EVERYTHING IN MODERATION: ARE ADOLESCENTS' OBESITY-RELATED HEALTH BEHAVIOURS MODERATED BY PARENTING STYLES AND FAMILY FUNCTIONING?

by

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Abstract

Background: The familial environment can influence an adolescent's risk for obesity. However, we do not fully understand the mechanisms through which parents can influence obesity-related adolescent health behaviours, specifically whether parenting practices (e.g., rules or routines) and/or their own health behaviours are associated with their adolescent's behaviours.

Objectives: This study examined, in a sample of overweight/obese adolescents, whether parenting practices and/or parental modeling of health behaviours are associated with adolescents' health behaviours (physical activity (PA), dietary, sedentary and screen behaviours) while considering the moderating effects of parenting styles and family functioning.

Methods: Baseline data from 172 overweight/obese adolescents and one of their parents who enrolled in a lifestyle modification intervention were analyzed [Mean age=13.1 (1.8); Mean BMI z-score=2.70 (0.83)]. Parent-adolescent dyads completed questionnaires about their PA and screen time, wore an accelerometer for 8 days to objectively measure PA and sedentary time, and completed three 24-hr dietary recalls online. Parents completed questionnaires about their family functioning, parenting practices, and styles (authoritative and permissive). Path analysis was used to model interrelationships among the variables.

Results: Both parenting practices and modeling of health behaviours were significantly associated with all adolescent obesity-related health behaviours. However, in many instances, these associations were significantly moderated by parenting styles or family functioning. When both parenting practices and modeling of health behaviours were entered in the analyses, both modeling and parenting practices remained significant for objective PA and sedentary time;

however parenting practices and modeling were moderated by parenting style for sedentary time (permissive style; $p<.05$). For accelerometer PA, styles moderated parenting practices (permissive style; $p<.05$). Finally, for dietary quality, styles moderated parental modeling (authoritative style; $p<.05$). The parenting style interactions, however, only partially supported the study hypotheses.

Conclusions: This work suggests that parenting practices and parental modeling are important; however, it is necessary to consider the broader emotional/relational context into which these are expressed since parenting style moderated these effects. This study provides insight into how parenting style may alter the effectiveness of parenting practices and parental modeling and highlights the need to account for parenting styles to improve the efficacy of current family-based interventions.

Preface

This thesis contains the work from a study conducted by the candidate, Nicole S. Carbert, under the supervision of Dr. Louise C. Mâsse with guidance from Dr. Mariana Brussoni and Dr. Josie Geller. This research used the secondary data of MySteps® study which was conducted under the supervision of Dr. Louise C. Mâsse and with the help of other research staff at British Columbia's Children's Hospital Research Institute (BCCHR).

Sections of this thesis will be submitted for publication in peer reviewed journals.

MySteps® study was approved by the Behavioural Research Ethics Board at the University of British Columbia (#H08-01638) and the Office of Research Ethics at the University of Waterloo (#16429).

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Dedication

To my parents

Chapter 1: Introduction

Over the last three decades, a marked increase in the prevalence of overweight or obese Canadian adolescents has raised serious concerns.[1] To help manage this ongoing problem, research suggests that engaging in positive health behaviours (increased physical activity (PA), decreased sedentary behaviours, and better eating behaviours) can act as a protective factor against obesity.[2–4] However, adoption of these weight-related health behaviours can be impacted by a number of proximal influences, including the family environment.[5,6] Therefore, understanding the familial factors that can influence behaviour change among overweight or obese adolescents is essential since these individuals have the potential to enroll in lifestyle modification interventions that target these powerful influences.

Parents, in particular, can influence their children directly through specific parenting practices (i.e., rules or routines) and their own health behaviours such as modeling healthy habits. Parenting practices are active strategies parents employ to elicit certain behaviours from their children that are typically context dependent (e.g., monitoring television (TV) viewing or applying rules about eating).[7] In addition, as children learn by observing individuals in their social environment,[8] the health behaviours that parents adopt or model (i.e., going for a jog or eating healthy foods) can directly shape adolescents' health behaviours. Evidence suggests that parenting practices[9] and parental modeling[10,11] are positively associated with young children's health behaviours associated with obesity; however, less is known about whether these influences remain important in adolescence and even less has been studied among overweight/obese adolescents.

In addition to these direct parental influences, more context-specific influences such as parenting styles and family functioning are thought to play a role in shaping adolescents' health behaviours. Parenting styles refer to the way the parent interacts with the child and are characterized by varying degrees of warmth and demand.[7] They can be classified into four prototypes: authoritative, authoritarian, permissive, and neglectful. This thesis will focus on two of these prototypes: authoritative and permissive. Family functioning on the other hand refers to how family subsystems (i.e., spousal, parent-child, and sibling relationships) interact with one another to influence the overall behaviour of the entire family system.[12] Despite limited research, models suggest that parenting styles and family functioning may operate at a more global level and moderate the effects of parenting practices and parental modeling on adolescents' health behaviours.[13,14] However, further exploration of these more global dimensions is necessary to understand whether context plays a role in achieving certain health behaviours among overweight or obese adolescents.

This research aims to explore whether parenting practices and/or parental modeling of health behaviours are associated with overweight/obese adolescent's health behaviours (PA, diet, and sedentary behaviours) while considering the potential moderating effects of parenting styles and family functioning.

The findings of this study will pave the way to understanding which parental mechanisms are important to target when trying to achieve certain health outcomes among overweight/obese adolescents. Additionally, the results of the moderation analyses will lead to an improved understanding of whether the emotional/relational context should be considered when trying to promote positive health behaviours among overweight/obese adolescents. Overall, the study

findings can contribute to the evidence base for structuring or developing future family-based obesity interventions.

Chapter 2: Literature Review

2.1 Obesity in Canadian Adolescents

A dramatic upsurge in the prevalence of overweight or obese Canadian children and adolescents has occurred since the late 1970s.[1] According to the Canadian Health Measures Survey (CHMS 2012-2013), which contains the most recent body mass index (BMI) data for adolescents (12-17) in Canada, approximately 37% are overweight or obese.[15] This is a striking increase from the rate in the 1970s which was around 15%.[1] This number raises a serious red flag as being overweight or obese tends to promote a large number of psychosocial, physical, and economic consequences. Specifically, child and adolescent overweight has been linked to an increased prevalence of low self- esteem,[16] type 2 diabetes,[17] and high blood pressure,[18] as well as a series of long-term health problems, such as cardiovascular disease and some forms of cancer (e.g., breast, prostate).[19,20] Today, it is estimated that obesity presents itself as a large economic burden on the country, with around $3.9 billion in direct, and $3.2 billion in indirect, health care costs in 2006.[21] Therefore, given the current trends in obesity among children and adolescents, the problem is likely to get worse. One way to help manage these physical, social, and economic consequences is through the promotion of health behaviours since inadequate engagement in physical activity,[22,23] sedentary,[3,22] and dietary behaviours[4,24] have all been linked to obesity.

2.2 Importance of Physical Activity

When it comes to understanding the link between PA and obesity, the relationship is not clear-cut. Although PA has been identified as a protective factor in the development of overweight or obesity, other findings negate this relationship.[25,26] As described by Wareham and colleagues, studies vary in their conclusions as a result of confounding, reverse causality, and measurement

error.[25] Acknowledging that this discrepancy exists, a large body of evidence suggests participation in PA not only attempts to slow down or reverse trends in obesity,[22,23] but has been found to prevent several chronic diseases.[33] For instance, Lee and colleagues[27] argue that if everyone participated in their recommended levels of PA according to the guidelines, 6% to 10% of the major non-communicable diseases (e.g., coronary heart disease, type 2 diabetes, breast and colon cancers) would be eliminated and result in an increased life expectancy in the world's population. In addition to limiting chronic diseases, regular PA during adolescence is essential to maintain bone strength and contributes to normal skeletal development.[28] Additionally, adolescents that engage in PA on a regular basis have shown improved cardiovascular and metabolic health (e.g., lower blood pressure, insulin levels, and waist circumference).[29,30] Alongside the apparent physical benefits of PA, a positive relationship between PA and aspects of mental (e.g., academic achievement),[31] emotional (e.g., improved mood),[23] and social (improved social skills)[32] health have been reported. Therefore, the benefits of regular PA participation make it a necessary precaution to take to not only prevent disease but also to prevent future diseases or health issues.

2.2.1 Physical Activity Guidelines for Canadian Adolescents

The amount of PA one acquires in childhood and adolescence is predictive of PA participation in adulthood.[33–35] Therefore, it is important for children and adolescents to form regular physical activity routines to build a healthy lifestyle. In hopes of encouraging children and adolescents to engage in the recommended PA levels by going beyond the typical activities they perform on a daily basis, health authorities have developed PA guidelines.[36] Recently, many developed countries - including Canada - have revised their PA guidelines based on new recommendations from the World Health Organization (WHO).[36] In Canada, the PA Guides for Children provides

national guidelines for adolescents aged 12-17 years to achieve health benefits.[37] The guide advises adolescents to engage in moderate-to-vigorous PA (MVPA) for at least 60 minutes per day with at least 3 days of vigorous PA (VPA). Moderate PA (MPA) includes any activity that gets an individual moving at a rate that burns off three to six times as much energy per minute while still being able to carry a conversation (e.g., brisk walking, bicycling, dancing).[38] VPA, on the other hand, includes any activity that gets an individual moving strenuously enough to burn off six or more times as much energy per minute without being able to hold a conversation (e.g., running, fast cycling, aerobics).[38] In addition to the above recommendations, the guideline also advises adolescents to carry out activities that strengthen muscle and bone at least 3 days a week (e.g., push-ups or climbing exercises).[37] Therefore, adolescent's health and well-being may depend on meeting or exceeding PA guidelines as doing so indicates healthy behavior habits. Additionally, it is important to note that these PA guidelines are sufficient to achieve health benefits, especially among individuals who were sedentary in the past.[37]

2.2.2 Physical Activity Levels of Canadian Adolescents

Despite the well-established health benefits of engaging in appropriate amounts of PA, many adolescents in Canada[39,40] and around the world are failing to meet adequate PA levels.[41] According to a recent review by Booth and colleagues,[42] overall PA levels among adolescents have remained consistently low over the past 20 years. These PA levels are particularly low among obese Canadian adolescents compared to normal weight adolescents.[43] As children get older, these observed declines in PA levels tend to become more prominent, decreasing at a striking 50% between the ages of 6 and 16,[44,45] with this trajectory likely continuing into adulthood.[33] Therefore, it is important to be aware of the current PA levels adolescents are engaging in as this can have a huge impact on the rest of their lives.

ParticipACTION's 2016 Report Card on PA provides findings of Canadian children and adolescents overall PA levels.[46] The report card is based on the most up-to-date findings from major nationally-representative surveys including: Canadian Health Measures Survey (2012-13 CHMS, Statistics Canada); Canadian PA Levels Among Youth survey (2014-15 CANPLAY, Canadian Fitness and Lifestyle Research Institute [CFLRI]); PA Monitor (2014-15 PAM, CFLRI); Opportunities for PA at School Survey (2015 OPASS, CFLRI); and the Canadian Health Behaviour in School-Aged Children Survey (2013-14 HBSC, World Health Organization [WHO]/Public Health agency of Canada [PHAC]). According to the report, for the fourth year in a row, Canadian children and adolescents received a D- when it comes to overall PA levels.[46] Canada has the lowest levels of PA alongside Australia and the United States who both received the same grade (D-).[46] The report goes on to discuss that accelerometer data reveal only 9% of 5-17 years olds in Canada meet the recommendation of at least 60 minutes of MVPA.[40] These low PA levels are also apparent in self-report data from the HBSC survey (2013-2014) which states approximately 20% of Canadians aged 11-15 meet the recommended levels of daily MVPA guidelines mentioned above.[47] Moreover, according to the 2014-15 results from the CANPLAY study, pedometer data reveal only 7% of 5-19 year olds in Canada take at least 12,000 steps daily.[48] This is drastically low in comparison to Western European regions such as the United Kingdom and France, as well as New Zealand.[49] Looking at these findings, it is evident that Canadian adolescents need more PA.

2.3 Importance of Reduced Sedentary Behaviours

More than ever, adolescents are exposed to an abundance of appealing sedentary activities (e.g., playing video games, watching television, computers, tablets, mobile phones) which limits their opportunities to expend energy.[50] A recent body of research suggests physical inactivity differs

from a lack of PA with regards to adverse health outcomes.[51] A current debate exists as to whether sedentary behavior displaces the PA one engages in. Evidence suggests that individuals can spend a majority of their time in sedentary behavior and still meet guidelines for MVPA. For example, Tammelin and colleagues[52] found that sedentary children (i.e. >4 hours of television viewing) can also participate in large amounts of PA. Findings suggest that although promoting reduced sedentary time is necessary for all children, it is especially important among the most sedentary group when trying to meet sedentary guidelines.[53] Nevertheless, continued engagement in these sedentary pursuits is not only linked to a less healthy lifestyle,[54] but is associated with an increased risk of cardio-metabolic disease, all-cause mortality, and a series of physiological and psychological problems.[54–57]A recent review by Tremblay and colleagues[3] found that minimizing any type of sedentary time is associated with lower health risk in children aged 5-17 and ultimately results in decreased BMI. Therefore, it is evident that engaging in a less sedentary lifestyle is necessary to improve health outcomes.

2.3.1 Sedentary Behaviour Guidelines

Sedentary behaviour can be defined as activities (e.g. sitting watching television) that keep energy expenditure around resting metabolic rate [1.0-1.5 metabolic equivalents (METs)] and below expenditure seen with light-intensity PA [1.6 to 2.9 METs].[58,59] Given that recent evidence has identified sedentary behaviours as a health risk independent of MVPA, a set of Canadian Sedentary Guidelines were recently proposed for sedentary behaviours.[53] To achieve health benefits, the Canadian Sedentary Guidelines for adolescents aged 12-17 years limits the amount of recreational screen time to < 2 hours per day (lower levels associated with additional health benefits). In addition, it suggests limiting sedentary transport, extended sitting time, and time spent indoors throughout the day.[53] Therefore, this first set of guidelines gives adolescents some

guidance into how much "sitting" time is too much and highlights that sedentary behaviour needs to be considered independent from PA.

2.3.2 Sedentary Behaviour Levels of Canadian Adolescents

According to ParticipACTION's 2016 Report Card on PA for Canadian Children and Youth, sedentary behaviours received an F.[46] Data from the CHMS suggests Canadian children and adolescents (aged 5-17) spend approximately 8.5 hours a day being sedentary (2012-2013 CHMS), with only a small percentage adhering to the Sedentary Behaviour Guidelines.[60] Moreover, a recent cross-sectional study found that overweight and obese children are generally more sedentary compared to their non-obese or overweight counterparts.[43] According to Spanier and colleagues,[61] Canadian children are not only beginning to watch television at younger ages than ever before, but are engaging in excess television watching and video gaming. It is important to acknowledge these increases in sedentary behaviours not only because they limit time that could have been spent in other ways being physically active, but also because such behaviours often occur in conjunction with unhealthy activities. For example, a systematic review found a clear association between total-screen viewing time and lower fruit and vegetable consumption as well as higher intake of energy-dense snacks, drinks, and fast foods.[62] Thus, it is crucial to pay attention to sedentary levels of adolescents when examining PA.

