has six different categories: married, living with common law, widowed, separated, divorced, and single/never married. The variable was recoded into two distinct categories: Married or Common law category (comprises of married participants and participants living with common law partners) and Single category (this comprises of widowed, separated, divorced, single and never married participants).

- ***Sex*.** The sex of the participants (respondents) as it affects the outcome variable under study (obesity and type 2 diabetes) was controlled for. The variable was coded as male and female in this study.
- ***Age*.** The effect of age on the relationship between sedentary behaviors and chronic diseases (obesity and type 2 diabetes) was adjusted for.

Analytical Techniques

Statistical Package for Social Sciences (SPSS) version 24 was used for data analysis. Descriptive and inferential statistics were performed on weighted CCHS (2016) data.

Data cleaning. The initial analysis of the data includes checking for the assumptions of the inferential analysis (logistic regression and the generalized linear models (GLM)). The logistic regression was used for the non-interactive analysis between dependent variables and independent variables. The data had no univariate and multivariate outliers. There are missing data, but these data were not replaced. This is because the data are missing at random. There were no issues with the multi-collinearity and the linearity of logit interaction terms is not statistically significant.

Descriptive analysis. The descriptive analysis was performed using normalized master weight (master weight divided by mean). The analysis comprises of frequency distribution for each of the independent, dependent, and sociodemographic variables in the CCHS data. Also, the percentage of respondents with low sedentary or high sedentary behavior in each independent groups and dependent groups were calculated.

Inferential analysis. The binary logistic regression analysis was used to examine how sedentary behaviors (reading time, computer viewing time, television viewing time, video game time, and total sedentary time) predict outcome variables (diabetes and obesity). The test is appropriate because the outcome variable is dichotomous in nature and the predictors are also categorical variables. Variables were entered into the regression model using the stepwise approach. The reference group in each analysis is the low sedentary category. The high sedentary category was then compared with the low sedentary category to interpret the regression analysis. Obesity was weighted using normalized master weight while diabetes was weighted using frequency weight. Frequency weight was used in weighing diabetes due to the inability of normalized weight to correct for sampling differences in participants that reported having diabetes and those that do not have diabetes. When diabetes was weighted using normalized master weight, 7% of participants reported having diabetes while the remaining 93% do not have diabetes. In order to maximize the overall classification accuracy due to the sampling differences in those who reported diabetes and those that do not report diabetes, there is a need to introduce a frequency weighting variable. The large difference was corrected with the introduction of frequency weight with 55.6% of participants reporting diabetes while 44.4% reported not having diabetes.

A generalized linear models was used to examine the interaction analysis. This method was chosen over logistic regression for the interaction analysis owing to the fact that GLM gives overall statistical significance for each model. Also, in the GLM, there is no need to manually calculate the interaction variables as compared to the logistic regression model. Considering these two advantages, GLM was used to examine the moderating effect of age on the interaction between dependent variables and independent variables. The reference group in each analysis is the high sedentary category and older adults in the age category. For interaction analysis, a frequency weight was created for the outcome variables (type 2 diabetes and obesity). The frequency weight for obesity and type 2 diabetes is necessary due to the inability of normalized master weight to correct for sampling distribution differences in age. When diabetes was weighted using normalized master weight, 6.1% of young adults, 45.7% of middle-aged adults, and 48.2% of older adults reported having diabetes; while 39.6% of young adults, 42.3% of middle-aged adults, and 18.1% of older adults reported not having diabetes. The sampling distribution of respondents' change with the introduction of normalized frequency weight for both age and diabetes is as follows: 7.3% of young adults, 38.2% of middle-aged adults, and 54.5% of older adults reported having diabetes while 46% of young adults, 34.3% of middle-aged adults, and 19.7% of older adults reported not having diabetes.

Similarly, when the BMI was weighted using normalized master weight, 29.3% of young adults, 50.5% of middle-aged adults, and 20.2% of older adults are obese while 46.7% of young adults, 36.7% of middle-aged adults, and 16.6% of older adults have normal weight. The sampling distribution of respondents changes with the introduction of normalized frequency weight for both age and BMI as follows: 35% of young adults, 42.2%

of middle-aged adults, and 22.8% of older adults are obese; while 53.1% of young adults, 29.1% of middle-aged adults, and 17.8% of older adults reported normal weight.

A 95% confidence interval (CI) was used in interpreting results and effects were reported as odd ratios.

Inferential analysis output. The following statistical terms were used to describe the output of the analysis

- ***Standard error*.** The measure with which the sample mean deviates from the population mean.
- ***Odds ratio (Exp. B)*.** This is a measure of increase (odd ratio is greater than 1) or decrease (odd ratio is less than 1) in the outcome when the independent variable (predictor) increases by one unit.
- ***Confidence interval for odds ratio*.** The confidence interval measures the precision and accuracy of the result since the study respondent are only a small sample of the entire population. There is a lower confidence interval and an upper confidence interval and the result is said to be statistically significant if the value of the confidence interval (CI) does not include 1.
- ***Degree of freedom.*** The degree of freedom means the number of independent ways in which the analysis can move without violating any condition.
- ***Statistical significance*.** The statistical significance is defined as the cut-off point at which the result obtained is not due to chance. In this study, the cut-off point $p < 0.05$ represented by *, and $P < 0.001$, represented by **, are used to represent the statistical significance of the study. Values less than 0.05 are accepted as being statistically significant, and values greater than 0.05 are rejected and thus

statistically non-significant (NS). Therefore, statistically significant results have less than five percent probability of occurrence due to chance.

Reliability and Validity

Researchers have argued that a study without reliability and validity is the same as a study without scientific knowledge and cannot lead to an advancement of knowledge (Tobin & Begley, 2004; Morse, Barrett, Mayan, Olson, & Spiers, 2002).

Validity is defined as the degree to which a concept is accurately determined, while reliability relates to the consistency of the measurement of concepts (Heale & Twycross, 2015).

Heale and Twycross (2015) stated that validity is essential for reliability; therefore, reliability and validity are inter-related. However, reliability is usually more straightforward to achieve compared to validity when the measure is concrete, precise, and observable (Heale & Twycross, 2015). To ensure quality in the outcome of research, it is necessary to incorporate quality into all facets of the study. Below is an overview of how I incorporate quality (validity and reliability) into my study to make it robust enough for publication and accurate knowledge dissemination.

Internal validity. Although the concept of internal validity in a quantitative research supports the cause and effect principle (Bleijenbergh, Korzilius, & Versch, 2011), this study focuses on the prevalence of chronic diseases among sedentary adults. Therefore, the study shows the relationship between different sedentary behaviors and odds of reporting either obesity or type 2 diabetes.

External validity. The questionnaire from Statistics Canada has given a consistent result judging from previous studies (Yergens, Dutton, & Patten, 2014) which enhances external validity. Also, the sample is representative of the Canadian population and hence the accuracy of external validity.

Ethics Approval

The main ethics approval to collect this data was done by Statistics Canada. The ethical consideration for conducting this study was submitted to the University of Lethbridge Human Research ethics committee and approval was granted.

CHAPTER 4: PRESENTATION OF RESULTS

This section provides the answers to the initial research questions:

a. How do different types of sedentary behaviors (computer use, reading time, television viewing time, video game time, and total sedentary time) relate to the prevalence of obesity and type 2 diabetes among adults in Canada?

b. How does age moderate the relationship between different types of sedentary behavior (computer use, reading, television viewing, video game time, and total sedentary behavior), obesity, and type 2 diabetes across the three age groups?

The answers to these questions are presented in three different sections: Descriptive analysis of the participants and the variables; binary logistic regression of how the various sedentary behaviors predict chronic diseases (obesity and diabetes); and generalized linear models showing the modifying effect of age on the relationship between sedentary behavior and chronic diseases (obesity and diabetes).

Descriptive Characteristics

Respondents' demographics. Table 1 shows the demographics of participants with their respective weighted percentage. The age group is distributed as follows: young adults (36.1%), middle-aged adults (43.3%) and older adults (20.1%). The majority of the respondents are female (50.7%), possess high school educational qualifications or lower educational status (41.8%) and are either married or living with common law partners (57.9%).

Table 1

Respondents Demographics

Variables	Levels	Weighted percentage
Age	Young adults	36.6
	Middle-aged adults	43.3
	Older adults	20.1
Gender	Male	49.3
	Female	50.7
Marital status	Married/Common law	57.9
	Single	42.1
Educational Levels	High school/Lower	41.8
	Certificate below Bachelors	32.9
	University degree	25.3

Characteristics of Respondents

Various sedentary types (Independent variables) as shown in table 2 represent the prevalence of sedentary behavior. There are 42.1% of adults in the high television viewing time category and 39.3% of adults are in the high reading time. However, 80.5% of adults spend less time in video game playing and 69.2% of adults spend less time in computer related activities.

In total, the summation of the above-named sedentary behaviors reveals that about 50% of adult (respondents) spend their waking hours in highly sedentary pursuits.

Table 2

Characteristics of Respondents

Variables	Levels	Weighted percentage
Independent Variables:		
Reading time	Low (≤ 6.7 hours/week)	60.7
	High (> 6.7 hours/week)	39.3
Television viewing time	Low (≤ 13.6 hours/week)	57.9
	High (>13.6 hours/week)	42.1
Video game time	Low (≤ 2.1 hours/week)	80.5
	High (>2.1 hours/week)	19.5
Computer time	Low (≤ 7.1 hours/week)	69.2
	High (>7.1 hours/week)	30.8
Total sedentary time	Low (≤ 25 hours/week)	51.2
	High (> 25 hours/week)	48.8

The distribution of chronic diseases such as type 2 diabetes and obesity as reported by the respondents is shown in Table 3. The majority of the adults (93%) reported "No" when asked whether they have diabetes and about 60% of the respondents have their body mass index within the normal range.

Table 3

Characteristics of Respondents

Variables	Levels	Weighted percentage
Dependent Variables:		
Diabetes	Yes	7.0
	No	93.0
Body Mass Index (BMI)	Normal weight	57.8
	Obese	42.2

Prevalence of Obesity across Sociodemographic Characteristics

The prevalence of obesity is higher among males (48.5%), middle-aged adults (49.9%), participants who are either married or common-law (46.7%) or possess educational qualification below bachelor's degree (46.1%).

Table 4

Prevalence of Obesity across Sociodemographic Characteristics

Sociodemographic	Obesity	Weighted percentage
Age		
Young adults	Normal weight	68.5
	Obese	31.5
Middle-aged adults	Normal weight	50.1
	Obese	49.9
Older adults	Normal weight	53.1
	Obese	46.9
Gender		
Male	Normal weight	51.5
	Obese	48.5
Female	Normal weight	63.3
	Obese	36.7
Marital Status		
Married/Common law	Normal weight	53.3
	Obese	46.7
Single	Normal weight	64.9
	Obese	35.1
Educational Levels		
High school or Lower	Normal weight	54.7
	Obese	45.3
Certificate below	Normal weight	53.9
Bachelor's degree	Obese	46.1
University degree	Normal weight	67.3
	Obese	32.7

Prevalence of Type 2 Diabetes across Sociodemographic Characteristics

The prevalence of type 2 diabetes is higher among males (7.6%), older adults (17.7%), participants who are either married or living common law (7.9%) or with high school or lower educational qualification (8.3%).

Table 5

Prevalence of Diabetes across Sociodemographic Characteristics

Sociodemographic	Diabetes	Weighted percentage
Age		
Young adults	Yes	1.2
	No	98.8
Middle-aged adults	Yes	8.2
	No	91.8
Older adults	Yes	17.7
	No	82.3
Gender		
Male	Yes	7.6
	No	92.4
Female	Yes	6.4
	No	93.6
Marital status		
Married/Common law	Yes	7.9
	No	92.1
Single	Yes	5.8
	No	94.2
Educational levels		
High school or Lower	Yes	8.3
	No	91.7
Certificate below	Yes	6.9
Bachelor's degree	No	91.3
University degree	Yes	4.7
	No	95.3

Prevalence of Obesity by High and Low Sedentary Time

Although the cut-off points are different for each sedentary indicator, the proportion of normal weight and obesity varies as shown in Table 6. The descriptive statistics shows that 58.6% of adults in the high reading time category have normal weight while 41.4%

reported obesity. Among adults in the low reading time category, 39% of adults reported obesity while 61% have normal weight.

Television viewing time varies significantly between normal weight and obese adults. About 34.2% of adults in the low television viewing category reported obesity while 48.5% of adults in the high television viewing category reported obesity. Thus, obesity seems to be more prevalent among adults with high television viewing time.

Obesity is less common among adults with low video game time as 38.6% of those adults reported obesity while 46.9% of adults in the high video gaming category reported obesity. With respect to computer use time, 41.3% of adults in the low sedentary category reported obesity while 37.4% of adults in the high sedentary category reported obesity.

Total sedentary time is the summation of all sedentary activities such as reading time, computer use time, video gaming time, and television viewing time. A total of 43.9% of adults in the high total sedentary time category reported obesity compared to 36.4% of adults in the low total sedentary time category.

Table 6

Prevalence of Obesity According to Different Sedentary Behavior

Independent Variable	Dependent Variable	Weighted percentage
Sedentary Time	**BMI**	
Reading time		
Low Sedentary time	Normal weight	61.0
	Obese	39.0
High Sedentary time	Normal weight	58.6
	Obese	41.4
Television viewing time		
Low Sedentary time	Normal weight	65.8
	Obese	34.2
High Sedentary time	Normal weight	51.5
	Obese	48.5

Video game time		
Low Sedentary time	Normal weight	61.4
	Obese	38.6
High Sedentary time	Normal weight	53.1
	Obese	46.9
Computer time		
Low Sedentary time	Normal weight	58.7
	Obese	41.3
High Sedentary time	Normal weight	62.6
	Obese	37.4
Total Sedentary time		
Low Sedentary time	Normal weight	63.6
	Obese	36.4
High Sedentary time	Normal weight	56.1
	Obese	43.9

Prevalence of Diabetes by High and Low Sedentary Time

The prevalence of diabetes by high and low sedentary time is shown in Table 7. The results show that 7.8% of adults in the high reading time category reported having diabetes while 7.1% of adults in the low reading time category reported having diabetes.

About 5% of adults with low television viewing time reported having diabetes and 10.9% of adults with high television viewing time reported having diabetes. This result shows that adults in the high television viewing category have higher prevalence of diabetes compared to adults in the low television viewing category. About 7.6% of adults who devoted less time to playing video games reported having diabetes while only 6.4% of adults who spend more time in playing video game reported having diabetes.

Regarding computer use time, about 5.7% of adults in the high computer use time category reported having diabetes while 8.2% of adults in the low computer use time category reported having diabetes.

Total sedentary time is the summation of all the above sedentary behaviors and 8.9% of adults in the high sedentary time category reported having diabetes while 6% of adults in the low sedentary time category reported having diabetes.

Table 7

Prevalence of Diabetes according to different sedentary behavior

Independent Variable	Dependent Variable	Weighted percentage
Sedentary Time	**Diabetes**	
Reading time		
Low Sedentary time	Yes	7.1
	No	92.9
High Sedentary time	Yes	7.8
	No	92.2
Television viewing time		
Low Sedentary time	Yes	4.8
	No	95.2
High Sedentary time	Yes	10.9
	No	89.1
Video game time		
Low Sedentary time	Yes	7.6
	No	92.4
High Sedentary time	Yes	6.4
	No	93.6
Computer time		
Low Sedentary time	Yes	8.2
	No	91.8
High Sedentary time	Yes	5.7
	No	94.3
Total Sedentary time		
Low Sedentary time	Yes	6.0
	No	94.0
High Sedentary time	Yes	8.9
	No	91.1

Regression Results

A binary logistic regression was used to predict the prevalence of obesity from a set of sedentary behaviors including reading time, television viewing time, video game time, computer use time, and total sedentary time. Results are shown in Tables 8 and 9.