2.4 Importance of Diet Quality

Alongside inadequate PA levels and increased sedentary behaviours, poor diet quality has been identified as a contributing factor to the rising prevalence of overweight and obesity among adolescents.[4,24]According to the 2015 Global Burden of Disease study (188 countries), poor diet is the number one risk factor for premature deaths, among adults, accounting for approximately

11.3 million deaths globally.[63] The authors mentioned that between 2000 and 2013, there was a marked increase in the number of deaths associated with low consumption of fruits, vegetables, nuts, seeds, and fibre and high consumption of sodium, red and processed meat intake.[63] This is primarily a result of a recent transformation of diets where refined carbohydrates, oils, and animal foods now play a central role in our diet.[63] Due to this transformation, people nowadays have an even greater struggle when it comes to consuming and managing healthy diets, which can have dire health consequences. Given that dietary behaviours adapted in childhood continue into adolescence,[64] which then track into adulthood,[65]childhood and adolescence is a crucial time to shape behaviours and make decisions that may contribute to the problem of obesity as well as other health problems.[66] A recent systematic review by Knai and colleagues found that consuming healthy foods such as fruits and vegetables might not only reduce childhood illnesses (i.e., respiratory illness reduction)[67] but have a protective effect against diseases in adulthood, such as cancer.[68] Furthermore, a recent longitudinal study found that those who consumed diets rich in fruits, vegetables, and dairy products in early childhood, had lower systolic blood pressure in adolescence compared to those with lower intakes of these foods.[69] Alongside the physical benefits of healthy eating, diet quality has also been found to be a predictor of better academic achievement among adolescents.[70] Therefore, minimizing low quality food and prioritizing high quality, healthy food consumption is essential to achieve positive health outcomes.

2.4.1 Nutrition Guidelines for Canadian Adolescents

To promote healthy eating and consumption of appropriate nutrients, Health Canada has made dietary guidance a top priority for many years in hopes of maintaining lifelong health and reducing risk of chronic conditions or diseases.[71] To ensure dietary guidelines are up to date,

reviews are performed by Health Canada on a regular basis to ensure they are in line with current scientific knowledge and continually changing environments.[72] Guidance in the form of the Canadian Food Guide to Healthy Eating (CFGHE),[72] Dietary Reference Intakes (DRIs)[73]and dietary quality indexes have been developed to provide recommendations on the consumption of specific foods and nutrients that impact overall lifestyles. With regards to Canadian children, Canada's Food Guide provides a series of recommendations specific to age and sex and can be summarized as follows for boys and girls aged 9-18: 1) approximately 6-8 servings of fruits and vegetables per day; 2) 6-7 servings of grain products per day; 3) 3-4 servings of milk and alternatives per day; and 4) 1-3 servings of meat and alternatives per day. The CFGHE also recommends foods in the "other" category be consumed in moderation as they contain high fat/salt, high calorie/low nutrients, or high sugar/fat.[74] Although each food group is important in its own way, it is essential to balance all four food groups to achieve well rounded health benefits.[72]Alongside Canada's Food Guide, the Institute of Medicine has established DRIs, which is a joint Canada-US initiative to evaluate nutrient intake.[73] Additionally, a number of dietary quality indexes have been developed over the years to assess up to four main areas, including adequacy, moderation, variety, and balance. Adequacy refers to the amount of nutrients and foods consumed, moderation is the ability to control intake of food and nutrients, variety is type of food one consumes, and balance is eating the proper amounts from each food group. These dietary indexes are tailored to countries and Canada's index is adapted from the American Healthy Eating Index.[73] Specifically, Garriguet[71] adapted the American Healthy Eating Index to conform to the recommendations of Canada's Food Guide. Therefore, since Canada has its own Healthy Eating Index, multidimensional factors of diet quality can be explored to learn more about what exactly constitutes adolescent's overall diets.

2.4.2 Diet Quality of Canadian Adolescents

Regardless of the benefits of eating healthy, the majority of adolescents consume diets that do not follow the proper dietary guidelines.[66,75,76] Specifically, more than half of Canadian adolescents are not consuming the recommended servings per day of fruits and vegetables and dairy products.[75]Additionally, Canadian adolescents do not seem to be consuming appropriate amounts of most nutrients, as nutrient such as magnesium, vitamin A, phosphorous, calcium, potassium, and fibre are inadequate.[75] Storey and colleagues suggest that these other nutrients may be missing as a result of adolescents consuming more foods from the "Other" food category (comprised mostly of fats, oils or sugar) instead of nutrient-dense food groups.[74] This assertion is supported by findings of a study conducted by Hanning and colleagues[66] in which the majority of food consumed by Ontario students in grades six through eight is from the "Other" food category (e.g. candy or chips). Additionally, Canada is found to be similar to the United States with regards to inadequate consumption of milk and dairy products, vegetables and fruit, and too much high fat, salty snacks and sugar-sweetened beverages.[66,75,77,78]

2.5 The Environment

It is well established that health habits formed in adolescence may be difficult to alter; therefore, targeting the environment as a vehicle for change is critical for influencing children's current and future behaviour.[79,80] As Bray[81] states, "Genetics loads the gun, environment pulls the trigger," overweight or obesity among children results from an interaction between environmental and genetic factors. Therefore, the effect that ongoing changes in the environment has on a stable genetic susceptibility provides some insight into why such a rapid increase in obesity among adolescents has occurred over the past 20 years.[82] In particular, an adolescent's environment is

complex and composed of many powerful influences. Following Bronfenbrenner's ecological model,[83] which suggests that the immediate physical and social environment can have the greatest impact on behaviour, studies have found that adolescent's weight-related health behaviours can be impacted by social structures including the family,[5,6] peers,[84] and school.[85,86] For example, schools may influence children's PA levels depending on the number of physical education (PE) classes they offer per week,[87] while parents may influence children's PA levels by providing support.[9,88] Therefore, understanding how these environments can impact adolescents' health behaviours is essential to manage adolescent's weight. While many aspects of the physical and social environment can influence adolescents' health behaviours, this section will focus on the familial environment.

2.6 Family Environment

One environment that has received little attention in the adolescent obesity literature is the family.[89] It has been well established that the adoption and maintenance of health-promoting behaviour is influenced by the family system.[112] Since childhood and adolescence marks a crucial time frame for the development of health behaviours,[79,80] continual exposure from many aspects of the family such as family rules, emotional support, reinforcement from other family members, and family member participation can all play a role in shaping these behavioural patterns.[90] Barlow and Dietz[91] stated that instead of concentrating efforts solely on the child's weight, which not only damages the child's self-esteem but jeopardizes the parent-child relationship, emphasis on the family environment as a pathway for change is crucial. Parents in particular play a crucial role in the growth, development, and socialization of children[7] with this role changing at different stages of their child's development.[92] As many researchers note, parents act as agents of change as they not only supply knowledge to their children but expose

them to different food choices and involvement in PA or play.[93] Despite much debate as to who influences children as they transition to adolescence,[94,95] researchers argue that parents still play a critical role in shaping behaviours, regardless of the more autonomous lifestyle changes the adolescent is adopting.[88,92,93,96] As Lindsay and colleagues state,[92] if parents recognize and understand their role based on their child's developmental stage, they can learn how to create healthy home environments that ultimately influence their adolescent's health behaviours in a positive way. Therefore, understanding how the family system plays a role in shaping adolescent health behaviours can provide some insight into potential determinants of adolescent weight status.

From a public health standpoint, the family environment is an attractive intervention setting as it provides a plethora of opportunities to communicate positive health behavior messages to children with the ultimate goal of reducing obesity.[90] In particular, a recent body of evidence suggests that interventions based in the home are most effective in changing health behaviors, compared to interventions aimed at the individual.[97] More specifically, literature findings suggest that family-based interventions can be an effective means of improving overall PA,[98,99] eating behaviors,[7,99] and decreased BMI.[99,100]A number of researchers argue that in order for childhood obesity interventions to be effective, one or more parents must actively be involved.[101–105] Epstein[102] argues that parents need to be involved in interventions because: 1) all family members need to be consistent when it comes to modeling and supporting behaviours to maintain the overall goal of the intervention 2) parents model and reinforce eating and PA behaviours in order for children to adopt such behaviours and 3) parents will learn supportive behavior-change strategies (i.e. encouragement). Although studies suggest that family-based interventions result in improvements in children's diet or PA,[106] the majority of interventions are only successful

short-term, with many children returning to their previous dietary and activity patterns upon completion of the program.[91] Therefore, further examination of family or parent-level mechanisms, such as those noted by Epstein (e.g., practices or modeling) is essential to improve the effectiveness of family-based interventions to ultimately manage adolescent weight outcomes.

2.6.1 Parenting Practices

Parents can directly influence their child by using specific parenting practices. Parenting practices can be defined as specific actions or strategies parents use to socialize their children.[8] As described by Darling and Steinberg,[8,125] practices are dependent on the context or situation, have a specific aim, and include a range of mechanisms to manage behaviour (e.g. restriction, pressure, monitoring, support). For example, practices can be described as rules or routines that promote health behaviours such as restriction of video game usage or a rule/routine about bed-time or meals.[8,125] However, the current definition of parenting practices is quite broad in that many of the actions parents use on a daily basis to target their children's health behaviours can be classified as a practice,[131] creating discrepancy as to how the definition is operationalized. Additionally, although a number of measures have been developed to assess parenting practices, little consistency exists among them resulting in uncertainty as to how parenting practices should be measured.[107]

Despite these challenges faced by researchers, studies have found many practices to be associated with adolescents' PA, eating, and sedentary behaviours. In the context of PA, more health-related practices such as parental support in the form of emotional and logistical support[108,109] have shown strong associations with adolescents' PA. For instance, parents who

provide encouragement[110,111] and transportation to parks or playgrounds[112,113] have been positively associated with adolescents' PA. Moreover, a systematic review by Pugliese and Tinsely[114] found that both children and adolescents whose parents did not engage in certain socialization behaviours (e.g. encouragement, instrumental support) had a 1.41 times greater relative risk of being inactive. In addition to these findings, other practices such as monitoring have been associated with increased PA among, but only among samples of younger children.[109] With regards to screen time use, the majority of studies have reported more controlling practices to be associated with lower levels of screen viewing.[115,116] For instance, parents that use more controlling screen practices (e.g., rules) have been associated with less TV watching while less controlling practices have been associated with more TV viewing and more time playing computer games.[115,116] Moreover, those children with more media access have also been associated with increased screen time levels.[117] Although more controlling practices for screen time tend to elicit more positive health outcomes in adolescents, more restricting or controlling dietary practices have been associated with unhealthy eating habits such as increased desire and consumption of restricted foods when they become available.[118–120] However, research suggests that parents who adopt more supportive eating practices (i.e. encouragement, access/availability) have been associated with increased fruit and/or vegetable consumption in children and adolescents.[121] This is especially important to consider since findings suggest that parents with overweight children tend to use more maladaptive control or management food strategies compared to parents of non-overweight children. [136] As a result, further research is necessary to determine how overweight/obese adolescents respond to these behaviour-specific parenting practices.

2.6.2 Parent Health Behaviours (Modeling)

In addition to the direct influence parents have on their adolescent's health behaviours through specific parenting strategies, parent health behaviors (which includes modeling) have been recognized as an important influence on adolescents' health behaviours. Although some researchers consider parental modeling as a parenting practice, it has also been considered as a separate indirect mechanism rather than a more active strategy (e.g., rules) that parents use to elicit a certain response from their child.[122] Even though evidence suggests that peers shape or influence the choices adolescent's make, parental modeling is still shown to play a role in the health behaviours of adolescents.[9] As described by Steinberg,[95] adolescents not only shape their health behaviours through their own experiences, but learn behaviours and values at home through observation, imitation, and practice. According to Social Cognitive Theory (SCT),[8] which suggests that the social environment, including parental behaviours, can influence a child's behaviour, literature findings suggest that changes in parents obesogenic behaviours are related to changes in their children's behaviours.[123,124] Additionally, evidence suggests that interventions targeting the improvement of health behaviours in children and adolescents have been successful when parents are involved.[125] However, research is limited in investigating the extent to which parents' health behaviours (PA, sedentary, and dietary quality) influence the health behaviours of adolescents who are overweight or obese.

Results have generally been mixed for studies examining parent PA (modeling) on adolescents' PA.[9,126] A possible explanation for this discrepancy may be due to measurement of PA. Since self-report and objectively-measured PA are significantly different from one another,[127] not having consistent types of measurement for parent and child may limit the usefulness of findings.

For instance, a few studies found a positive association between parent and child/adolescent MVPA when both parent and child/adolescent MVPA was measured using accelerometers.[10,128] However, studies that used parent-adolescent self-report were inconsistent. Additionally, studies that have assessed modeling more indirectly through children's perceptions of their parent's modeling of PA have also been inconclusive.[9,88]Although less research has explored parent-adolescent sedentary time, studies report that children and adolescents are more likely to engage in excess screen time if their parents do.[129–131] For instance, research suggests that children are more likely to watch more than 4 hours of TV per day if their parents spend more time watching TV.[130] Despite limited research among adolescents, a recent study exploring this association with overweight/obese adolescents' and their parents, found an association between screen time (video game and computer).[10] With regards to parent-child dietary intake, results from a systematic review suggest moderate to weak associations, with findings varying considerably due to different methodologies. According to a study by Arcan and colleagues,[142] parents who overeat lead a poor example for their children. Moreover, a recent study found that parent intake of several dietary components (i.e., servings of fruit and vegetables, grams of sugar, etc.) was associated with overweight or obese adolescent intake.[11] Therefore, these findings suggest that parents can have an influence on their children through the positive health behaviours they engage in and should make these habits a priority for their children whether it is through healthy consumption of foods, regular participation in PA, and/or decreased sedentary time.

2.6.3 Parenting Styles

Alongside parenting practices and parental modeling is another aspect of parenting, known as parenting styles. Although parenting styles and practices are related, they are distinct constructs

that differentially influence health behaviours of adolescents. A parenting style is the emotional climate in which parents raise their child or the way the parent interacts with their child. As Rhee states, parenting practices are what parents do, while parenting styles describe how parents do it.[122] According to Maccoby and Martin,[132] parenting styles can be divided into 2 dimensions based on Baumrind's[133] studies and theories about parenting style: emotional warmth/responsiveness (parental displays of sensitivity or nurturance with children) and control/demanding (expectations for displays of maturity by their children, parental control, and discipline). Based on these two dimensions, a four-fold classification of parenting styles emerges: authoritative (high in warmth and control), authoritarian (low in warmth and high in control), permissive (high in warmth and low in control), and neglectful (low in warmth and control).

Studies have found the authoritative parenting style to be linked with positive childhood health outcomes such as increased fruit and vegetable consumption,[134] increased PA,[126,135] and lower BMI levels,[136] compared to those children and adolescents raised with more negative styles (authoritaritan, permissive, neglectful). Additionally, findings on the relationship between parenting styles and adolescent screen time suggest that the risk of watching >4 hours of TV per day was 5.2 times higher for children (10-11 year olds) with a permissive (versus authoritative or authoritarian) mother.[116] Despite the majority of studies indicating a positive effect of authoritative style on adolescent health outcomes, other findings have been mixed suggesting a permissive style to have a similar effect.[137] For instance, one study found that authoritative and permissive parenting styles were associated with greater fruit and vegetable intake in adolescent girls.[137] Given that authoritative and permissive parenting styles are both high in warmth, this may indicate that the key variable for increased fruit and vegetable intake is related to warmth

and caring along with other factors. However, further research is warranted to understand which parenting styles are most successful in eliciting positive health behaviours.

2.6.4 Family Functioning

Family functioning focuses on how families function in terms of cohesion and flexibility.[138] Cohesion refers to the emotional connectedness or bonding that family members have towards one another while flexibility is the quality and expression of leadership and organization, role relationship, and relationship rules and negotiation. As a result, family functioning acts as an all-encompassing dimension that focuses on how family subsystems (i.e. spousal, parent-child, and sibling relationship) interact with one another to influence the overall behaviour of the entire family system.[12] To better understand family functioning in terms of how adolescent behaviours are shaped, a theory known as Family Systems Theory (FST) was developed, which recognizes the importance of the family in the formation of behaviours.[139] According to FST, the family as a whole is important rather than considering family members individually. The main assumption being that all family members are interconnected to one another and that a reciprocal interaction exists in which each family member not only shapes, but is also being shaped by other family members.[139] In this sense, the relationships among family members can shape and sustain a problematic behavior, such as dysfunctional eating, smoking, and drinking among adolescents.[140,141] As a result, the way family members interact with one another or how they function as a family may give particular insight into the behaviours that ultimately determine dietary intake, PA, and sedentary behaviour in adolescents.