The odds of being obese are not different between adults with high and low reading time (Odd ratio (OR) = 1.04, $p = 0.254$). Reading time did not predict obesity even after controlling for demographics such as educational level, age, marital status, and sex ($p = 0.311$).

Adults with high television viewing times significantly differ in their odds of being obese (OR = 1.78, $p < 0.001$). Those who spend more time (>13.6 hours/week) viewing television have 78% greater odds of being obese than adults who spend less time (≤ 13.6 hours/week) viewing television. This relationship remains significant after controlling for demographic characteristics (OR = 1.61, $p < 0.001$). This means that adults with high television viewing times (>13.6 hours/week) have 61% greater odds of being obese compared to adults with low television viewing time after controlling for demographic characteristics.

High video game playing time (>2.1 hours/week) has a significant relationship with obesity (OR = 1.33, $p < 0.001$). Adults with high video game playing times have 33% greater odds of reporting obesity as compared to adults with low video game playing times. The relationship remains significant even when demographic characteristics such as educational level, marital status, age and sex are controlled for (OR = 1.46, $p < 0.001$). The result reveals that adults with high video gaming times (>2.1 hours/week) are 46% more likely to report being obese than those with low video game playing time after adjusting for demographic characteristics.

Concerning computer use time, adults with higher time (>7.1 hours/week) have lower odds of being obese (OR = 0.87, $p < 0.001$) and the relationship becomes non-significant after controlling for covariates (OR = 0.94, $p = 0.111$).

Adults with high sedentary times (>25 hours/week) have 37% greater odds of being obese (OR = 1.37, p < 0.001) than adults with low sedentary time (≤ 25 hours/week) and the relationship remains significant after adjusting for covariates (OR = 1.42, p < 0.001). Thus, adults with high sedentary times have 42% greater odds of obesity than those with low sedentary times after adjusting for covariates.

Table 8

Regression Coefficient Showing the Association Between Sedentary Time and Odds of Obesity

Variable	b	SE	Odd ratio	95% CI	
Model I					
Reading Time					
High	0.037	0.034	1.04	0.971	1.11
Low (*Ref.*)					
Television Time					
High	0.586**	0.034	1.78	1.681	1.921
Low (*Ref.*)					
Video Game Time					
High	0.288**	0.043	1.33	1.225	1.452
Low (*Ref.*)					
Computer Time					
High	-0.244**	0.036	0.87	0.744	0.858
Low (*Ref.*)					
Model II					
Total Sedentary Time					
High	0.311**	0.033	1.37	1.28	1.456
Low (*Ref.*)					

Note: The sample size is weighted to correct for any undue overrepresentation. b means unstandardized regression coefficient, SE represent standard error, and CI represent confidence interval.

**p* < 0.05; ***p* < 0.

Table 9

Regression Coefficient Showing the Association Between Sedentary Time and Odds of Obesity while Controlling for Socio-demographics

Variable	b	SE	Odd ratio	95% CI	
Model I					
Reading Time					
High	0.037	0.036	1.04	0.97	1.12
Low (*Ref.*)					
Television Time					
High	0.475**	0.036	1.61	1.5	1.72
Low (*Ref.*)					
Video Game Time					
High	0.376**	0.046	1.46	1.33	1.59
Low (*Ref.*)					
Computer Time					
High	-0.062	0.039	0.94	0.87	1.01
Low (*Ref.*)					
Education Level					
College Diploma	0.105*	0.041	1.11	1.03	1.2
University Degree	-0.526**	0.046	0.59	0.54	0.65
High School (*Ref.*)					
Marital Status					
Single/Divorced	-0.404**	0.038	0.67	0.62	0.72
Married/Common Law (*Ref.*)					
Sex					
Male	-0.437**	0.035	0.65	0.6	0.69
Female (*Ref.*)					
Age Groups					
Middle-aged adults	0.648**	0.041	1.91	1.76	2.07
Older adults	0.425**	0.053	1.53	1.38	1.7
Young adults (*Ref.*)					
Model II					
Total Sedentary Time					
High	0.350**	0.035	1.42	1.33	1.52
Low (*Ref.*)					
Education Level					
College Diploma	0.068	0.041	1.07	0.99	1.16
University Degree	-0.615**	0.045	0.54	0.5	0.59
High School (*Ref.*)					

Marital Status					
Single/Divorced	-0.405**	0.038	0.67	0.62	0.72
Married/Common Law (*Ref.*)					
Sex					
Male	-0.449**	0.035	0.64	0.6	0.68
Female (*Ref.*)					
Age Groups					
Middle-aged adults	0.677**	0.04	1.97	1.82	2.13
Older adults	0.496**	0.05	1.64	1.49	1.81
Young adults (*Ref.*)					

Note: The sample size is weighted to correct for any undue overrepresentation.
b means unstandardized regression coefficient, SE represent standard error, and CI represent confidence interval.

*$p < 0.05$; **$p < 0.001$

Binary logistic regression was used to predict the prevalence of diabetes with sedentary behaviors like reading, television viewing, video games, computer use, and total sedentary behavior and the results are shown in Tables 10 and 11.

Adults with high reading times (> 6.7 hours/week) are 1.06 times more likely to report having diabetes than those in the low reading group (OR = 1.06, p = 0.014). However, after controlling for demographic covariates, high reading time was associated with lower odds of diabetes (OR = 0.87, p < 0.001). This represents a reduction of 13% in the odds of reporting diabetes among adults in the high reading category.

Adults with high television viewing times (>13.6 hours/week) are 2.37 times more likely to report having diabetes than those in the low television viewing group (OR = 2.37, p < 0.001). Even when covariates such as educational level, sex, age and marital status are controlled, the association remains significant (OR = 1.56, p < 0.001). This shows that adults with high television viewing time have 56% greater odds of reporting diabetes than adults with low television viewing time (≤ 13.6 hours/week) after controlling for covariates.

Regarding video games, high gaming time (> 2.1 hours/week) is associated with lower odds of reporting diabetes (OR = 0.91, p = 0.002). However, after controlling for covariates, high video gaming time is associated with higher odds of diabetes (OR = 1.23, p < 0.001).

Computer related activities are statistically significant in predicting the odds of having diabetes or not (OR = 0.70, p < 0.001). The result indicates that the more time spent in computer use, the less likely the odds of having diabetes. However, the result was insignificant after controlling for age, educational level, marital status, and sex (OR = 1.05, p = 0.119).

Adults with high sedentary time (>25 hours/week) have 60% greater odds of reporting diabetes than adults with low sedentary time (OR = 1.60, p < 0.001). When education level, age, sex, and marital status are controlled, sedentary time remains a significant predictor (OR = 1.39, p < 0.001). The result shows that adults with high sedentary times have 39% greater odds of having diabetes than adults with low sedentary times after controlling for covariates.

Table 10

Regression Coefficient Showing the Association Between Sedentary Time and Odds of Diabetes

Variable	**b**	**SE**	**Odd ratio**	**95% CI**	
Model I					
Reading Time					
High	0.062*	0.025	1.06	1.01	1.12
Low (*Ref.*)					
Television Time					
High	0.864**	0.025	2.37	2.26	2.49
Low (*Ref.*)					
Video Game Time					
High	-0.097*	0.032	0.91	0.85	0.97
Low (*Ref.*)					

Computer Time					
High	-0.360**	0.029	0.70	0.66	0.74
Low (*Ref.*)					
Model II					
Total Sedentary Time					
High	0.470**	0.024	1.60	1.53	1.68
Low (*Ref.*)					

Note: The sample size is weighted to correct for any undue overrepresentation. b means unstandardized regression coefficient, SE represent standard error, and CI represent confidence interval.

*$p < 0.05$; **$p < 0.001$

Table 11

Regression Coefficient Showing the Association Between Sedentary Time and Odds of Diabetes while Controlling for Socio-demographics

Variable	**b**	**SE**	**Odd ratio**	**95% CI**	
Model I					
Reading Time					
High	-0.143**	0.029	0.87	0.82	0.92
Low (*Ref.*)					
Television Time					
High	0.443**	0.029	1.56	1.47	1.65
Low (*Ref.*)					
Video Game Time					
High	0.205**	0.037	1.23	1.14	1.32
Low (Ref.)					
Computer Time					
High	0.052	0.033	1.05	0.99	1.13
Low (*Ref.*)					
Education Level					
College Diploma	-0.216**	0.031	0.81	0.76	0.86
University Degree	-0.535**	0.038	0.59	0.54	0.63
High School (*Ref.*)					
Marital Status					
Single/Divorced	0.05	0.029	1.05	0.99	1.11
Married/Common Law (*Ref.*)					

Sex					
Male	-0.371**	0.028	0.69	0.65	0.73
Female (*Ref.*)					
Age Groups					
Middle-aged adults	1.854**	0.05	6.39	5.8	7.04
Older adults	2.607**	0.051	13.6	12.3	15
Model II					
Total Sedentary Time					
High	0.331**	0.28	1.39	1.32	1.47
Low (*Ref.*)					
Education Level					
College Diploma	-0.244**	0.031	0.78	0.74	0.83
University Degree	-0.613**	0.037	0.54	0.5	0.58
High School (*Ref.*)					
Marital Status					
Single/Divorced	0.46	0.028	1.05	0.99	1.11
Married/Common Law (*Ref.*)					
Sex					
Female	-0.377**	0.028	0.69	0.65	0.72
Male (*Ref.*)					
Age Groups					
Middle-aged adults	1.878**	0.049	6.54	5.94	7.19
Older adults	2.632**	0.049	13.9	12.62	15.31
Young adults (*Ref.*)					

Note: The sample size is weighted to correct for any undue overrepresentation. b means unstandardized regression coefficient, SE represent standard error, and CI represent confidence interval.

*$p < 0.05$; **$p < 0.001$

Interaction Analysis

The moderating effect of age on the relationship between different sedentary behaviors and chronic diseases such as obesity and diabetes are examined using the generalized linear models (GLM). The reference group for each analysis is older adults and high sedentary behavior category. The significance of the overall p-value of the model reveals the significance of one or more interaction analysis.

The modifying effects of age on the relationship between sedentary time and body mass index (BMI) (Table 12) is explained below. Age moderates the relationship between computer time and body mass index ($p < 0.001$). Young adults with low computer time are not significantly different from older adults with high computer use time ($p = 0.075$). Also, middle-aged adults with low computer time are not significantly different from older adults with high computer use time ($p = 0.154$). However, there is significant interaction between young adults with low computer time and middle-aged adults with high computer time ($OR = 1.43$, $p < 0.001$). Middle-aged adults with high computer use time have 43% higher odds of being obese than young adults with low computer use time.

The overall association between reading time and body mass index is not significant across age groups ($p = 0.066$). This shows that there is no difference in the interaction between any of the sub-groups of reading time (low and high reading times) and body mass index from one age group to another (young adults, middle-aged adults, and older adults).

Similarly, the association between television viewing time and body mass index does not vary significantly by age ($p = 0.248$). The result reveals that age does not moderate the interaction between television viewing time (low and high) and body mass index.

Video game playing time and age have significant effects on the odds of obesity ($p < 0.001$). Middle aged adults with low video game playing time have 0.6 lower odds of being obese than older adults with high video game playing time ($OR = 0.597$, $p < 0.001$). However, young adults with low video game playing time do not differ from older adults with high playing time in their odds of being obese ($OR = 1.13$, $p = 0.315$).

Total sedentary time and age interact to influence the odds of being obese ($p = 0.005$) (See Appendix B). Young adults with low sedentary time have 1.35 ($p = 0.002$) higher odds of being obese than older adults with high sedentary time. On the other hand, middle-aged adults with low sedentary time are not significantly different from older adults with high sedentary time in their odds being obese (OR = 1.14, p = 0.185).

Table 12

The Modifying Effect of Age on the Association between Sedentary Time and Odds of Obesity

		Age (Older Adults-*Ref.*)					
	Overall interaction	Young Adults			Middle-aged Adults		
Variable		*b*	*Odd ratio*	*p-value*	*b*	*Odd ratio*	*p-value*
Computer Time*Age Groups	<0.001**						
Computer Time							
Low		0.193	1.21	0.075	-0.163	0.85	0.154
High (*Ref*)							
Reading Time*Age Groups	0.066						
Reading Time							
Low		-0.068	0.94	0.475	0.117	1.12	0.221
High (Ref)							
Television Time*Age Groups	0.248						
Television Time							
Low		0.159	1.17	0.099	0.088	1.09	0.368
High (*Ref*)							
Video Game Time*Age Groups	<0.001**						
Video Game Time							
Low		0.122	1.13	0.315	-0.515	0.597	<0.001
High (*Ref*)							
Total Sedentary Time*Age Groups	0.004*						
Total Sedentary Time							
Low		0.297	1.35	0.002	0.129	1.14	0.185
High (*Ref*)							

Note: The sample size is weighted to correct for any undue overrepresentation. b means unstandardized regression coefficient.

*$p < 0.05$; **$p < 0.001$

The moderating effect of age on the association between sedentary behavior and diabetes (Table 13) is discussed below;

The relationship between computer time and diabetes is moderated by age ($p < 0.001$). A significant interaction is observed between young adults with low computer use time (≤ 7.1 hour/week) and older adults with high computer use time (OR = 0.76, $p = 0.007$). Young adults with low computer use time have 24% lower odds of reporting diabetes than older adults with high computer use time. Also, middle-aged adults with low computer use time had 27% lower odds of reporting diabetes than older adults with high computer use time (0.73, $p < 0.001$). Comparatively, younger adults with low computer use time are less likely to report having diabetes than middle-aged adults with low computer use.

The association between reading time and diabetes is moderated by age ($p < 0.001$). Young adults with low reading time (≤ 6.7 hours/ week) were 59% less likely to report having diabetes than older adults with high reading time (OR = 0.41, $p < 0.001$). The odds of reporting diabetes among middle-aged adults with low reading time is 33% less compared to older adults with high reading time (OR = 0.67, $p < 0.001$). Generally, younger adults with low reading time are less likely to report having diabetes compared to middle-aged adults with low reading time.

Age has a significant moderating effect on the relationship between television viewing time and diabetes ($p < 0.001$). The odds of type 2 diabetes are 26% (OR = 0.74, $p = 0.001$) lower in young adults with low television viewing time (≤ 13.6 hours/week) than in older adults with high television viewing time. Also, middle-aged adults with low television viewing time have 52% (OR = 0.48, $p < 0.001$) lower odds of reporting diabetes than older adults with high television viewing time. Middle-aged adults with low television viewing time are less likely to report having diabetes compared to young adults with low television viewing time.

Age does not moderate the relationship between video game time and diabetes ($p = 0.202$). Young adults with low game playing time (≤ 2.1 hours/week) and middle-aged adults with low playing time (≤ 2.1 hours/week) are not significantly different from older adults with high video gaming time (> 2.1 hours/week) with regard to their odds of reporting diabetes.