Despite limited research in this area, evidence suggests that family functioning has the potential to act as a protective factor against adverse outcomes such as childhood obesity. Research suggests that families of obese children tend to have more familial conflict, less cohesion, and

poor family communication which puts children at risk for obesity.[141–143] Additionally, adolescents in families with poor levels of functioning tend to be associated with higher levels of depression and hopelessness.[144] However, little is known about the role of family functioning in the *development* of overweight and obesity. To date, only a small number of studies have examined the impact of family functioning on health behaviours (e.g. PA & eating behaviours). According to Wen and colleagues,[145] poor family functioning increases the number of obesity risk behaviours among first-time mothers which is an important determinant of child obesity risk behaviours and hence child obesity. Moreover, a recent study by Berge and colleagues,[146] identified healthy family functioning (e.g., healthy communication, and problem solving skills) as a protective factor for a series of health behaviours including increased fruit and vegetable intake, more family meals, increased PA, and lower BMI in adolescents. Finally, findings from a longitudinal study by Ornelas and colleagues,[6] found family cohesion and parent-child communication to be associated with adolescent's long-term MVPA. Therefore, further research is necessary to understand the role family functioning plays in the health behaviours of overweight or obese adolescents.

2.7 Interaction of Family-Level Factors

Although multiple dimensions of the family are assumed to interact to influence the health of children and adolescents, relatively few studies have explored these context-specific dimensions (parenting styles, family functioning) with respect to adolescent obesity.

As mentioned previously, parenting styles are considered independent of parenting practices. According to a conceptual model proposed by Darling and Steinberg[7], parenting styles have the potential to impact child development indirectly by changing the effectiveness of parenting practices. As postulated by Darling and Steinberg,[7] a combination of parents' general attitudes

and beliefs they have about raising their child ultimately captures the emotional climate of the parenting environment. As a result, this parenting environment can alter how adolescents view their parents and potentially modify how children respond to their parents' socialization efforts. In other words, parenting styles can either have a positive or negative impact on these mechanisms (practices and modeling) performed by parents.[7] For example, parents' limits around screen time or junk food may come off as very controlling to the child if the interplay between parents and children is such that parents have strict rules and the child is expected to follow them. In comparison, limit setting may be experienced as very nurturing if the emotional/relational context of the parent-child relationship includes age-appropriate dialogue about the reasons for limits, consideration for revising limits, etc.[147] Thus, a parents' style may buffer the otherwise negative consequences of restrictive practices. Therefore, practices or modeling expressed within the context of a positive parenting style has the potential to improve the health behaviours of children and adolescents, compared to those expressed in a more negative parenting style, as reported in a small number of studies.[147–150]

In addition to examining parenting styles as a moderator, family functioning has emerged over recent years as a mechanism that should be explored further. According to Rhee,[122] parenting mechanisms such as practices and modeling may depend on how well the family functions as a unit. An example noted by Kitzmann and colleagues[13] suggests that parents who involve their children in activities such as food preparation might be quite successful in families with high levels of family functioning because they are already used to interacting together and enjoying spending time together. As a result, this may be an effective way for the child to adapt more healthy eating habits compared to families who spend less time together and have low levels of family functioning. However, since no evidence to date has explored family functioning as a

moderator on the relationship between parenting practices and adolescent health behaviours, further exploration of this relationship is necessary.

2.8 Proposed Theoretical Model

Given that past research has explored parenting practices and parental modeling separately with respect to adolescent health behaviours, limited research has explored the extent to which both factors are important while considering the moderating effects of parenting styles and family functioning. Therefore, this study explores the relationship between parenting practices, parental modeling and adolescent health behaviours in the context of these higher-level familial factors. We constructed a research model in which parental modeling, parenting practices, adolescent health behaviours, as well as parenting styles and family functioning were considered (Figure 1). In line with Bronfenbrenner's ecological model[83] and suggestions from others,[7,13,14,122,151] we conceptualized parenting style and family functioning as potential moderators, implying that the delivery and impact of specific parenting practices and parental modeling on adolescent health behaviours can vary depending on these higher-level conditions.

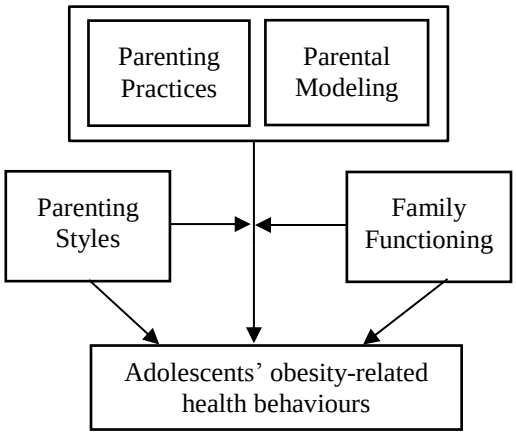

Figure 1: Relationships between parenting practices, parenting styles, and family functioning on adolescent health behaviours

2.9 Purpose

The purpose of this research was to examine in a sample of overweight/obese adolescents, whether parenting practices and/or parental modeling of health behaviours are associated with adolescents' obesity-related health behaviours (PA, dietary, sedentary and screen behaviours) while considering the moderating effects of parenting styles and family functioning.

2.10 Aims & Hypotheses

Aim 1:To determine whether parenting practices are associated with adolescents' obesity-related health behaviours, while considering the moderating effects of parenting styles and family functioning. (See Figure 2)

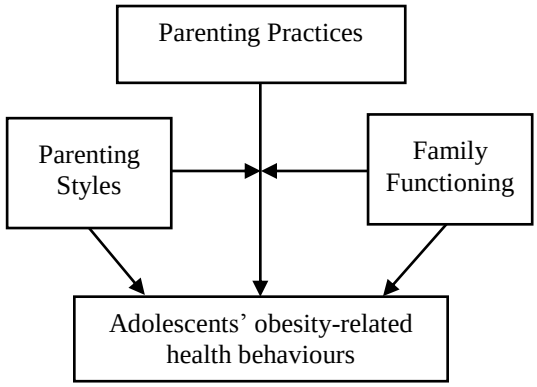

Figure 2: Moderating effects of parenting styles and family functioning on the relationship between parenting practices and adolescents' obesity-related health behaviours

Hypothesis 1: The effect that parenting practices has on adolescents' obesity-related health behaviours will be significantly moderated by parenting styles and family functioning as follows: More healthful parenting practices will be positively associated with adolescents' health behaviours but association will be more pronounced among adolescents whose parents use more authoritative and less permissive styles, and in families with high levels of family functioning. Conversely, this association will be less pronounced among adolescents whose parents use less authoritative and more permissive styles, and in families with low levels of family functioning.

Aim 2: To determine whether parental modeling of health behaviours are associated with adolescents' obesity-related health behaviours, while considering the moderating effects of parenting styles and family functioning. (See Figure 3)

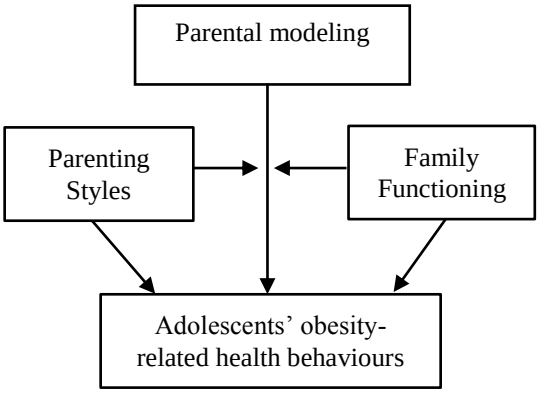

Figure 3: Moderating effects of parenting styles and family functioning on the relationship between parental modeling and adolescent's obesity-related health behaviours

Hypothesis 2: The effect that parental modeling has on adolescents' obesity-related behaviours will be significantly moderated by parenting styles and family functioning as follows: More healthful parental modeling will be positively associated with adolescents' health behaviours but

this association will be more pronounced for adolescents whose parents use more authoritative and less permissive styles, and in families with high levels of family functioning. Conversely, this association will be less pronounced among adolescents whose parents use less authoritative and more permissive styles, and in families with low levels of family functioning.

Aim 3: To determine whether both parenting practices and parental modeling of health behaviours are associated with adolescents' health behaviours, while considering the moderating effects of parenting styles and family functioning when included in the same model.
(See Figure 4)

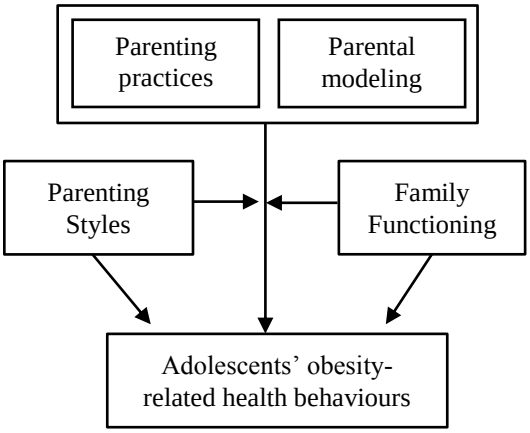

Figure 4: Moderating effects of parenting styles and family functioning on relationships between both parenting practices and parental modeling on adolescent health behaviours

Hypothesis 3: The effect that both parenting practices and parental modeling has on adolescents' obesity-related health behaviours will be significantly moderated by parenting styles and family functioning as follows: More healthful parenting practices and parental modeling will be positively associated with adolescents' health behaviours but these associations will be more

pronounced among adolescents whose parents use more authoritative and less permissive styles, and in families with high levels of family functioning. Conversely, these associations will be less pronounced among adolescents whose parents use less authoritative and more permissive styles, and in families with low levels of family functioning.

2.11 Rationale

Although parenting practices and parental modeling have been found to be independently related to adolescent weight and health behaviours, relatively little research has explored the extent to which both of these mechanisms are related to adolescent health behaviours or have focused on overweight/obese adolescents.[151–154] Furthermore, few studies have examined whether these relationships depend on more global aspects of the familial environment such as parenting styles and family functioning.[147–150] Therefore, understanding the influence of parent and family level mechanisms that contribute to weight status for overweight or obese adolescents may provide some insight into targeting modifiable family behaviours that have the potential to improve adolescent health outcome.

Chapter 3: Methods

3.1 Data Source

To answer the study questions, secondary data analyses were performed using data collected from the MySteps web-based lifestyle family intervention that was conducted in Vancouver, BC from December 2010 to March 2013. Ethics approval for the main study was granted by the University of British Columbia Behavioral Research Ethics Board and the University of Waterloo. Permission to access and analyze the data was granted in 2015 for this thesis by the University of British Columbia Behavioral Research Ethics Board.

3.2 Participants

Overweight or obese adolescents (aged 11-16) and one parent were recruited from the Greater Vancouver Metropolitan area of British Columbia (BC), Canada. Around 68% of participants were recruited by means of advertisements, namely newspapers (62%) and parenting magazines, Facebook, or Craigslist (5%). Another 28% of participants were recruited through referrals from the BC Children's Hospital Endocrinology and Diabetes Clinic (13%) and Centre for Healthy Weights Shapedown program in BC (15%). The remaining 5% of participants were recruited by word of mouth. To ensure the majority of the population of interest was captured, paid advertisements were placed in free local newspapers at subway exits, bus terminals, and fast food outlets. In total, 172 adolescent/parent pairs completed the baseline assessment.

Certain inclusion criteria had to be met in order to participate in the main study, including: being an overweight or obese adolescent based on WHO cut-points[1] and having a parent consent to participate in the intervention with the adolescent. Additionally, participants had to have internet

access at home, live in the greater metropolitan area of Vancouver (BC), not plan to move within the study period, and be fluent in English. Participants were excluded from the study if any of the following were present: comorbidities that required medical attention, health problems that prevented adolescents from being physically active, a history of psychiatric problems or substance abuse; use of medication that affects body weight, or a diagnosis of Type 1 diabetes.

3.3 Protocol

Parents and adolescents were contacted via telephone to assess interest and eligibility in the study. Eligible participants came to the BC Children's Hospital evaluation center in Vancouver, where they were briefed about what the study entailed and filled out consent forms (a child assent form was completed if younger than 14 years). At this visit, participants also completed a baseline assessment. During the baseline assessment, adolescents and parents completed a series of surveys on their PA, sedentary habits, and dietary intake, and were fitted with an accelerometer. Adolescents and parents were required to wear the accelerometer (over their hip under their clothes) for eight full days following the in-person meeting, during waking hours. Additionally, parents and adolescents were asked to keep track of their sleep duration and times when they were not wearing the accelerometer in a logbook. To assess dietary recall, parents and adolescents completed three online 24-hour dietary recalls. One was completed at the evaluation center and the other two at home. Data collection ensured that 24-hour recalls included one weekday and one weekend day, to ensure accuracy. Approximately one or two weeks after the initial visit, families came back to the evaluation center and were provided with a demonstration of the web-based intervention. The intervention itself consisted of the parent and child logging into a website each week to learn about topics, skills, goal-setting, and tracking of healthy eating,

PA, screen time, and bi-weekly counseling calls and/or emails from project staff. The intervention lasted 8 months and similar to the baseline assessment mentioned above, participants completed these assessments at 4 and 8-month intervals. At each session (baseline, 4-month, 8-month), each adolescent and their parent received an honorarium of $20. The proposed study focused on data from the baseline assessment.

3.4 Measures

A series of self-report measures were used to capture parenting practices, parenting styles, and family functioning. Adolescent and parent health behaviours (PA, sedentary activities, and dietary intake) were assessed using both self-report and objective measures. A snapshot of each measure is captured in Table 1 and is followed by a lengthier description of what each measure entails.

Table 1: MySteps® assessment for parents and adolescents

Construct	**Measure**	**Measure completed by:**
Parenting Practices	Family nutrition and physical activity screening tool[155]	Parent
Parenting Styles	Authoritative Parenting Scale[156]	Parent
Family Functioning	Family Adaptability and Cohesion Evaluation Scales (FACES IV)[157]	Parent
Parent and adolescent health behaviours	Physical Activity: Measured with accelerometer and a 7-day Physical Activity Recall[158]	Parent & adolescent
	Sedentary Activities: Measured with accelerometer and the Sedentary Behaviour Questionnaire[159]	Parent & adolescent
	Dietary Quality: 24-hour dietary recalls[160]	Parent & adolescent

3.4.1 Parenting Practices

Behaviour-specific parenting practices were measured with the family nutrition and PA screening tool (Appendix A.1).[155] The original tool included 15 items and the 1-factor structure of the tool was supported by an exploratory factor analysis with scores that had a high internal consistency (0.70) and were associated with BMI categories of children (Odds Ratio (OR)=1.7; 95% Confidence Interval (CI)=1.07-2.80).[155] As this study examined practices related to specific behaviours, we determined in our sample whether a 4-factor structure (PA, eating, breakfast, and screen time) would be supported. Based on examination of modification indices and post-hoc modifications with conceptual relevance, 4 items were removed and the confirmatory factor analysis was rerun with the remaining 11 items and an adequate fit was found [X^2 $(df=38)$ = 59.28; p=0.015; Root Mean Square Error of Approximation (RMSEA)=0.062 and 90% CI= 0.028-0.091; Comparative Fit Index (CFI)=0.892; Standardized Root Mean Square Residual (SRMR)=0.070]. Cronbach's alphas were 0.60, 0.64, 0.55, 0.33 for PA, eating, breakfast, and screen time practices, respectively. Each item consisted of two opposing statements in which parents were asked to choose the statement that best fit their child and/or family for each health behaviour. For *PA practices*, three items asked whether the child participates in organized sports, whether the child is spontaneously active, and whether the family is active together. For *eating practices*, four items asked whether the child drinks sodas, whether the family regularly eats at fast-food restaurants, consumes pre-packaged food or meals, and eats desserts. For *breakfast practices*, two items asked whether the child eats breakfast everyday and whether the family eats breakfast together. For *screen time practices*, two items asked whether the child watches television and whether child plays on computer or with video games. This response style was

selected to normalize both positive and negative response options to minimize social desirability bias.[107] Responses were converted to a 4-point numerical scale, and reverse coded as needed, so that a score of 4 indicated more healthful parenting practices.

3.4.2 Parenting Styles

Cullen's authoritative parenting scale was used to assess parenting styles (Appendix A.2).[156] The original measure includes 16 items across two subscales: authoritative (11 items) and negative (5 items) parenting styles. The 2-factor structure of the tool was previously tested in a sample of ethnically diverse parents and grade 4 to 6 students.[156] Based on principal component analysis in that sample, the authoritative and negative subscales explained 30% and 11% of the item variance, had internal consistencies of 0.72 and 0.73, and Pearson test-retest of 0.53 and 0.82, respectively. Initial confirmatory factor analysis in the present sample, did not support the structure [X^2 (df=89) = 187.6, p< 0.00; RMSEA= 0.084 and 90% CI 0.067-0.101; CFI=0.844; SRMR=0.080]. Based on modification indices and conceptual relevance, the authoritative and negative subscales were reduced to 10 and 3 items, respectively, along with the addition of two correlated error terms between the items "I make my child feel better" and "I tell my child times when he/she must come home," as well as two correlated error terms between "I am interested in my child's school work" and "I check to see if my child does his/her homework." Based on the more permissive parenting focus of the content of the remaining 3 items on the negative parenting scale, the scale name was changed from "negative" to "permissive" parenting. The new factor structure was supported by confirmatory factor analysis [X^2 (df=62)= 109.8, p< 0.00; RMSEA= 0.070 and 90% CI 0.048-0.091; CFI=0.919; SRMR=0.067] in the current sample and the Cronbach's alphas were 0.85 and 0.59 for authoritative and permissive parenting styles, respectively. Examples of items measuring authoritative parenting were: "I want to hear about

my child's problems" and "I tell my child when he/she does a good job on things." Examples of items measuring permissive parenting were: "It is hard for me to say 'no' to my child" and "I can be talked into things easily." A four-point Likert type scale was used where 1 indicates "Never" and 4 "Always." Items 1-10 were summed, with a higher score indicating a more authoritative style. Items 11-13 were also summed, with a higher score indicating a more permissive parenting style. Each subscale (authoritative and permissive) was dichotomized based on the median and two categories were created for each scale as follows: high/low authoritative style and high/low permissive style. Although an equal split in participants was achieved for the authoritative style (High=78; Low=82), this was not achieved for permissive style (High=50; Low=120). This unequal split is the result of a large number of individuals (n=70) scoring at the median (i.e., score of 6). However, since the scale ranged from 3 to 12, 6 is better suited within the low range (i.e., 3 4 5 **6** 7|8 9 10 11 12), confirming the placement of these participants in the low permissive group.

3.4.3 Family Adaptability and Cohesion Evaluation Scales (FACES IV) to Measure Family Functioning

Family functioning was assessed using the Family Adaptability and Cohesion Evaluation Scale IV (FACES IV).[157] The original measure is a 42-item self-report instrument based on the Circumplex Model of family functioning that is composed of six subscales that assess the overarching dimensions of family cohesion and flexibility.[157] Four scales assess the lower and upper extremes of cohesion (disengaged and enmeshed) and flexibility (rigid and chaotic). The remaining two scales assess balanced cohesion and balanced flexibility. Balanced levels of cohesion and flexibility indicate healthy family functioning whereas unbalanced levels of

cohesion and flexibility are associated with problematic family functioning. The six-factor structure of the scale was validated using exploratory factor analysis on a sample of US college students with a mean age of 28. According to Olson's study, the internal consistency for each of the scales were as follows: 0.89 for balanced cohesion, 0.84 for balanced flexibility, 0.77 for enmeshed, 0.87 for disengaged, 0.86 for chaotic, 0.82 for rigid.[157] For the current sample, the internal consistency for each of the scales was as follows: balanced cohesion=0.59, balanced flexibility=0.56, enmeshed=0.72, disengaged=0.75, chaotic=0.84, rigid=0.59. Examples of items from each of the six scales are as follows: Balanced Cohesion: "Family members are involved in each others' lives" and Family members feel very close to each other"; Balanced Flexibility: "Our family tries new ways of dealing with problems" and "My family is able to adjust to change when necessary"; Enmeshed: "We spend too much time together" and "We resent family members doing things outside the family"; Disengaged: "We get along better with people outside our family than inside" and "Family members seem to avoid contact with each other when at home"; Rigid: "There are strict consequences for breaking the rules in our family" and "Our family has a rule for almost every possible situation"; Chaotic: "We never seem to get organized in our family" and "Our family feels hectic and disorganized." A five-point Likert scale was used where 1 indicates "Strongly Disagree" and 5 "Strongly Agree." Therefore, a maximum raw score of 35 could be obtained for each of the six scales. The raw scores for each of the six subscales were then converted into individual percentile scores, using the conversion chart developed by Olson.[157] As shown in Table 2, these percentile scores were then used to compute individual ratio scores for cohesion and flexibility. The Cohesion Ratio is calculated by dividing the Balanced Cohesion percentile score by the average of the two unbalanced scales (Disengaged and Enmeshed). The Flexibility Ratio is calculated by dividing the Balanced Flexibility

percentile score by the average of the two unbalanced scales (Rigid and Chaotic). For the analyses, cohesion and flexibility ratio was dichotomized and those with ratios above the median on both of these ratios represented the high family functioning group. Those who were below the median on both of these dimensions or were above the median for one ratio but not the other, represented low family functioning. Therefore, families that scored >1.9 on the cohesion ratio and >1.4 on the flexibility ratio were classified in the high family functioning group. Families below the median on both of these dimensions or above the median for one ratio but not the other were placed into the low family functioning group.

Table 2: Formulas for ratio scores

Ratios:	**Score (use percentiles)**
Cohesion Ratio	Balanced Cohesion/ ((Enmeshed+Disengaged)/2)
Flexibility Ratio	Balanced Flexibility/ ((Chaotic+Rigid)/2)

Table 3 provides a visual of these classifications. Due to an unequal number of categories (1 high vs. 3 low), an equal split among participants was not achieved, resulting in 49 families with high family functioning and 110 with low family functioning.

Table 3: Classification based on cohesion and flexibility ratios

	High Flexibility Ratio	Low Flexibility Ratio
High Cohesion Ratio	High Family Functioning	Low Family Functioning
Low Cohesion Ratio	Low Family Functioning	Low Family Functioning

3.4.4 Health Behaviours of Parents (Modeling) and Adolescents

To measure daily PA levels, MVPA was captured using both accelerometry and a 7-day Physical Activity Recall (PAR) interview. Sedentary behaviour was also assessed with accelerometry and a self-report questionnaire on screen time use. Finally, dietary quality was assessed with a self-administered online 24-hour Dietary Recall. These measures are outlined below.

Accelerometer to measure MVPA: Two types of accelerometers (Actigraph GT3X or GT3X+) were used to measure MVPA. Data from the Actigraph accelerometers was processed using a program in Stata that processed the data following previous recommendations.[161,162] Data from the accelerometers were collected in spans of 10 seconds and aggregated into one-minute intervals for the analyses. A day of recording was considered valid if the accelerometer was worn at least 10 hours per day, which represents 63% of the time participants are awake (for those who sleep 8 hours). Non-wear time was described as a period of at least 60 minutes that resulted in no activity.[161] If participants had three valid days (including one weekend day) of wear time, they were included in the analyses. To help determine the appropriate minutes of MVPA, child and parent-specific MVPA cutoffs were used ($\geq$2296 and $\geq$1952 accelerometer counts in a one-minute time frame, respectively).[163] Counts above this cut-point were combined to calculate total minutes of MVPA during the assessment week.[164] To determine the average minutes of MVPA at baseline, total MVPA was divided by number of days.

7-Day Physical Activity Recall (PAR) to measure MVPA: The 7-Day PAR is a semi structured interview aimed at estimating the amount of MVPA the parent or child has engaged in for 10 minutes or longer in the seven days leading up to the interview. The measure, which is adapted from the Stanford Five-City Project[158] is primarily used to record the intensity and duration

(minutes) of participants' activities. To aid participants in identifying which level of intensity corresponded to the activity they performed, they were provided an overview of 3 different levels of intensity. These levels included leisure walking (i.e. relaxing walk), moderate activities (i.e. brisk walking) and very hard activities (i.e. running hard). In addition to the regular interview questions, probing methods were employed to ensure that sufficient information was obtained from each participant. The Compendium of Energy Expenditure for Youth[165] was used to assign the appropriate number of metabolic equivalents (where 1 MET is the amount of energy expended at resting) to each activity the participant performed. Self-reported MVPA time was defined as the average minutes per day spent performing activities that were ≥ to 4 MET.[163,166,167] Time spent in MVPA was computed by summing all the activities above this point. The total minutes in a week was divided by seven to obtain average minutes of MVPA per day.

Accelerometer to measure percent of sedentary time: Sedentary activities were estimated using the accelerometer data (described previously). This was done by dividing the total minutes of sedentary time by the amount of time participants wore the accelerometer. Sedentary activities for both parents and adolescents were defined as activity levels ≤ 100 counts per minute.[168] Percentage of sedentary time was computed for each day, excluding periods of non-wear. Three valid days of wear were necessary to compute.

Screen Time questionnaire: Adolescents and parents answered a series of questions on the amount of time they spent watching TV or movies, playing video games, or using their phone last Saturday and on the most recent weekday (sample item: "Last Saturday, how much time did

you spend watching TV or movies?"). Average screen time per day was computed by multiplying the amount of screen time reported on Saturday by two and multiplying the same time reported on previous weekday by five. Then screen time on weekends and weekdays was added and divided by seven which produced an average screen time per day. These questions were developed and validated in overweight adults and adolescents by Rosenberg and colleagues.[159,169]

Dietary Quality measured by 24-Hour Dietary Recall: Both parents and adolescents completed three self-administered online 24- hour dietary recalls developed by the University of Waterloo, that assessed everything they consumed the previous day.[160] Participants chose from more than 900 brand or generic food items. If a particular food item was not on the list, participants were allowed to substitute it with a similar item. To determine accurate portion sizes, photographs were used to assist the participants. Additionally, participants could select common toppings associated with certain foods (e.g. spreads on toast). Once participants confirmed their selection, a final screen showed their individual intakes in comparison with the current Canada's Food Guide to Healthy Eating recommendations. Validation of the web-based tool was conducted against a dietician-administered dietary recall among an ethnically diverse sample of 11 to 14 year olds with an interclass correlation coefficient of 0.56 for total energy intake.[160] Nutrient and Canadian food group estimates were retrieved using the Food Processor software package (version 8.0, ESHA Research, Salem, OR, 2002) that uses the 2007 Canadian Nutrient File.[170] Mean nutrient and food category estimates were used to compute a Healthy Eating Index (HEI) score.[71] The HEI measured diet quality (adequacy and moderation) based on recommended intakes in Canada's Food Guide.[72] The food participants reported in the 24-hour dietary recall

were sorted into eleven different categories. The Food Guide recommends eight of these to be present in larger amounts (total vegetable and fruit, whole fruit, dark green and orange vegetables, total grain products, whole grains, milk and alternatives, meat and alternatives, and unsaturated fats). The remaining three categories were present in smaller amounts (saturated fat, sodium, and other foods which include solid fat, alcohol, and sugar). For the 'other food' component, saturated and trans-fat were used as a proxy for solid fats and total sugar was used as a proxy for added sugar. An HEI score was created by summing the scores for the eleven food categories. Since parents and adolescents completed three 24-hour dietary recalls (one at evaluation center and two at home during one weekday and one weekend day), an average of the three HEI scores was used to assess their dietary quality at baseline. A maximum score of 100 could be obtained, with a higher score indicating better dietary quality.

3.5 Data Analysis

To assess the research questions, all analyses were conducted in Stata 13 using path analysis. Path analysis is an extension of multiple regression that is used to analyze more complicated models (i.e. multiple dependent variables) and can explore the role of two potential moderators. A full information maximum likelihood estimation procedure was used to handle missing values. To address Aim 1 (Figure 2), separate models were run to examine whether parenting practices had a direct effect on adolescents' obesity-related health behaviours while considering the moderating effects of parenting style and family functioning. In total, five separate models were run for each of the five adolescent obesity-related health behaviours and their corresponding behaviour-specific parenting practices. Parenting practices (PA, eating, breakfast, and screen time) were entered as independent variables and adolescent health behaviours were entered as dependent variables. Adolescent MVPA and sedentary behaviours were measured with

accelerometers and questionnaires. Dietary quality was computed using three 24-hour dietary recalls. Next, parenting styles (authoritative and permissive) and family functioning variables were entered into the analyses. Interaction terms were then entered into the analysis one at a time for each of the corresponding models and remained in the model if significant with a p value <0.1. Additionally, all variables were standardized prior to including them to address the issue of convergence. Each model adjusted for the following covariates: adolescent age, adolescent sex, and parent income.

Similar analytical procedures were conducted for Aim 2 (Figure 3) and Aim 3 (Figure 4) except that Aim 2 explored the direct effect of parental modeling and Aim 3 explored the direct effect of both parenting practices and parental modeling. Parental modeling of PA and sedentary behaviours were assessed using both accelerometers and questionnaires. Parental modeling of eating was assessed using three 24-hour dietary recalls.

To ensure assumptions of linear regression are met, bivariate scatter plots and residual plots were assessed for each model. The magnitude, depicted by the Standard Coefficient (SC) of a path and p-value associated with it explained the significance of the path.

Chapter 4: Results

4.1 Demographic Characteristics of Adolescents and Their Parents

The demographic characteristics of the adolescents and their parents (N=172) are highlighted in Table 4. On average, adolescents were 13 years old and equally split by sex. Families in the sample were comprised predominantly of mothers, with an average age of 46 years. Additionally, families ranged in household income, educational attainment, marital status and ethnicity.

Table 4: Demographic characteristics of adolescents and their parents

Demographic Characteristics		(%)	Mean ± SD [Range]
Adolescent Age (Year) N=172			13.1 ± 1.8 [11-16]
Adolescent Sex N=172	Female Male	55.2% 44.8%	
Adolescent Body Mass Index z-score N=172			2.70 ± 0.83 [1.1-6.0]
Parent Age (Year) N=172			45.7 ± 6.2 [31-66]
Parent Sex N=172	Female Male	84.3% 15.7%	
Parent Body Mass Index N=172			30.3 ± 7.3 [18.3-69.0]
Household Income N=169	≤$60,000 or less $60,001-$100,000 ≥$100,001	34.9% 33.7% 31.4%	
Parent Education N=172	High school or less Trade certificate/diploma Bachelor degree Above Bachelor degree	17.4% 41.3% 18.6% 22.7%	
Parent Marital Status N=172	Married/Common-Law Single/Widowed/Separated/ Divorced	70.9% 29.1%	
Ethnicity N=171	White East/Southeast Asian South Asian Aboriginal Other	48.0% 13.5% 12.3% 10.0% 16.4%	

SD=Standard deviation, %=Percentage

4.2 Characteristics of the Households and Adolescents' Health Behaviours

As shown in Table 5, adolescents and parents accumulated around half an hour of MVPA per day as measured by accelerometry and self-reported to accumulate about 56 and 69 minutes of MVPA per day. Additionally, both parents and adolescents spent approximately 61% of their time in sedentary activities as measured by accelerometry. Adolescents exceeded the recommended amount of screen time per day by close to two and a half hours, while parents self-reported approximately one hour and 30 minutes of screen time. Parents and adolescents dietary habits were also inadequate as their dietary quality averaged around 65%.