The association between total sedentary time and diabetes is significantly moderated by age ($p < 0.001$) (See Appendix C). Young adults with low sedentary time (≤ 25 hours/week) have 42% lower odds of reporting diabetes than older adults with high sedentary time (OR = 0.58, $p < 0.001$). Similarly, middle-aged adults with low sedentary time have 43% lower odds of reporting type 2 diabetes than older adults with high sedentary time (OR = 0.57, $p < 0.001$). These interactions show that middle-aged adults with low sedentary time are more at risk of reporting having diabetes than young adults.

Table 13

The Modifying Effect of Age on the Association between Sedentary Time and Odds of Diabetes

		Age (Older Adults-*Ref.*)					
	Overall interaction	Young Adults			Middle-aged Adults		
Variable		*b*	*Odd ratio*	*p-value*	*b*	*Odd ratio*	*p-value*
Computer Time*Age Groups	<0.001**						
Computer Time							
Low		-0.269	0.76	0.007	-0.311	0.73	<0.001
High (*Ref*)							
Reading Time*Age Groups	<0.001**						
Reading Time							
Low		-0.898	0.41	<0.001	-0.396	0.67	<0.001
High (Ref)							
Television Time*Age Groups	<0.001**						
Television Time							
Low		-0.301	0.74	0.001	-0.743	0.48	<0.001
High (*Ref*)							
Video Game Time*Age Groups	0.202						
Video Game Time							
Low		-0.076	0.927	0.485	-0.166	0.847	0.076
High (*Ref*)							
Total Sedentary Time*Age Groups	<0.001**						
Total Sedentary Time							
Low		-0.552	0.58	<0.001	-0.566	0.57	<0.001
High (*Ref*)							

Note: The sample size is weighted to correct for any undue overrepresentation. b means unstandardized regression coefficient.

$*p < 0.05$; $**p < 0.001$

CHAPTER 5: DISCUSSION

Prevalance of Obesity and Type 2 Diabetes with High and Low Sedentary Behaviors

This study shows that in most cases, the prevalence of obesity and diabetes is higher among adults with high sedentary times. About 43.9% of Canadian adults who spend their leisure time in high sedentary pursuits (> 25 hours/week) reported obesity and 8.9% of adults with high sedentary times reported having type 2 diabetes. This outcome is consistent with the findings of Maharjan and Timalsina (2017) who reported that high sedentary behavior is associated with higher odds of obesity and type 2 diabetes among adults. Similarly, Bertoglia et al. (2017) revealed that 64% of type 2 diabetes cases can be prevented with a reduction in sedentary time.

In the current study, television viewing has the highest mean cut-off point of 13.6 hours in a week and it has a high contribution to the prevalence of obesity and type 2 diabetes. 48.5 % of adults with high television viewing time (> 13.6 hours/week) are obese and 10.9% of adults with high television viewing time reported type 2 diabetes. In North America, adults have been reported to spend 50% of their waking hours in sedentary pursuits (Saunders, Larouche, Colley, & Tremblay, 2012) with almost 60% of adults viewing television for more than 2 hours in a day (Bowman, 2006). This high prevalence of television viewing among adults might be responsible for the use of television viewing as a marker for sedentary behavior in several studies (Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008).

This study shows that the prevalence of obesity is high among middle-aged adults compared to young adults; however, there is no significant difference in the prevalence of obesity among middle-aged adults and older adults. Older adults reported the highest prevalence of type 2 diabetes. In the high television viewing group, 39% of young adults are obese compared to 57.2% of middle-aged adults and 52.9% of older adults respectively while adults who reported type 2 diabetes with high television viewing time comprised of 15.2% of young adults compared to 60.7% of middle-aged adults and 71.3% of older adults respectively. This result is consistent with the findings of Ogden, Carroll, Fryar, and Flegal (2015) who reported that obesity increases from young adulthood to middle-aged adulthood but the difference between middle-aged adults and older adults is not significant. This might be partly due to the decline in body mass index after the age of 60 years (Elia, 2001).

The increasing rate of obesity in Canada is a public health concern with differences in gender (Luo et al., 2007). The prevalence of obesity is higher among males compared to the females in the present study. Almost 50% of male adults (excluding overweight and underweight) reported obesity while 36.7% of female adults (excluding overweight and underweight) reported a high body mass index greater than $30 kg/m^2$. Historically, obesity among Canadian adults reportedly increased between 1981 and 1996 with an increase from 9% to 14% in men while women have a prevalence growth from 8% to 12% (Katzmarzyk, 2002).

The prevalence of type 2 diabetes increases with age with 1.2% of young adults, 8.2% of middle-aged adults and 17.7% of older adults reporting having type 2 diabetes in the current study. This is similar to the findings of Wild, Roglic, Green, Sicree, and King (2004) who reported a high prevalence of diabetes among adults over 65 years old. Also, Ng, McGrail, and Johnson (2010) reported that the prevalence of type 2 diabetes increases among Canadian males with the highest prevalence seen among adults over 75 years old while the rate of type 2 diabetes among females increases up to age 64 years with no significant increase in prevalence for females over 75 years of age.

Gender differences exist in the prevalence of type 2 diabetes among adults in Canada. It was observed that occurences of obesity follows a similar trend as type 2 diabetes with respect to gender. About 8% of male adults and 6.4% of female adults reported having type 2 diabetes in this present study. Choi, Liu, Palaniappan, Wang, and Wong (2013) observed similar prevalence among American adults aged 18 years and above. It was reported that Mexican and Caucasian men have a higher prevalence of type 2 diabetes compared to women.

In summary, sedentary behavior such as high television viewing has been linked to a high prevalence of chronic diseases such as obesity and type 2 diabetes among adults (Thorp et al., 2011). Also, the high rate of obesity has been described as one of the risk factors for type 2 diabetes (Zaninotto, Head, Stamatakis, Wardle, & Mindell, 2009).

The Relationship between Sedentary Behaviors, Obesity, and Type 2 Diabetes

The relationship between different sedentary times and total sedentary times with obesity and type 2 diabetes among Canadian adults are enumerated below.

The association between total sedentary time, obesity, and type 2 diabetes. In the present study, adults with high total sedentary time (greater than 25 hours per week) have higher odds of obesity. After controlling for covariates such as age, educational attainment, marital status and sex, the relationship remained significant. The total sedentary time is made up of television viewing time, reading time, video game time, and computer time, and this represents cummulative sitting/reclining time.

Dunstan et al. (2007) reported that television viewing time has a stronger predictive association with obesity than total sedentary times. This might be due to the relatively lower energy expenditure of television viewing compared to other sedentary behaviors like writing, playing board games, sewing, or driving a car (Ainsworth et al., 1993). In a study to determine the prevalence of obesity among US adults, Hu (2003) used television viewing as a marker of total sedentary time and the results revealed increased odds of obesity with high television viewing. Similarly, a study conducted among Australian adults revealed a high prevalence of obesity with sedentary leisure time activities. In another study conducted among adults of Mexican origin in the US, de Heer, Wilkinson, Strong, Bondy, and Koehly (2012) reported a similar relationship between obesity and total sedentary time.

In the United Kingdom (UK), Prentice and Jebb (1995) studied the impact of a diet rich in fat on the increased rate of obesity. The researchers concluded that an unbalanced diet is as important as increased sitting time as the main cause of obesity in the UK. In the light of new evidence, other researchers have inferred that increased sitting time, particularly screen time, is associated with higher caloric intake. Hu et al. (2003) emphasized increased food intake (mainly an unbalanced diet) during prolonged screen viewing among adults. This shows that total sedentary time has an association with increased odds of obesity.

The relationship between total sedentary times and type 2 diabetes was significant in the current study. Adults with high total sedentary times have 1.60 times the odds of reporting type 2 diabetes compared with adults with low sedentary times. The association remained significant after adjusting for demographic covariates. The positive relationship between total sedentary times and type 2 diabetes have been reported by several studies. Wilmot et al. (2012) reported an increase of 112% in the relative risk of type 2 diabetes with high sedentary times. Furthermore, Dunstan et al. (2007) used television viewing time as marker of total sedentary behavior and found that high television viewing time is associated with increased blood sugar among adults not diagnosed with diabetes.