Table 5: Descriptive statistics for parenting practices, parental modeling, and adolescents' health behaviours

Independent Variables	n	Mean ± SD [Range]
Parenting Practices		
Physical Activity	160	2.4 ± 0.8 [1-4]
Eating	160	2.9 ± 0.7 [1.5-4]
Breakfast	166	2.7 ± 0.9 [1-4]
Screen Time	168	1.5 ± 0.6 [1-4]
Parental Modeling		
Measured MVPA (min/day)	155	29.3 ± 20.3 [1.0 - 103.1]
Self-reported MVPA (min/day)	170	68.9 ± 89.7 [0.0 - 488.6]
Measured Sedentary Time (%/day)	170	61.3 ± 9.0 [21.6 - 80.1]
Self-reported Screen Time (min/day)	171	88.4 ± 128.0 [0.0 - 668.6]
Dietary Quality Score	165	65.1 ± 9.8 [36.2 - 86.4]
Dependent Variables		
Adolescent Health Behaviours		
Measured MVPA (min/day)	131	34.4 ± 20.9 [2.8 - 119]
Self-reported MVPA (min/day)	158	56.1 ± 47.7 [0.0 - 272.1]
Measured Sedentary Time (%/day)	160	61.6 ± 9.0 [33.2 - 83.9]
Self-reported Screen Time (min/day)	170	276.2 ± 205.4 [17.1 - 994.3]
Dietary Quality Score	169	63.9 ± 9.1 [39.1 - 83.8]

MVPA=Moderate-to-vigorous physical activity, SD=Standard deviation, %=Percentage
Parenting Practices: Active strategies parents use to elicit a certain response from their child (e.g., rules)
Parental Modeling: Parent's own health behaviours

4.3 Descriptive Statistics for Parenting Styles and Family Functioning

As shown in Table 6, the majority of parents scored high on the authoritative parenting style scale as they had an average score of 34.8 on a scale that ranged from 10 to 40. For the permissive parenting scale, the majority of parents scored in the middle of the scale as they had an average score of 6.0 on a scale that ranged from 3 to 12.

As explained in the method section, the median split was used to categorize parents who scored high or low on the parenting style variables. This resulted in a balanced split for the authoritative parenting style variable as 48.8% were categorized in the high group. However, this was unbalanced for the permissive parenting style variable as only 30% were placed in the high group. This unequal distribution resulted because many families scored at the median split (median split=6) and the median had to be regrouped with the low permissive group given that this score was low overall.

As shown in Table 6, the majority of parents were balanced on both the cohesion and flexibility ratios as the mean ratios were both greater than 1. Similar to the parenting style variables, the median split was also used to classify families in the high group. Therefore, families that scored >2.0 on the cohesion ratio and >1.4 on the flexibility ratio were classified in the high family functioning group, resulting in 30.8% of the families. Families below the median on both of these dimensions or above the median for one ratio but not the other were placed into the low family functioning group.

Table 6: Descriptive statistics for parenting styles and family functioning

Moderators	Mean ± SD [range]	% categorized as high
Parenting Style		
Authoritative **(N =160)**	34.8± 4.3 [21-40]	48.8%
Permissive **(N=170)**	6.0 ± 1.4 [3-11]	30.0%
Family Functioning		30.8%[a]
Cohesion ratio **(N=168)**	2.1 ± 0.63 [0.88-4.4]	
Flexibility ratio **(N=162)**	1.4 ± 0.35 [0.68-3.1]	

[a] classified as high on family functioning if both the cohesion and flexibility ratios were >2.0 and >1.4, respectively

Parenting Style: Way the parent interacts with the child (warmth/control)
*Authoritative (*high warmth, high control); *Permissive (*high warmth, low control)
Family Functioning: How the family functions as a unit (cohesion/flexibility)

4.4 Association Between Parenting Practices and Adolescents' Health Behaviours

Table 7 presents the association between PA parenting practices and adolescents' MVPA and whether the association was moderated by parenting styles and family functioning. As shown in Table 7, model 1 (excluding the moderators) highlights that PA parenting practices were significantly associated with adolescents' self-report of MVPA and that there was a trend towards significance (p=0.06) with adolescents' MVPA measured by accelerometry. Specifically, more healthful PA parenting practices were associated with increased adolescents' MVPA. As the moderators were added into the model, the interaction term between permissive style and PA parenting practices was significant. In contrast, PA parenting practices was the only significant predictor for adolescents' self-report MVPA when the moderators were included in the model. Figure 5 illustrates the permissive style by PA parenting practices interaction and suggests that more healthful PA parenting practices were positively associated with adolescents' MVPA but this association was more pronounced among adolescents whose parents use a high permissive style compared to those with a low permissive style. However, as shown in the graph, this association is in the opposite direction when parents use less healthful PA practices.

In all models, adolescents' sex was the only significant covariate. The results suggest that adolescent boys had significantly higher MVPA than adolescent girls and this was observed for both accelerometry and self-report assessment of MVPA (Table 7).

Table 7: Association between physical activity (PA) parenting practices and adolescents' accelerometer and self-report moderate-vigorous PA (MVPA) time

		Accelerometer MVPA Time		Self-Reported MVPA Time	
		Model 1	Final Model	Model 1	Final Model
		SC (SE)	SC (SE)	SC (SE)	SC (SE)
Independent Variable	PA Practices	0.17 (0.09) p=0.06	0.09 (0.11) p=0.43	0.38 (0.08) p=0.00	0.38 (0.08) p=0.00
Moderators	Authoritative Style	--	-0.15 (0.09) p=0.10	--	0.01 (0.08) p=0.85
	Permissive Style	--	-0.07(0.09) p=0.46	--	-0.06 (0.08) p=0.41
	Family Functioning	--	-0.05 (0.09) p=0.53	--	0.12 (0.08) p=0.15
	Authoritative Style* PA Practices	--	NS	--	NS
	Permissive Style* PA Practices	--	0.23 (0.11) p=0.03	--	NS
	Family Functioning* PA Practices	--	NS	--	NS
Covariates	Adolescent sex	0.22 (0.08) p=0.01	0.21 (0.08) p=0.01	0.17 (0.07) p=0.02	0.18 (0.07) p=0.02
	Adolescent age	0.00 (0.09) p=0.98	-0.06 (0.09) p=0.53	0.02 (0.08) p=0.76	0.06 (0.08) p=0.47
	Parent income	-0.06 (0.09) p=0.46	-0.02 (0.09) p=0.83	0.01 (0.08) p=0.88	-0.03 (0.08) p=0.67

Footnote:
SC=Standardized Coefficient, SE=Standard Error, NS=Not significant
Model 1: Test association between PA parenting practices and adolescents' amount of MVPA and account for the following covariates—adolescent age, adolescent sex, parent income
Final Model: Adds to model 1 test of moderation and keeps effects that are significant at $p < 0.1$
*Denotes interaction term

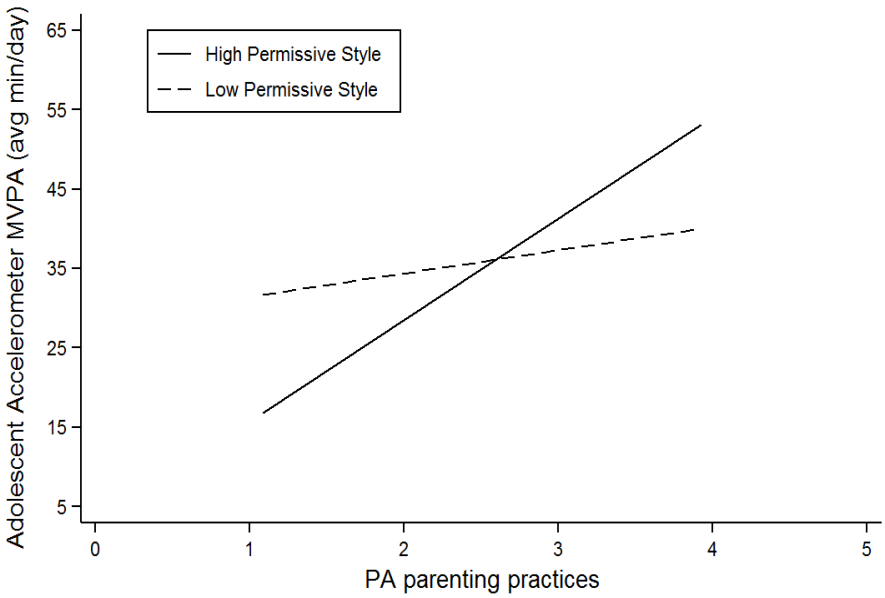

Figure 5: Graph showing how the association between adolescents' amount of moderate-vigorous physical activity (MVPA) and physical activity (PA) parenting practices was moderated by a permissive parenting style

Table 8 presents the association of eating and breakfast parenting practices on adolescents' dietary quality and whether the association was moderated by parenting styles and family functioning. As shown in model 1 (excluding the moderators), breakfast parenting practices were significantly associated with adolescents' dietary quality, which means that more healthful breakfast parenting practices were associated with more healthful dietary habits in youth. As the moderators were added into the model, a significant family functioning by breakfast parenting practices interaction emerged and the main effect of breakfast parenting practices was no longer significant. Figure 6 illustrates the family functioning by breakfast parenting practices interaction and suggests that breakfast parenting practices were positively associated with adolescents' dietary quality and this association was more pronounced among families with high levels of family functioning compared to those with low levels of family functioning. However, this effect was in the opposite direction when parents used less healthful breakfast practices.

Both adolescent age and parent income were significant covariates in the final model. The results suggest that adolescent dietary quality decreased 0.78% for every one unit increase in adolescent age. Additionally, adolescents in households with incomes greater than or equal to $100,001 had better dietary quality than those adolescents in households with incomes less than $100,001.

Table 8: Association between nutrition parenting practices and adolescents' dietary quality

		Adolescent Dietary Quality	
		Model 1	Final Model
		SC (SE)	SC (SE)
Independent Variables	Eating Practices	0.03 (0.08) p=0.74	0.03 (0.08) p=0.74
	Breakfast Practices	0.18 (0.08) p=0.02	0.05 (0.09) p=0.60
Moderators	Authoritative Style	--	-0.13 (0.08) p=0.10
	Permissive Style	--	0.09 (0.07) p=0.24
	Family Functioning	--	-0.03 (0.08) p=0.60
	Authoritative Style * Eating Practices	--	NS
	Permissive Style* Eating Practices	--	NS
	Family Functioning* Eating Practices	--	NS
	Authoritative Style* Breakfast Practices	--	NS
	Permissive Style* Breakfast Practices	--	NS
	Family Functioning* Breakfast Practices	--	0.23 (0.09) p=0.01
Covariates	Adolescent sex	-0.10 (0.07) p=0.16	-0.10 (0.07) p=0.18
	Adolescent age	-0.14 (0.08) p=0.060	-0.18 (0.08) p=0.02
	Parent income	0.21 (0.07) p=0.00	0.24 (0.07) p=0.00

Footnote:
SC=Standardized Coefficient; SE=Standard Error; NS=Not significant
Model 1: Test association between nutrition parenting practices and adolescents' dietary quality and accounts for the following covariates—adolescent age, adolescent sex, parent income
Final Model: Adds to model 1 test of moderation and keeps effects that are significant at $p < 0.1$
*Denotes interaction term

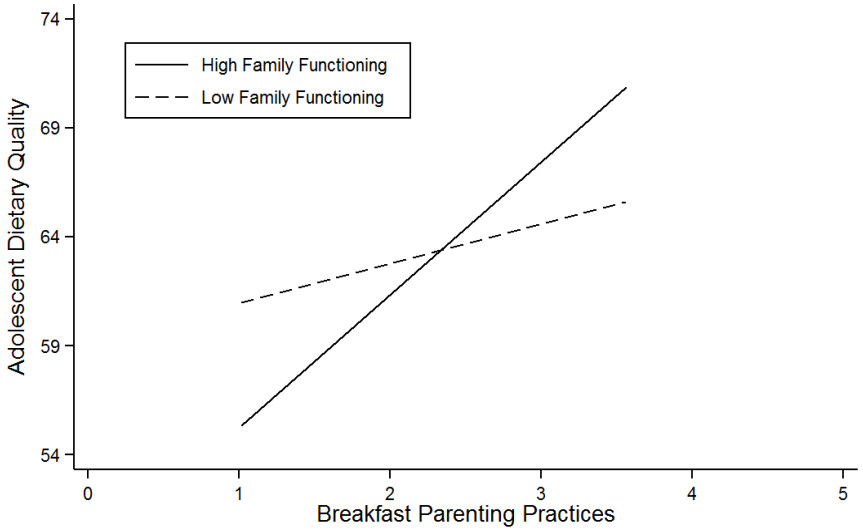

Figure 6: Graph showing how the association between adolescents' dietary quality and breakfast parenting practices was moderated by family functioning

Table 9 presents the association between screen time parenting practices and adolescents' sedentary behaviours and whether the association was moderated by parenting styles and family functioning. As shown in model 1 (excluding the moderators), screen time parenting practices were significantly associated with adolescents' self-report of screen time only. Specifically, more healthful screen time parenting practices were associated with decreased screen time. However, tests of moderation for both accelerometer and self-report of sedentary behaviours found a significant interaction term between permissive style and screen time parenting practices and an authoritative style by screen time parenting practices interaction, respectively. Figure 7 suggests that more healthful screen time parenting practices were positively associated with adolescents' sedentary time but this association was more pronounced among adolescents whose parents use a more permissive style compared to a less permissive style. On the other hand, Figure 8 suggests that more healthful screen time parenting practices were negatively associated with adolescent's screen time when adolescents parents used a more authoritative parenting style compared to a less authoritative style. Finally, a trend towards significance (p=0.06) was observed for family functioning and adolescents' self-report screen time.

In all models, adolescents' age was a significant covariate. The final models for accelerometer sedentary time and self-report screen time suggest that for every one unit increase in adolescent age, there was decrease of 1.7% and 34.7 minutes, respectively. Additionally, parent income was a significant covariate in both models for self-report screen time. Therefore, adolescents in households with incomes greater than or equal to $100, 001 had decreased screen time compared to those adolescents in households with incomes less than $100,001.

Table 9: Association between screen time parenting practices and adolescents' sedentary behaviours

		Accelerometer Sedentary Time		Self-Report Screen Time	
		Model 1	Final Model	Model 1	Final Model
		SC (SE)	SC (SE)	SC (SE)	SC (SE)
Independent Variable	Screen Time Practices	0.05 (0.08) p=0.47	-0.08 (0.09) p=0.35	0.22 (0.07) p=0.00	-0.09 (0.10) p=0.36
Moderators	Authoritative Style	--	-0.04 (0.08) p=0.59	--	0.10 (0.08) p=0.21
	Permissive Style	--	0.00 (0.08) p=0.95	--	0.03 (0.07) p=0.65
	Family Functioning	--	-0.05 (0.08) p=0.52	--	0.15 (0.08) p=0.06
	Authoritative Style* Screen time Practices	--	NS	--	-0.20 (0.10) p=0.05
	Permissive Style* Screen Time Practices	--	0.28 (0.09) p=0.00	--	NS
	Family Functioning* Screen Time Practices	--	NS	--	NS
Covariates	Adolescent sex	-0.15 (0.08) p=0.05	-0.12 (0.07) p=0.09	0.03 (0.07) p=0.67	0.04 (0.07) p=0.61
	Adolescent age	0.38 (0.07) p=0.00	0.37 (0.07) p=0.00	0.24 (0.07) p=0.00	0.27 (0.07) p=0.00
	Parent income	-0.06 (0.08) p=0.42	-0.05 (0.08) p=0.50	-0.30 (0.07) p=0.00	-0.34 (0.07) p=0.00

Footnote:
SC=Standardized Coefficient; SE=Standard Error; NS=Not significant
Model 1: Test association between screen time practices and adolescents' amount of sedentary time while accounting for the following covariates: adolescent sex, adolescent age, and parent income
Final Model: Adds to model 1 test of moderation and keeps effects that are significant at $p < 0.1$
*Denotes interaction terms

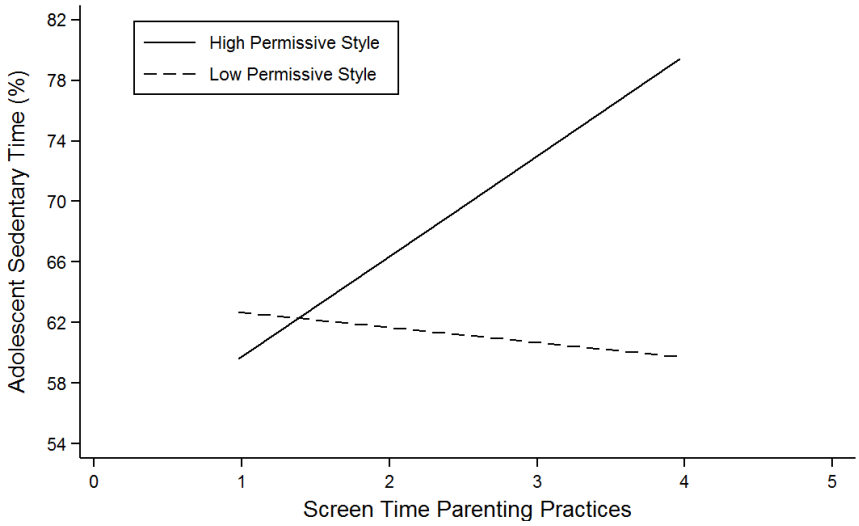

Figure 7: Graph showing how the association between adolescents' amount of sedentary time and parenting practices was moderated by a permissive parenting style

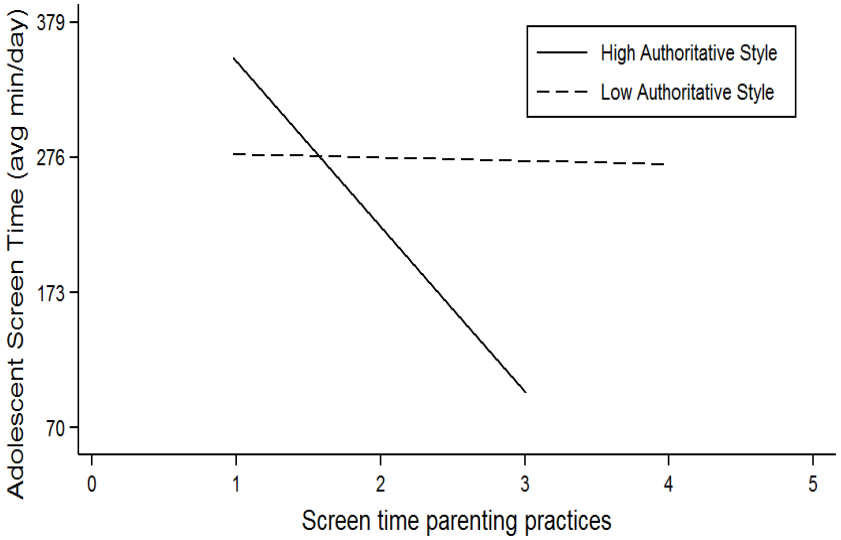

Figure 8: Graph showing how the association between adolescents' screen time and parenting practices was moderated by an authoritative parenting style

4.5 Association Between Parental Modeling and Adolescents' Health Behaviours

Table 10 presents the association between parental modeling of PA and adolescents' MVPA and whether the association was moderated by parenting styles and family functioning. As shown in Table 10, model 1 (excluding the moderators) highlights that parental modeling of PA was significantly associated with adolescents' MVPA for both accelerometer and self-report. Specifically, parents' modeling PA was associated with increased adolescent MVPA, where more active parents had more active adolescents. As the moderators were added into these models, no significant effects emerged for parenting styles or family functioning but parental modeling of PA remained significant.

In all models, adolescents' sex was a significant covariate. The results suggest that boys had greater PA in comparison to girls for both accelerometer and self-report of MVPA (Table 10).

Table 10: Association between parental modeling of physical activity (PA) and adolescents' accelerometer and self-report of moderate-vigorous physical activity (MVPA)

		Accelerometer MVPA		Self-report MVPA	
		Model 1	Model 2	Model 1	Model 2
		SC(SE)	SC(SE)	SC(SE)	SC(SE)
Independent Variable	Parental Modeling (PA)	0.22 (0.08) p=0.00	0.21 (0.08) p=0.01	0.29 (0.08) p=0.00	0.30 (0.07) p=0.00
Moderators	Authoritative Style	--	-0.06 (0.09) p=0.54	--	0.09 (0.08) p=0.27
	Permissive Style	--	-0.02 (0.09) p=0.83	--	-0.07 (0.08) p=0.38
	Family Functioning	--	0.00 (0.10) p=0.99	--	0.12 (0.09) p=0.18
	Authoritative Style* Parental Modeling PA	--	NS	--	NS
	Permissive Style* Parental Modeling PA	--	NS	--	NS
	Family Functioning* Parental Modeling PA	--	NS	--	NS
Covariates	Adolescent sex	0.19 (0.08) p=0.02	0.23 (0.08) p=0.00	0.23 (0.07) p=0.00	0.23 (0.07) p=0.00
	Adolescent age	-0.04 (0.09) p=0.63	-0.05 (0.09) p=0.57	-0.07 (0.08) p=0.35	-0.02 (0.08) p=0.78
	Parent income	-0.05 (0.09) p=0.60	-0.06 (0.09) p=0.54	0.08 (0.08) p=0.33	0.02 (0.08) p=0.80

Footnote:
SC=Standardized Coefficient; SE=Standard Error, NS=Not significant
Model 1: Test association between parental modeling (PA) and adolescents' amount of MVPA and account for the following covariates—adolescent age, adolescent sex, parent income
Final Model: Adds to model 1 test of moderation and keeps only effects that are significant at $p < 0.1$.
*Denotes interaction term

Table 11 presents the association between parental modeling of dietary behaviours and adolescents' dietary quality and whether the association was moderated by parenting styles and family functioning. As shown in model 1 (excluding the moderators), parental modeling of dietary behaviours was significantly associated with adolescents' dietary quality. Specifically, parental modeling of healthy dietary behaviours was associated with improvements in adolescents' dietary quality. As moderators were added into the model, a significant interaction between authoritative style and parental modeling was observed for adolescents' dietary quality. Figure 9 illustrates this interaction and shows parental modeling of healthy dietary behaviours was positively associated with dietary quality among adolescents and this association was more pronounced among adolescents whose parents used a more authoritative parenting style compared to a less authoritative style. However, this effect is in the opposite direction when parents model less healthful dietary intake.

Both adolescents' age and parent income were significant covariates in the final model. The results suggest that adolescents' dietary quality decreased by 0.80% for every one unit increase in adolescents' age. Additionally, adolescents in households with incomes greater than or equal to $100,001 had better dietary quality than those adolescents in households with incomes less than $100,001 (Table 11).

Table 11: Association between parental modeling of a healthful diet and adolescents' dietary quality

		Adolescent Dietary Quality	
		Model 1	Model 2
		SC(SE)	SC(SE)
Independent variable	Parental Modeling (Diet)	0.37 (0.07) p=0.00	0.16 (0.10) p=0.10
Moderators	Authoritative Style	--	-0.11 (0.07) p=0.12
	Permissive Style	--	0.09 (0.07) p=0.18
	Family Functioning	--	0.05 (0.08) p=0.53
	Authoritative Style* Parental Modeling (Diet)	--	0.29 (0.10) p=0.00
	Permissive Style* Parental Modeling (Diet)	--	NS
	Family Functioning* Parental Modeling (Diet)	--	NS
Covariates	Adolescent sex	-0.09 (0.07) p=0.18	-0.09 (0.07) p=0.17
	Adolescent age	-0.13 (0.07) p=0.05	-0.15 (0.07) p=0.03
	Parent income	0.19 (0.07) p=0.05	0.21 (0.07) p=0.00

Footnote:
SC=Standardized Coefficient; SE=Standard Error, NS=Not significant
Model 1: Test association between parental modeling (diet) and adolescents' dietary quality and account for the following covariates—adolescent age, adolescent sex, parent income
Final Model: Adds to model 1 test of moderation and keeps only effects that are significant at $p < 0.1$
*Denotes interaction term

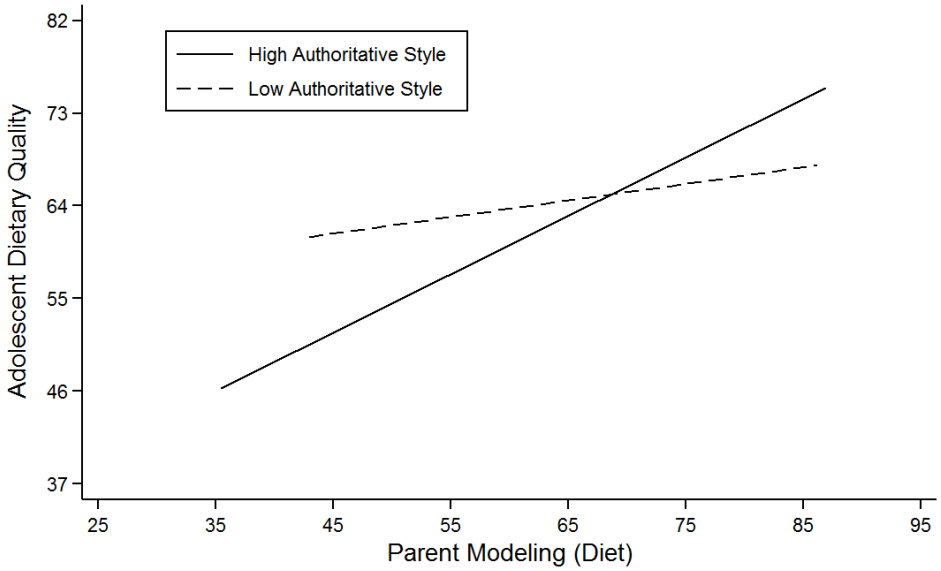

Figure 9: Graph showing how the association between adolescents' dietary quality and parental modeling of a healthful diet was moderated by an authoritative parenting style

Table 12 presents the association between parental modeling of sedentary behaviours and adolescents' sedentary behaviours and whether the association was moderated by parenting styles and family functioning. As shown in model 1 (excluding the moderators), parental modeling of screen time was significantly associated with adolescents' self-report of screen time. Specifically, parents who modelled more screen time had adolescents who spent more time in front of a screen. As the moderators were added into these models, a significant interaction between permissive style and parental modeling was observed for adolescents' sedentary time. Figure 10 illustrates this interaction and shows more sedentary time modeled by the parent was positively associated with adolescents' sedentary time but this association was pronounced among adolescents whose parents used a more permissive style compared a less permissive style. However, this effect is in the opposite direction when parents model less sedentary time. Finally, a trend towards significance (p=0.09) was observed for family functioning and adolescents' self-report screen time.

In all models, adolescents' age was a significant covariate. The final models for accelerometer sedentary time and self-report screen time suggest that for every one unit increase in adolescents' age, there was an increase of 1.8% and 34.8 minutes, respectively. Additionally, parent income was a significant covariate for screen time. Therefore, adolescents in households with incomes greater than or equal to $100,001 had decreased screen time compared to those adolescents in households with incomes less than $100,001. Finally, adolescents' sex was a significant covariate in the final model for adolescents' percent time spent sedentary. The results suggest that boys had significantly less sedentary time than girls (Table 12).

Table 12: Association between parental modeling of sedentary behaviour and adolescents' amount of sedentary behaviour

		Accelerometer Sedentary Time		Self-Report Screen Time	
		Model 1	Model 2	Model 1	Final Model
		SC (SE)	SC(SE)	SC(SE)	SC(SE)
Independent Variable	Parental Modeling (Sedentary/Screen)	0.07 (0.08) p=0.37	-0.05 (0.09) p=0.56	0.20 (0.07) p=0.00	0.21 (0.09) p=0.01
Moderators	Authoritative Style	--	0.01 (0.08) p=0.88	--	0.06 (0.08) p=0.45
	Permissive Style	--	-0.03 (0.08) p=0.71	--	0.02 (0.07) p=0.78
	Family Functioning	--	0.00 (0.08) p=0.96	--	0.13 (0.08) p=0.09
	Authoritative Style* Parental Modeling (Sedentary/Screen)	--	NS	--	NS
	Permissive Style* Parental Modeling (Sedentary/Screen)	--	0.21 (0.09) p=0.02	--	NS
	Family Functioning* Parental Modeling (Sedentary/Screen)	--	NS	--	NS
Covariates	Adolescent sex	-0.16 (0.07) p=0.28	-0.18 (0.07) p=0.02	0.07 (0.07) p=0.28	0.07 (0.07) p= 0.28
	Adolescent age	0.36 (0.07) p=0.00	0.35 (0.08) p=0.00	0.26 (0.07) p=0.00	0.30 (0.07) p=0.00
	Parent Income	-0.08 (0.08) p=0.31	-0.10 (0.08) p=0.21	-0.24 (0.07) p=0.00	-0.28 (0.07) p=0.00

SC=Standardized Coefficient; SE=Standard Error; NS=Not significant
Model 1: Test association between parental modeling of sedentary/screen time and adolescents' amount of sedentary time while considering the following covariates: adolescent sex, adolescent age, and parent income
Final Model: adds to model 1 test of moderation and keeps only effects that are significant at $p < 0.1$.
* denotes interaction term

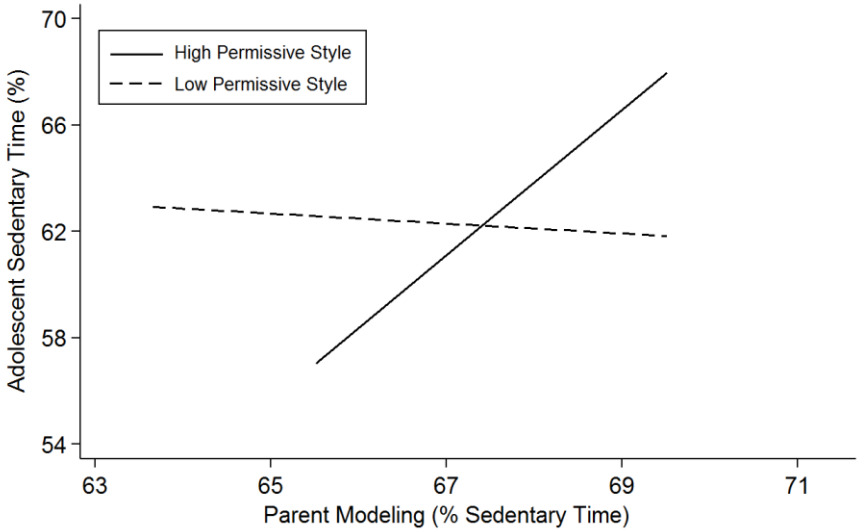

Figure 10: Graph showing how association between adolescents' amount of sedentary time and parental modeling of sedentary time was moderated by a permissive parenting style

4.6 Association Between Parenting Practices and Parental Modeling on Adolescents' Health Behaviours

Table 13 presents the association of both PA parenting practices and parental modeling of PA on adolescents' MVPA and whether these associations are moderated by parenting styles and family functioning. Model 1 (excluding the moderators) highlights that PA parenting practices and parental modeling of PA were significantly associated with self-report of MVPA. Specifically, more healthful PA parenting practices and parental modeling of PA were both associated with increased adolescents' MVPA. Although parental modeling of PA was significantly associated with adolescents' MVPA measured with accelerometry in Model 1, a trend towards significance ($p=0.07$) was observed for this relationship in the final model. When the moderators were added into the model, a significant interaction between permissive style and PA practices was observed; however, this was only observed for MVPA measured with accelerometry. Figure 11 illustrates this interaction and shows more healthful PA parenting practices were positively associated with adolescents' MVPA when parents used a more permissive parenting style than those who used a less permissive style. However, this effect is in the opposite direction when parents use less healthful PA parenting practices.

In all models, adolescents' sex was a significant covariate. Adolescent boys had significantly higher accelerometer and self-report of MVPA than adolescent girls (Table 13).