Moreover, the maladaptive behaviors such as unhealthy diet that accompany sedentary behaviors can also result in type 2 diabetes. Mohan, Sandeep, Deepa, Shah, and Varghese (2007) emphasized that type 2 diabetes is no longer a disease of the rich due to its high prevalence among middle income earners owing to the prevalence of fast foods and sedentary behaviors. Also, Steyn et al. (2004) mentioned the importance of maintaing normal body weight through a reduction of sedentary time and healthy food consumption in the prevention of type 2 diabetes. Sadly, food containing high fats such as snacks are taken in high quantity during television viewing and other sedentary activities (French, Story, & Jeffery, 2001) and it contributes to the high prevalence of type 2 diabetes.This shows that total sedentary times may increase the likelihood of reporting type 2 diabetes.

The association between reading time, obesity, and type 2 diabetes. In the present study, reading time was not a significant predictor of obesity. Regardless of the number of hours spent reading, the odds of being obese does not increase among Canadian adults. The association remained insignificant after adjusting for demographic covariates. The difference in energy expenditure between reading and watching TV is trivial. However, it is much less convenient to eat while reading a book. Furthermore, TV adds might be prompting us to eat fast food and snacks, unlike reading books (Gore, Foster, DiLillo, Kirk, & West, 2003). Also, there might be a higher likelihood of taking breaks during reading time compared to television viewing time which might leads to higher energy expenditure although this hypothesis should be examined in future studies. This explanation is supported by the findings of Ainsworth et al. (1993) which reported more energy expenditure when there is interruption in sedentary behaviors. Activities carried out during the interruption period include walking, stretching, jogging, and visiting friends among others. Similarly, Swartz, Squires, and Strath (2011) conducted a study on energy expenditure among adults who performed 30-minute bouts of sedentary activities such as working on computer, reading, and other desk activities consecutively. The outcome shows that taking 1-minute, 2-minute and 5-minute bouts of walking during the sedentary behaviors resulted in dissipation of additional 3.0, 7.4, and 16.5 kilocalories of energy compared to 8 hours of an uninterrupted sitting period. Therefore reading has an insignificant predictive effect on the odds of obesity.

On the other hand, reading time is positively associated with type 2 diabetes in the current study before adjusting for cofounders. Adults with reading time above 6.7 hours in a week were significantly different in their odds of reporting type 2 diabetes. Reading time remained a significant predictor of type 2 diabetes when adjusted for age, educational levels, marital status, and sex.

However, I observed that high reading time is associated with lower odds of reporting type 2 diabetes when demographics were controlled. The reason for the change in effect direction can be explained using socio-economic characteristics. The descriptive results (see Appendix A) shows that few adults in the high reading time category had high school education or less (36.4%) compared to 63.6% of adults in the low reading time category. In the literature, adults who are less educated have been found to be highly sedentary (Van der Horst et. al., 2007). One may conclude that adults with high reading time possessing higher education might be involved in other activities that reduces their odds of having diabetes compared to their counterparts with lower education.

The association between television viewing time, obesity, and type 2 diabetes. In the current study, viewing television, internet videos, movies or DVDs more than 13.6 hours in a week was associated with a 78% increase in odds of being obese regardless of demographic characteristics. Television viewing time is associated with reduced energy expenditure compared to other sedentary behaviors and hence the high correlation with obesity. Studies in the literature revealed a similar relationship between obesity and television viewing time. Boulos, Vikre, Oppenheimer, Chang, & Kanarek (2012) described the cause of obesity to be multifaceted with increased television viewing as the main contributor. Also, a study done in the US showed that the prevalence of obesity is parallel in trend to the prevalence of television viewing, and hence television viewing was concluded to be associated with a high prevalence of obesity (Hu, Li, Colditz, Willett, & Manson, 2003).

Behavior such as inappropriate eating has been linked with television viewing and perhaps the result is obesity. Snacking in front of the television is a highly prevalent environmental factor among adults in the US which results in decreased energy expenditure and increased energy input (French, Story, & Jeffery, 2001). On the other hand, television viewing can be a source of inappropriate eating through food advertisements and other television commercials (Gore, Foster, DiLillo, Kirk, & West, 2003). Research on television advertisements in the US showed that the majority of commercials are food-related, and these foods are high in energy contents such as sugar, fat, and sodium (Byrd-Bredbenner & Grasso, 2000). Thus, television viewing can cue adults into inapproriate eating through television advertisements. Apart from eating food rich in energy content while viewing television, the quantity of food taken can be largely underestimated. This is because people are less sensitive to physiological satiety signals when distracted by television viewing (Coon, Goldberg, Rogers, & Tucker, 2001).

Viewing television for more than 13.6 hours in a week strongly predicts the odds of reporting type 2 diabetes in this study and this remained significant after adjusting for covariates. This result is consistent with the findings of other studies. Hu, Li, Colditz, Willett, and Manson (2003) found a positive relationship between television viewing time and the risk of type 2 diabetes among US adults.

Moreover, Tuomilehto et al. (2001) described physical activity as an effective measure to prevent type 2 diabetes while Healy et al. (2008) described a negative association between television viewing and physical activity among Australian adults. This might be due to displacement of physical activities like brisk walking and jogging with high television viewing. Hu et al. (2003) also revealed the displacement of physical activities with high television viewing among adults. This reduction of physical activities further increases the risk of having type 2 diabetes with prolonged television viewing. In summary, television viewing is a strong predictor of type 2 diabetes and their association remained significant after adjusting for covariates.

Compared to total sedentary time, the odds of reporting obesity with television viewing time was 1.78-fold. These odds changed to 1.61-fold after controlling for covariates while the odds of reporting obesity with total sedentary times was 1.37-fold in the uncontrolled model. This changed to 1.42-fold after adjusting for covariates. The odds of reporting type 2 diabetes with television viewing time was 2.37-fold and the odds of reporting type 2 diabetes with total sedentary times was 1.60-fold in the uncontrolled model. A similar trend was observed in the controlled model with television viewing time having 1.56-fold increase of the odds of type 2 diabetes while the odds of reporting type 2 diabetes with total sedentary time was 1.39-fold. This shows an increase in odds of reporting obesity and type 2 diabetes with television viewing compared to total sedentary times in both the controlled and uncontrolled model.

The association between video gaming time, obesity, and type 2 diabetes. In the current study, video gaming time of 2.1 hours in a week was associated with 13% increased odds of being obese regardless of demographic covariates. Video gaming is usually associated with limited movement and hence the increased odds of obesity. Lyons et al. (2011) compared energy expenditure and enjoyment among different types of video games and the result revealed more enjoyment and less energy expenditure in sedentary games compared to active video games which have less enjoyment and more energy expenditure.

However, another study conducted in the US revealed that there is no significant association between video game playing time among adults and body mass index (Wack & Tantleff-Dunn, 2009). Although this is contrary to my findings, the participants in the study only played video games when they are bored, stressed, or lonely.

Video gaming has been described to promote food intake and as a consquence results in obesity. Although there is no increase in hunger sensation or appetite, the increase in food intake obesrved with video gaming (Chaput et al., 2011) is similar to increased food intake during television viewing (Bellisle, Dalix, & Slama, 2004), and computer related activities (Chaput & Tremblay, 2007). The lack of association between hunger or increased appetite and increased food intake accompanying video gaming activities is elusive and can only be explained using psychological stress. Born et al. (2010) observed that a mental arithmetic task (psychological stress) that occurs with video gaming activities increases eating habits without being hungry. Also, Chaput et al. (2011) speculated that increased food intake without corresponding increase in appetite or hunger observed with video gaming might be a result of blockage in the satiety signal which might promote a stress-induced reward system. This might be a probable reason for the high risk of obesity accompanying various video gaming activities. In summary, video gaming time is a significant predictor of obesity.