Table 13: Association between parenting practices and parental modeling of physical activity (PA) on adolescents' accelerometer and self-report of moderate-vigorous PA (MVPA)

		Accelerometer PA		Self-Report PA	
		Model 1	Final Model	Model 1	Final Model
		SC (SE)	SC(SE)	SC(SE)	SC(SE)
Independent Variables	PA Practices	0.12 (0.09) p=0.19	0.04 (0.11) p=0.75	0.33 (0.08) p=0.00	0.33 (0.08) p=0.00
	Modeling (PA)	0.19 (0.08) p=0.02	0.16 (0.09) p=0.07	0.22 (0.08) p=0.00	0.23 (0.07) p=0.00
Moderators	Authoritative Style	--	-0.12 (0.09) p=0.20	--	0.03 (0.08) p=0.71
	Permissive Style	--	-0.04 (0.09) p=0.64	--	-0.09 (0.08) p=0.22
	Family Functioning	--	-0.01 (0.10) p=0.91	--	0.12 (0.08) p=0.15
	Authoritative Style* PA Practices	--	NS	--	NS
	Permissive Style* PA Practices	--	0.23 (0.11) p=0.03	--	NS
	Family Functioning* PA Practices	--	NS	--	NS
	Authoritative Style* Modeling (PA)	--	NS	--	NS
	Permissive Style* Modeling (PA)	--	NS	--	NS
	Family Functioning* Modeling (PA)	--	NS	--	NS
Covariates	Adolescent sex	0.22 (0.01) p=0.01	0.21(0.08) p=0.00	0.18 (0.07) p=0.01	0.19 (0.07) p= 0.00
	Adolescent age	-0.01 (0.09) p=0.89	-0.05 (0.09) p=0.53	0.00 (0.08) p=0.90	0.05 (0.08) p=0.53
	Parent income	-0.06 (0.09) p=0.48	-0.03 (0.09) p=0.75	0.05 (0.07) p=0.55	-0.01 (0.08) p=0.92

SC=Standardized Coefficient; SE=Standard Error; NS=Not significant

Model 1: Test association between PA parenting practices and parental modeling of sedentary/screen time on adolescents' amount of physical activity while considering the following covariates-- Adolescent sex, age, and parent income

Final Model: adds to model 1 test of moderation and keeps only significant effects at $p < 0.1$

* denotes interaction term

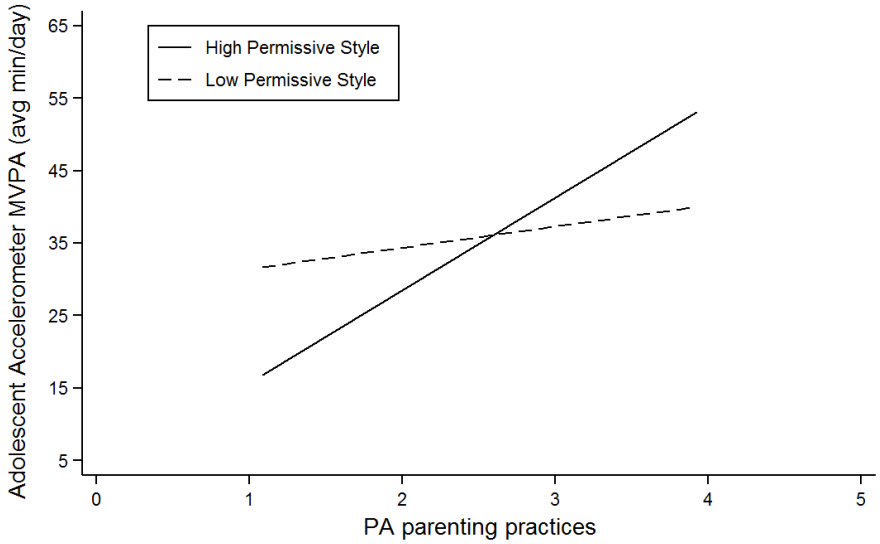

Figure 11: Graph showing how the association between adolescents' amount of moderate-vigorous physical activity (MVPA) and physical activity (PA) parenting practices were moderated by a permissive parenting style

Table 14 presents the association of both parenting practices and modeling related to eating with adolescents' dietary quality and whether these associations are moderated by parenting styles and family functioning. Model 1 (excluding the moderators) suggests that parental modeling of dietary quality was the only factor associated with adolescents' dietary quality. Specifically, parental modeling of healthy dietary habits was associated with better adolescents' dietary quality. As the moderators were added into the model, a significant authoritative style by parental modeling interaction was observed. Figure 12 illustrates this interaction and shows parental modeling of healthful dietary habits was positively associated with dietary quality among adolescents and this association was more pronounced among adolescents whose parents used a more authoritative style than those who used a less authoritative style. However, this effect is in the opposite direction when parents model less healthful dietary intake. In addition, a trend towards significance was observed for authoritative parenting style ($p=0.09$) as well as a permissive style by eating practices interaction ($p=0.07$) on adolescents' dietary quality.

Parent income was the only significant covariate in the final model. The results suggest that adolescents in households with incomes greater than or equal to $100, 001 had better dietary quality than adolescents in households with incomes less than $100,001 (Table 14).

Table 14: Association between eating practices, breakfast practices, and parental modeling of a healthful diet on adolescents' dietary quality

		Adolescent Dietary Quality	
		Model 1	Model 2
		SC (SE)	SC(SE)
Independent Variables	Eating Practices	0.01 (0.07) p=0.93	-0.07 (0.08) p=0.39
	Breakfast Practices	0.12 (0.07) p=0.12	0.11 (0.07) p=0.11
	Parental Modeling (Diet)	0.35 (0.07) p=0.00	0.14 (0.10) p=0.16
Moderators	Authoritative Style	--	-0.12 (0.07) p=0.09
	Permissive Style	--	0.12 (0.07) p=0.10
	Family Functioning	--	0.04 (0.08) p=0.59
	Permissive Style* Eating Practices	--	0.15 (0.08) p=0.06
	Authoritative Style* Eating Practices	--	NS
	Family Functioning* Eating Practices	--	NS
	Authoritative Style* Breakfast Practices	--	NS
	Permissive Style* Breakfast Practices	--	NS
	Family Functioning* Breakfast Practices	--	NS
	Authoritative Style* Parent Modeling (Diet)	--	0.30 (0.09) p=0.00
	Permissive Style* Parental Modeling (Diet)	--	NS
	Family Functioning* Parental Modeling (Diet)	--	NS
Covariates	Adolescent sex	-0.10 (0.07) p=0.15	-0.08 (0.07) p=0.26
	Adolescent age	-0.11 (0.07) p=0.13	-0.13 (0.07) p=0.07
	Parent Income	0.18 (0.07) p=0.01	0.23 (0.07) p=0.00

SC=Standardized Coefficient; SE=Standard Error; NS=Not significant
Test association between eating practices, breakfast practices, and parental modeling (diet) on adolescents' dietary quality while considering the following covariates: adolescent sex, age, and parent income
Final Model: adds to model 1 test of moderation and keeps only effects that are significant at $p < 0.1$.
*denotes interaction term

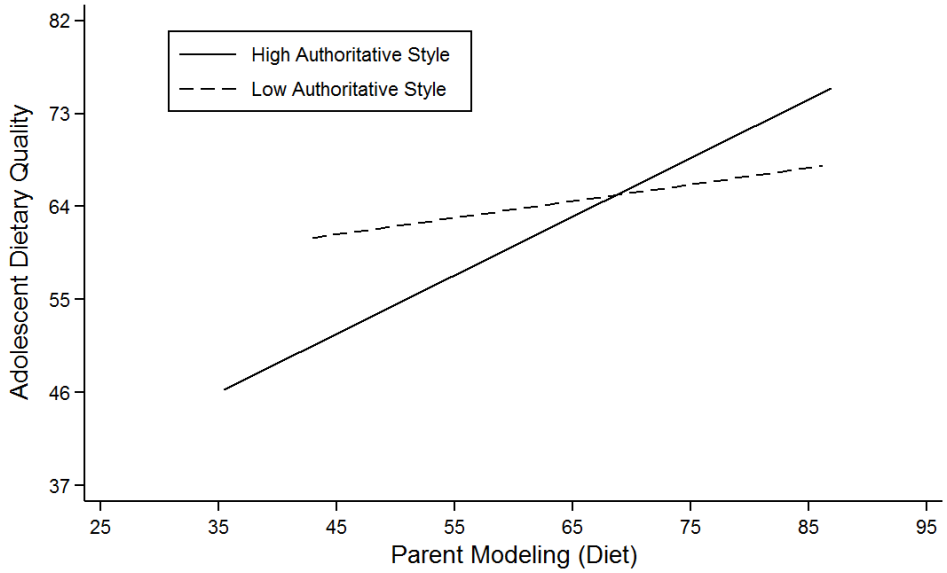

Figure 12: Adolescents' dietary quality as a function of parental modeling of healthful dietary habits and authoritative parenting style

Table 15 presents the association of both parenting practices and modeling related to sedentary behaviours on adolescents' sedentary behaviours and whether these associations were moderated by parenting styles and family functioning. Model 1 (excluding the moderators) suggests that both screen time parenting practices and parental modeling of screen time were significantly associated with adolescents' screen time but not associated with adolescents' percent sedentary time. Specifically, more healthful screen time parenting practices and parental modeling of less screen time were both associated with decreased screen time. As the moderators were added into the model, a significant main effect of family functioning was observed for adolescents' screen time. This suggests that high family functioning was positively associated with adolescents' screen time compared to those with low family functioning. Also, a significant interaction between permissive style and screen time parenting practices was found. Figure 13 illustrates this interaction and shows that screen time parenting practices were positively associated with adolescents' sedentary time but this association was more pronounced among adolescents whose parents used a more permissive style than those who used a less permissive style. Finally, a significant permissive style by PA parenting practices interaction emerged. Figure 14 illustrates this interaction and shows parents who modeled more sedentary time was positively associated with adolescents' sedentary time but this association was more pronounced among adolescents whose parents used a more permissive parenting style compared to a less permissive style. However, this effect is in the opposite direction when parents modeled less sedentary time.

In all models, adolescents' age was a significant covariate. The final models for accelerometer sedentary time and self-report screen time suggest that for every one unit increase in adolescents' age, there was an increase of 1.7% and 34.8 minutes, respectively. Additionally, parent income was a significant covariate in both models for self-report screen time. Therefore, adolescents in

households with incomes greater than or equal to $100,001 had decreased screen time compared to those adolescents in households with incomes less than $100,001. Finally, adolescent sex was a significant covariate in the final model for adolescent accelerometer sedentary time. The results suggest that boys had significantly less sedentary time girls (Table 15).

Table 15: Association between screen time practices and parental modeling (sedentary behaviours) on adolescent objectively measured percent of sedentary time and self-report screen time

		Accelerometer Sedentary Time		Self-report screen Time	
		Model 1	Model 2	Model 1	Final Model
		SC (SE)	SC(SE)		SC (SE)
Independent Variables	Screen Time Practices	0.05 (0.08) p=0.50	-0.09 (0.08) 0.29	-0.19 (0.07) p=0.00	-0.08 (0.10) p=0.44
	Parent Modeling (Sedentary/Screen)	0.67 (0.78) p=0.50	-0.07 (0.09) p=0.45	0.16 (0.07) p=0.02	0.15 (0.07) p=0.03
Moderators	Authoritative Style	--	-0.03 (0.08) p=0.69	--	0.07 (0.08) p=0.35
	Permissive Style	--	-0.00 (0.08) p=0.95	--	0.03 (0.07) p=0.67
	Family Functioning	--	0.04 (0.08) p=0.62	--	0.16 (0.08) p=0.04
	Authoritative Style* Screen Time Practices	--	NS	--	NS
	Permissive Style* Screen Time Practices	--	0.25 (0.09) p=0.00	--	NS
	Family Functioning* Screen Time Practices	--	NS	--	NS
	Authoritative Style* Modeling (Sedentary/Screen)	--	NS	--	NS
	Permissive Style* Modeling (Sedentary/Screen)	--	0.17 (0.09) p=0.05	--	NS
	Family Functioning* Modeling (Sedentary/Screen)	--	NS	--	NS
Covariates	Adolescent sex	-0.15 (0.75) p=0.05	-0.15 (0.07) p=0.05	0.03 (0.07) p=0.63	0.04 (0.07) p=0.56
	Adolescent age	0.36 (0.07) p=0.00	0.35 (0.07) p=0.00	0.25 (0.07) p=0.00	0.28 (0.07) p=0.00
	Parent Income	-0.07 (0.08) p=0.34	-0.07 (0.08) p=0.37	-0.27 (0.07) p=0.00	-0.31 (0.07) p=0.00

SC=Standardized Coefficient; SE=Standard Error; NS=Not significant
Model 1: Test association between screen time practices and parental modeling (sedentary behaviours) on adolescents' sedentary behaviours while considering the following covariates: adolescent sex, age, and parent income
Final Model: adds to model 1 test of moderation and keep only significant interactions <0.1
*denotes interaction term

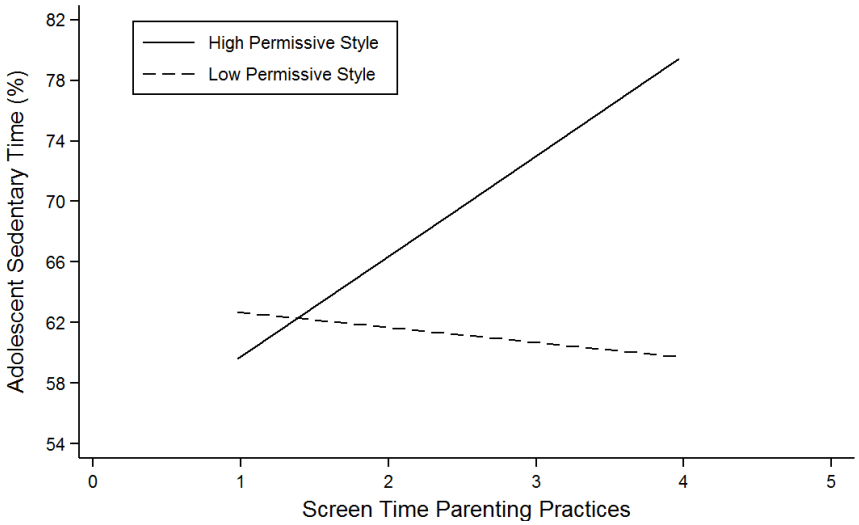

Figure 13: Adolescents' percent of sedentary time as a function of screen time practices and permissive style

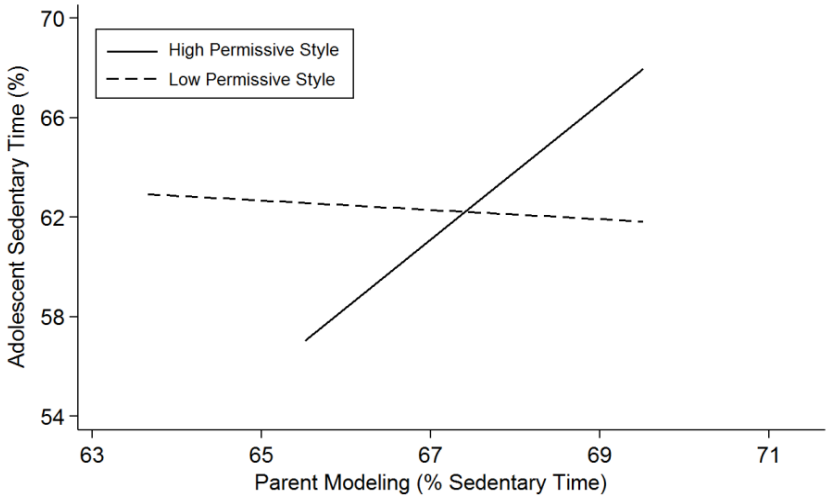

Figure 14: Adolescents' percent of sedentary time as a function of parental modeling (percent sedentary time) and permissive style

4.7 Summary of Results (Final Models Only) for Adolescents' MVPA, Dietary Quality, and Sedentary Behaviours

Table 16 highlights consistency and inconsistency in the findings across health behaviours. Key highlights are as follows: 1) both parenting practices and parental modeling are significantly associated with adolescents' health behaviours, 2) in many instances, the effect of either parenting practices or parental modeling were moderated by parenting styles (either permissiveness or authoritative styles) except for self-report of MVPA, 3) family functioning was not observed as a moderator in any of the associations when both practices and modeling were included together.