In the current study, the relationship between video gaming time and the odds of reporting type 2 diabetes is significant. Adults with video gaming activities of more than 2.1 hours in a week have lower odds of type 2 diabetes. However, adjusting for covariates such as age, educational levels, marital status, and sex made high video gaming time a significant predictor of type 2 diabetes. Although the association between video gaming time and type 2 diabetes is not well established in the literature, video games are associated with obesity and, given the strong relationship between obesity and diabetes, it makes sense that video games are also associated with diabetes.

The association between computer use time, obesity, and type 2 diabetes. The relationship between computer use time and the odds of reporting obesity was significant in the current study. Canadian adults with computer use time over 7.1 hours in a week are less likely to report being obese. However, the association between computer use time and obesity was no longer significant after adjusting for covariates. This shows that the effect of computer use time on obesity is dependent on demographic covariates. The descriptive statistics show that 41.3% of adults with low computer use time reported obesity while 37.4% of adults with high computer use time reported obesity. The reason for this might be associated with leisure time computer use. The computer use time in the Canadian study does not include time spent on computer, tablets, or smart phones while at work, class, or during transportation. These places might be where computer related activities occur most frequently. Moreover, computer use time during leisure among Canadian adults might be positively related to other leisure time sedentary behaviors like television viewing, and video gaming among others. This means adults using smart phones, tablets, and other electronic computerized devices might be simultaneously involved in television viewing, reading books or other sedentary activities, hence the less likelihood of being obese with only computer use time. A study done by Vandelanotte, Sugiyama, Gardiner, and Owen (2009) revealed that adults with high computer use time have higher prevalence of obesity compared to adults with no computer use. Although this finding is different from my outcome, the comparison was made between high computer use time and no computer use time while my study focus is on high computer use time and low computer use time. Thus, high leisure time computer use is not a significant predictor of obesity among adults after adjusting for covariates.

The association between computer use time and type 2 diabetes was significant in the current study. Canadian adults with computer use time over 7.1 hours in a week are less likely to report having type 2 diabetes. However, the association was insignificant after adjusting for demographic covariates. The reason for this effect is explained using cross-tabulation (see Table 7). The table shows that 8.2% of adults with low computer use time reported having type 2 diabetes while 5.7% of adults with high computer use time reported having type 2 diabetes. Also, there is the possiblity of correlation between computer use time and other sedentary behaviors like television viewing time that can have a strong predictive effect on type 2 diabetes. This means adults with high computer use time might have a high television viewing time and thus higher odds of type 2 diabetes. Moreover, the effect of socio-economic characteristics made high computer use time an insignificant predictor after adjusting for covariates such as educational levels and age. The majority of adults with high computer use have educational qualifications more than high school and are younger (young and middle-aged adulthood). Since type 2 diabetes is more prevalent among older adults, adjusting for these covariates made high computer use time an insignificant predictor of type 2 diabetes. Similar findings were reported by Jackson et al.

(2005). Thus, high leisure time computer use is not a predictor of type 2 diabetes among adults after adjusting for covariates.

The Moderating Effect of Age on the Prevalance of Sedentary Behaviors, Obesity and Type 2 Diabetes

Computer use time is related to obesity, but this does not vary by age. All age groups that used a computer for 7.1 hours or more per week had similar rates of obesity. In the United Kingdom (UK), Hamer and Stamatakis (2014) mentioned that approximately 65% of the older adult population is actively involved in computer-related activities such as emailing, and surfing the internet. However, a study conducted in Canada shows that less than 10% of older adults use computers for more than 1.6 hours per day (Shields & Tremblay, 2008). Morrell, Mayhorn, and Bennett (2000) also found low use of computers in older adults compared to middle-aged adults. This low computer use pattern among Canadian older adults might be responsible for the insignificant difference between older adults with high computer use time and middle-aged and young adults with low computer use time.

Similarly, in the current study, older adults with high computer use time have lower odds of obesity while young and middle-aged adults with low computer use time have lower odds of obesity. Given this parrellel relationship, it can be said that there is no significant interaction between young and middle-aged adults with low computer use time and older adults with high computer use time in their odds of reporting obesity. On the other hand, the relationship between computer use time and type 2 diabetes is dependent upon age. For older adults, type 2 diabetes odds increases when they spend more than 7.1 hours per week in computer-related activities.

Spending more time reading does not increase obesity significantly for any age group, but increases the odds of type 2 diabetes in older adults. Biessels, Deary, and Ryan (2008) found the prevalence of type 2 diabetes to be less than 0.1% among young adults under 30 years old and this increased to 1% among older adults aged 70 years and above. Older people spend more time reading because of retirement-related issues such as boredom (Scales & Biggs, 1987). Thus, it is possible that high reading time in addition to increased age seen among older adults are responsible for the high odds of reporting type 2 diabetes.

The television viewing and obesity relationship is not dependent upon age. However, viewing television for more than 13.6 hours per week increases the odds of reporting type 2 diabetes in older adults. Although the prevalence of obesity is lowest among the young adults and highest in middle-aged adults, the relationship between television viewing and obesity does not vary across age groups. This can be explained using eating habits that accompanies television viewing. Eating unbalanced diet is highly prevalent among adults who spend more or less time watching television, and this predisposes them to obesity (Gore, Foster, DiLillo, Kirk, & West, 2003). Thus one may conclude that there is a parallel association between television viewing and the odds of obesity across age groups. Vioque, Torres, and Quiles (2000), whose study examined the association between television viewing and prevalence of obesity across age groups found the relationship to be independent of age.

High television viewing time among older adults might be responsible for higher odds of type 2 diabetes while young and middle-aged adults with low television viewing time are less at risk of reporting type 2 diabetes. Considering this unparrallel relationship, it can be inferred that there is a significant interaction between television viewing and odds of diabetes across age groups. Depp, Schkade, Thompson, and Jeste (2010) reported a similar relationship.

Older adults with more than 2.1 hours of video game playing per week were more likely to be obese than middle-aged adults. In western societies, including Canada, Germany, and the US, older adults now spend more time playing video games (Wiemeyer & Kliem, 2012). Although limited literature was found on the link between video game playing time and obesity prevalence among older adults, our result suggests that the association might be stronger for older adults than for middle-aged adults. It was, however, found that video game playing time is not associated differently with the prevalence of type 2 diabetes across age groups. This findings should be interpreted with caution because few older adults reported high video game times.

Having a higher overall level of sedentary behavior, as measured by reading, video gaming, computing, and television viewing time, was associated with higher obesity rates, particularly in young adults. Sedentary time of 25 hours or more per week doubles obesity risk for young people. Higher sedentary time was associated with higher odds of type 2 diabetes prevalence in older adults. Older adults have the highest level of sedentary behavior and the prevalence of type 2 diabetes increases with age suggesting that older adults have a higher risk of type 2 diabetes compared to other age groups. This is consistent with the findings of Biessels, Deary, and Ryan (2008). The researchers described the relationship between type 2 diabetes prevalence and age to be linear, with progression from normal glucose metabolism to elevated glucose (diabetes) over many years. Also, young adults with low sedentary time are less likely to report having type 2 diabetes compared to older adults with high sedentary time. Sadly, obesity and sedentary behavior are among the risk factors for type 2 diabetes (Stumvoll, Goldstein, & van Haeften, 2005); thus, the stronger relationship between total sedentary time and obesity in young adults is concerning.

Strengths and Limitations of the Study

National survey data was used in the study. This means that the data gives an accurate representation of the Canadian population. Therefore, the outcome of the study can be generalized to the whole population.

Moreover, this study focuses on the relative contribution of four different sedentary behaviors (reading, computer time use, video gaming and television viewing) and overall sedentary time. Hence, the study gives a holistic overview of the relationship between sedentary behaviors, obesity and type 2 diabetes.

There are several limitations to this study starting from the data collection method. The survey is cross-sectional with subjective data collection. This makes assessment of time effect impossible as in a longitudinal study. Also, participants might estimate the time they spend in sedentary behaviors; therefore, they might overestimate or underestimate (recall bias) the time spent in each sedentary behavior. Similarly, new weighting variables were created in the analysis to correct for uneven distribution. These weighting variables overestimate the response of the participants with low response rates in a bid to equalize the percentage. This process might result in an over representation of one group and underestimation of the second group. The appropriateness of body mass index calculation as a measure of obesity among older adults has been questioned (Roubenoff, Dallal, & Wilson, 1995). Deurenberg, Weststrate and Seidell (1991) described the human body composition as consisting of muscle mass (fat free mass) which decreases with advancing age and hence the decrease of body mass indices among older adults which might represent a form of bias.

Methodologically, computer use time and video game time might be measuring similar things. This is because video games are played on handheld devices such as phones nowadays. Hence, there might be a need to combine these variables together to get a clearer understanding of the association between computer use on the prevalence of obesity and type 2 diabetes. Also, I was unable to determine whether adults who did not answer questions related to sedentary behaviors, obesity, diabetes, and demographic characteristics differ from those who answered them.

Furthermore, there are two main types of diabetes, namely type 1 and type 2 diabetes. Findings have shown that only type 2 diabetes is caused by sedentary activities while type 1 is an autoimmune disorder. However, the participants reported having either diabetes or not and there was no distinction between the two main types. Thus, the study assumes that the diabetes reported are all type 2 diabetes.

Implications for Practice and Policy

Television viewing time can be described as the best marker for total sedentary behavior in this study. Also, television viewing strongly predicts the prevalence of obesity and type 2 diabetes among Canadian adults. Since sedentary behavior is a modifiable risk factor, socioecological approaches targeting multiple levels of influence should be implemented as a strategy to reduce sedentary behavior. Also, obesity is a risk factor for type 2 diabetes, and it has a high odd among young and middle-aged adults. To prevent the development of type 2 diabetes among young adults and middle-aged adults, there is the need to reduce sedentary time. Similarly, older adults are the most sedentary of the three age groups and there is a high prevalence of type 2 diabetes among them. Therefore, there is the need for older adults to break bouts of sedentary behavior.

Recommendations for Future Study

The findings of this study revealed the association between different leisure time sedentary behaviors, obesity, and type 2 diabetes. However, I recommend that future researchers examine the association between overall (not just leisure) sedentary behaviors on the prevalence of obesity and type 2 diabetes among Canadian adults. Also, due to a possible relationship between computer use time and video gaming time, I suggest researchers examine the combination of these variables in a bid to find the association between them and chronic diseases such as obesity and type 2 diabetes. Video gaming time is more prevalent due to advancement in technology, particularly in developed countries; therefore there will be a need for researchers to focus more on the relationship between video gaming as a form of sedentary behavior and chronic diseases.

Conclusion

This study examines the prevalence of chronic diseases such as obesity, type 2 diabetes, and their association with sedentary behaviors across age groups. Even though the majority of studies focus on a single sedentary behaviour in relation to obesity and type 2 diabetes, the study focuses on the relative contribution of various types of sedentary behaviors on the prevalence of obesity and type 2 diabetes. Television viewing time is the most significant contributor to the prevalence of obesity and type 2 diabetes while computer use time contributed the least to the prevalence of these chronic health outcomes. Sedentary behavior is a risk factor for the prevalence of obesity and type 2 diabetes among Canadian adults and the prevalence of these chronic diseases varies with age. Obesity increases from young adulthood to middle-aged adulthood; however, it decreases from middle-aged adulthood to older adulthood. Also, the prevalence of type 2 diabetes increases with age: older adults are more likely to report having type 2 diabetes than young adults. Moreover, with respect to the moderating effect of age on the association between sedentary times and chronic diseases, young adults with low sedentary time are more likely to have higher odds of obesity compared to older adults with high sedentary time. Also, the prevalence of type 2 diabetes is higher among older adults with high sedentary time compared to young and middle-aged adults with low sedentary time.

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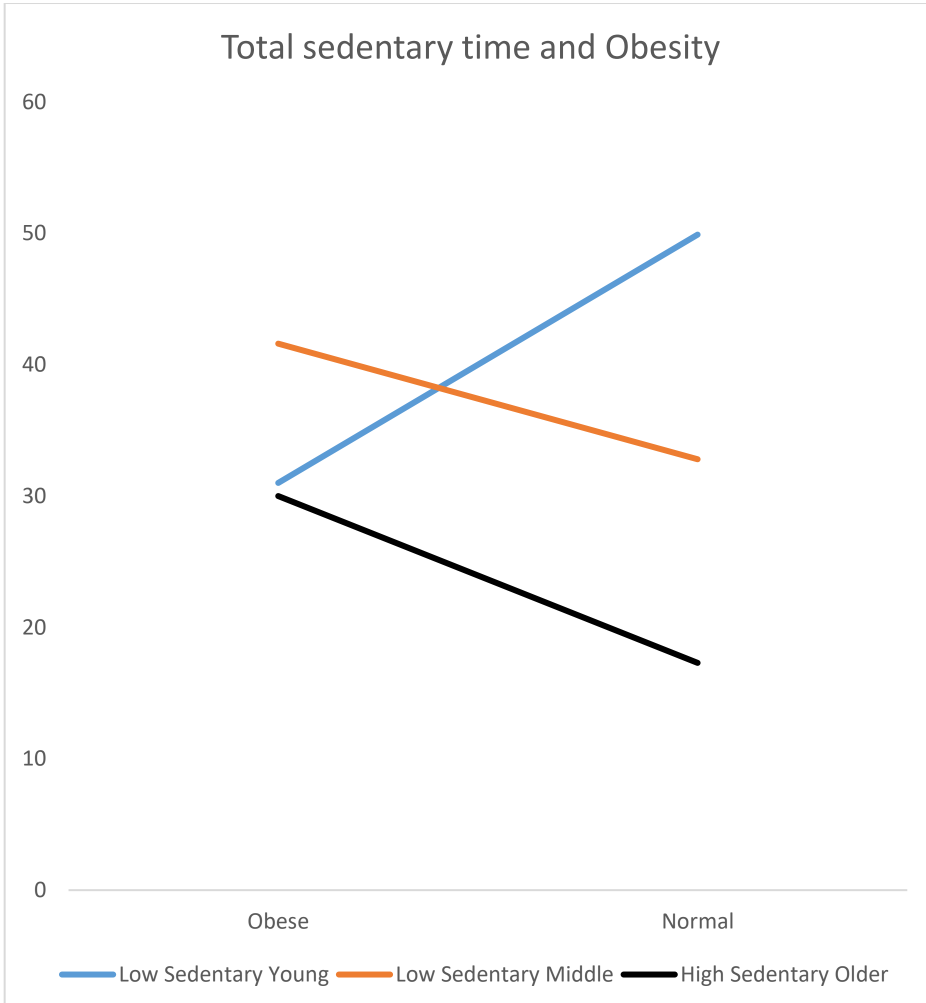
APPENDICES

APPENDIX A: CROSS TABULATION OF READING TIME WITH EDUCATIONAL LEVELS

		High school/Lower	Certificate below bachelor degree	University degree
Reading time	Low sedentary	63.60%	59.90%	52.20%
	High sedentary	36.40%	40.10%	47.80%

APPENDIX B: GRAPH SHOWING INTERACTION BETWEEN TOTAL SEDENTARY TIME AND OBESITY



APPENDIX C: GRAPH SHOWING INTERACTION BETWEEN TOTAL SEDENTARY TIME AND DIABETES