Table 16: Overview of results (final models only)

	Moderate-Vigorous Physical Activity		Dietary Quality	Sedentary Behaviour	
	Objective	Self-report		Objective	Self-report
AIM 1					
Parenting Practices (PP)		X +			
Parenting Styles*PP	X + (Permissive)			X + (Permissive)	X - (Authoritative)
Family Functioning*PP			X +		
Adolescent sex	X b > g	X b > g			
Adolescent age			X -	X +	X +
Parent income			X +		X -
AIM 2					
Parental Modeling (PM)	X +	X +			X +
Parenting Styles*PM			X + (Authoritative)	X + (Permissive)	
Family Functioning*PM					
Adolescent sex	X b > g	X b > g			X b < g
Adolescent age			X -	X +	X +
Parent income			X +		X -
AIM 3					
Parenting Practices (PP)		X +			
Parenting Styles*PP	X + (Permissive)		~ + (Permissive)	X + (Permissive)	~ - (Authoritative)
Family Functioning*PP					
Parental modeling	~ +	X +			X +
Parenting Styles*PM			X + (Authoritative)	X + (Permissive)	
Family Functioning*PM					
Adolescent sex	X b > g	X b > g			X b < g
Adolescent age			~ -	X +	X +
Parent income			X +		X -

* denotes interaction effect

X= significant effect, ~ =trend towards significance

+ = increase; - = decrease

b= boys; g=girls

Parent income: reference group is lower income

Chapter 5: Discussion

The purpose of this study was to examine the effect of both parenting practices and parental modeling on the health behaviours of overweight/obese adolescents, while considering the moderating effects of parenting styles and family functioning. Consistent with other studies,[152–154] parenting practices and parental modeling of health behaviours were positively associated with adolescents' health behaviours. In many instances, these associations were moderated by parenting styles (authoritative or permissive) with little evidence of family functioning as a moderator. However, the parenting style interactions only partially supported the hypotheses, meaning that a supportive parenting style was associated with more healthful adolescents' health behaviours only when parents modeled healthful behaviours or used supportive parenting practices. Finally, inconsistent effects were observed when MVPA was measured with different assessment tools (accelerometry or self-report questionnaires). For instance, parenting styles only moderated the relationship between parenting practices and adolescents' MVPA when MVPA was measured with accelerometry and not with self-report. The results from this study provide some insight into the parent-level mechanisms that are important for shaping adolescents' health behaviours as well as which factors should be considered in future family-based obesity interventions.

5.1 Associations with Either Parenting Practices or Parental Modeling

This study investigated whether parenting practices and/or parental modeling were associated with adolescents' health behaviours. One of the key findings of this study was that both parenting practices and parental modeling appeared to be associated with obesity-related health behaviours in a sample of overweight/obese adolescents. This section discusses how the current

findings align with previous studies and why parenting practices and parental modeling are likely both important in shaping overweight/obese adolescents' health behaviours.

With respect to PA, both parenting practices and parental modeling of PA were positively associated with adolescents' behaviours. These findings were consistent for accelerometer and self-report with the exception of a trend towards significance for the association between parental modeling and adolescent MVPA measured with accelerometry (p=0.07). The few studies that have explored both practices and modeling together in the context of PA report conflicting results in comparison to the present study. Previous studies have reported that the importance of parental modeling is diminished by other constructs, such as parental encouragement and support.[152,171,172] For instance, a study conducted among grade 7-12 students found parenting practices, namely parental support, to be more influential than parental modeling.[152] However, these studies targeted a general sample of adolescents while the present study focused on overweight/obese adolescents, which may explain the discrepancies. It may be that parents who are more active or model an active lifestyle are in a better position to support their overweight/obese adolescents' health behaviours as they can, for example, be active together. On the other hand, adolescents who are not overweight/obese may only need support from their parents to be physically active, such as transportation to a playground, while overweight/obese adolescents may need the additional modeling component to enhance their drive and motivation to be active. Therefore, the combination of parental modeling along with specific parenting practices such as taking the child to an appropriate location for PA or encouragement, may be necessary to influence the activity of overweight/obese adolescents.

For sedentary behaviours, the results suggest that both parenting practices and parental modeling were associated with adolescents' self-report and accelerometry measured sedentary behaviours. However , a trend towards significance was observed between parenting practices and adolescents' screen time. Previous studies that investigated the association of parenting practices and parental modeling on children's sedentary behaviours have predominantly focused on younger children. Findings from a systematic review suggest that both parenting practices and parental modeling are associated with screen time behaviours of young children.[154] Limited studies among adolescents have also focused on screen time and found support for both parenting practices[173] and parental modeling.[10] For instance, having clear rules, setting limits on screen time, and not having screen- based media in the bedroom were associated with fewer hours of screen time for adolescents.[173] Additionally, a study by Tu and colleagues found associations between parent-adolescent video game time on weekends and computer time on weekdays.[10] This study is one of the few that examined both screen and sedentary times among adolescents and jointly assessed parenting practices and parental modeling. Therefore, it is evident that both parenting practices and parental modeling appear to be important influences of adolescent sedentary behaviours (i.e., screen and sedentary times).

With respect to dietary habits, only parental modeling of dietary behaviours was associated with adolescent dietary quality. However, a trend towards significance was also observed between parenting practices and adolescent dietary quality ($p=0.07$). The majority of the literature suggests that both parenting practices and parental modeling of dietary behaviours are related to adolescents' dietary behaviours.[153,174–178] Specifically, a number of studies have identified both parental modeling and parenting practices, such as home availability of foods (i.e., fruits and

vegetables) to be associated with adolescent's intake of fruits, vegetables, and dairy intake.[153,174–178] The current study did not examine intake of specific dietary components but instead examined the whole diet, which may partly explain the discrepancies with the findings of the previous study. Other findings suggest parenting strategies such as encouragement, restrictive, or negotiating practices along with parental modeling are related to dietary quality among overweight or obese adolescents.[178,179] However, further studies are needed to verify whether both parenting practices and parental modeling are consistently associated with adolescents' dietary quality, given that a trend towards significance was observed for parenting practices.

The study suggests that both parenting practices and parenting modeling were associated with adolescents' health behaviours and in the two instances where this was not fully supported, there were trends towards significance (p=0.07). Even in adolescence, parental influences were observed and the findings highlight that it is important to intervene on the familial environment and encourage parents to using supportive parenting practices as well as model healthy behaviours.

5.2 Moderating Effects of Family Functioning

One of the main hypotheses of this study was that family functioning would moderate the relationship between parenting practices and/or parental modeling and adolescents' health behaviours. However, family functioning did not emerge as an important moderator for most health behaviours, except for the relationship between breakfast parenting practices and adolescents' dietary quality, but this effect disappeared when both parenting practices and parental modeling were entered into the model. Although not identified as a moderator, a direct effect of high family functioning appeared to be associated with increased screen time among

adolescents. According to past literature, limited studies have examined the moderating effects of family functioning.[13,180]Although not directly targeting overweight/obese adolescents, Loth and colleagues found significant effect modification by overall family functioning for the association between family meals and unhealthy weight control behaviours (e.g., eating very little food or skipping meals).[180] Although no research to date has examined the moderating effect of family functioning in the treatment of pediatric obesity, a review by Kitzmann and colleagues points to indirect evidence for this assertion.[13] For instance, correlational research suggests that compared to normal-weight children, overweight/obese children are more likely to experience more family conflict and less family cohesion.[181,182] Although the directionality of this effect remains unclear, these correlations suggest that families with an overweight child may need additional help to effectively manage or support the health behaviours of their child.[13] While this review suggests family functioning is an important moderator for adolescent health behaviours, the evidence is currently mixed and sparse.[13,122] Although family functioning was not found to moderate any of the parent-adolescent associations, this may be partly explained by the characteristics of the sample. The sample predominantly included families that were mostly balanced on both the cohesion and flexibility scales. Thus, it may be that in this study, families in each high or low functioning group may not be all that different. Therefore, future studies should ensure a more diverse sample in terms of family adversity to capture families that truly fit into the high or low family functioning groups to further examine the potential role of family functioning.

5.3 Moderating Effects of Parenting Styles

The study examined whether parenting styles moderated the association between parenting practices and/or parental modeling on adolescents' health behaviours. Overall, parenting styles was a significant moderator and for many of the health behaviours – it moderated either or both the effects of parenting practices and/or parental modeling of health behaviours. However, the parenting style interactions were only partially consistent with the study hypotheses. These findings are discussed below.

5.3.1 Consistency of Parenting Style Interactions with Study Hypotheses

A majority of the associations between parenting practices and/or parental modeling on adolescents' health behaviours were moderated by parenting styles, however, all were partially consistent with the study hypotheses. These findings highlight that the moderating effect of parenting styles on the association between parenting practices and modeling on adolescents' health behaviours was more complex than anticipated. In some cases, moderation was observed in the opposite direction. Instead of amplifying the effect of healthful parenting practices, parenting styles had the opposite effect. For instance, it made more healthful parenting practices associated with less healthful behaviours (e.g., associated with more sedentary time among adolescents). A potential explanation for this finding may be that in adolescence, these associations are more complex and a time when parents have to readjust their parenting practices as more unhealthful behaviours emerge (e.g., screen time). Therefore, it may be that more permissive parents have just started to implement more healthful screen time practices in response to their child's behaviour instead of having established practices which can partly explain the findings of this study. As a result, healthful parenting practices may be more

effective if they have been established early on, rather than only being used to deal with emerging issues (e.g., high sedentary time).

In terms of PA, two other studies have reported similar results, suggesting that more healthful practices performed in a more permissive way are associated with more adolescent MVPA.[147,148] According to Hennessy and colleagues, two types of PA parenting practices (monitoring and reinforcement) were associated with child accelerometer PA when expressed in the context of a permissive parenting style.[147] Similar findings were also observed by Langer and colleagues who found parental support was only associated with adolescent PA when expressed in the context of a permissive parenting style.[148] One potential explanation for this finding may be that that permissive parenting characterized by high warmth and low demand is associated with more unstructured playtime and more enjoyable activities.[149] Therefore, being permissive in the context of PA may provide adolescents with more free time for active play and if they feel encouraged and supported by their parent with respect to PA, they may choose to be physically active.

In terms of dietary quality, a number of studies have supported the notion that food parenting strategies are related to healthier eating when exercised in an authoritative parenting context.[183–186,187] Interestingly, this was only apparent for those adolescents whose parents modeled the most healthful dietary habits. Thus, it may be that parents with an authoritative style are better able to influence their adolescents' health behaviours when they model more healthful behaviours in conjunction with a more authoritative style. Thus a parents' style has the potential to alter how children view their parents' behaviours and ultimately respond to these behaviours.

5.4 Inconsistency of Effects Within Behaviours

The association between PA parenting practices, styles, and adolescents' MVPA was only observed when adolescents' MVPA was measured by accelerometry. While both accelerometer and self-report measures have been validated to assess PA, there are clear differences in the two measures. For instance, accelerometer data gives more accurate estimates of walking-based activities and avoids many of the issues that go along with self-report such as recall and response bias.[188] However, it is important to highlight that accelerometers are unable to capture certain types of activities such as swimming and activities involving the use of upper extremities. Compared to direct measures, self-report methods appear to estimate greater amounts of higher intensity (i.e. vigorous) PA than in the low-to-moderate levels.[188] The main difference in the present study is that the self-report MVPA interaction with parenting practices and styles did not appear while it was found with the accelerometer. Measurement error with self-report tends to be higher as noted by the increased chance of recall and response bias which may lead to decrease power and perhaps explain why a significant interaction was not observed with the self-report data.

5.5 Covariates

The covariates that were associated with adolescents' health behaviours are described in this section. First, the study found that adolescents' sex was significantly related to PA of adolescents. Specifically, this study found that boys had significantly higher PA levels than girls. The majority of studies that have examined a sex effect on adolescents' PA are consistent with the findings of this study. Among a Canadian sample of normal weight children, boys in grade 3, 7, and 11, respectively, spent 9, 22, and 27% more time in MVPA than girls.[189] Additionally,

data from the 2007-2009 CHMS survey of Canadian children and youth suggests that 9% of boys and 4% of girls accumulate at least 60 minutes of MVPA on 6 or more days a week.[39] Although limited, similar findings were also observed in a sample of overweight/obese adolescents.[190] A potential explanation for these findings may be that as a society, boys are generally expected and encouraged to be active while less emphasis is placed on girls. For instance, girls may play less energetically and prefer to chat with one another. Thus, it appears that Canadian boys engage in more PA than girls and this is also observed in a sample of overweight/obese adolescents.

Second, study findings suggested that adolescents' age was inversely related to dietary quality of adolescents. According to a recent systematic review, children of younger ages are shown to have better dietary quality than older children.[191] A study conducted among a large sample of 9 to 14 year olds in the US, found younger children were more likely to have a higher score on the Healthy Eating Index.[192] Similar findings were also observed in a study by Bastiotis and colleagues that reported a mean value of the Healthy Eating Index score was 66 for children aged 7-10 years and lower (around 61) for those aged 11-14 years.[187] These findings may be apparent because younger children typically stay around home where parents can monitor their eating habits, resulting in better dietary quality. In comparison, older children may be more autonomous and make more independent choices about what they eat (e.g., eating chips after school when parents are not around). As a result, it is evident that age may play a role in adolescents' dietary quality.

Third, the study found that family income was significantly related to adolescents' dietary quality. Specifically, we found that adolescents in households with incomes greater than or equal to $100,001 had better dietary quality than adolescents in households with incomes less than

$100,001. According to a systematic review of dietary indexes, children from high-income families have consistently reported better dietary quality scores.[191] Additionally, a study of US children and adolescents report that those individuals from higher household income groups had significantly higher Healthy Eating Index compared to those from the lower Healthy Eating Index groups.[193,194] A potential explanation for this may be attributed to the fact that higher quality or healthier foods are typically more expensive, and those households with higher incomes may be more willing to purchase these healthier foods, which in turn contributes to a higher dietary quality overall for adolescents. With this being said, income also appears to be associated with dietary quality among overweight or obese adolescents.

The study also found that age was positively associated with adolescents' sedentary and screen time. This pattern has been consistently shown in a number of studies. According to Caspersen and colleagues,[195] the amount of leisure inactivity significantly increases in US children from ages 14 to 20 years. Findings from another study reported that boys aged 6–11, 12–15 and 16–19 years spent 6.0, 7.4 and 7.9 h/day, respectively, in sedentary behaviour.[168] Girls in the same age groups spent 6.1, 7.7 and 8.1 h/day, respectively, in sedentary behaviour.[168] Additionally, older children (13-17 years) showed a higher prevalence of physical inactivity and time spent with screen time of ≥2h/day when compared to their younger counterparts aged 8–12.[196] As a result these findings may be due to the fact that as adolescents get older, they may prefer to engage in more screen time with friends compared to when they were younger. Thus, these findings taken together suggest that age plays a role in adolescents' sedentary pursuits.

Finally, the study found that adolescents in households with incomes greater than $100,000 had less screen time than adolescents in households with incomes less than $100,000. According to a

US study by Gordon-Larsen,[197] consisting of a study population of nationally representative data, high family incomes were associated with decreased likelihood of falling in the highest category of inactivity. Additionally, a study found that more children in lower SES households had a TV, DVD/VCR player, and video game system in their bedrooms compared to children of higher SES.[198] A potential explanation for these findings may be that higher income parents may be more educated and aware of the health effects and recommendations of screen time use, and have decided that children should not have them in their bedrooms. Therefore, according to the current study findings and others,[197,198] income does play a role in adolescents' screen time behaviours.

5.6 Limitations

The findings of this study should be interpreted in light of the study limitations. First, the study targeted a sample of overweight or obese adolescents who volunteered to participate in a lifestyle modification intervention aimed at improving their health behaviours and reducing weight. Therefore, study findings are only generalizable to those families willing to participate in a weight loss intervention and change their lifestyles. Second, due to the cross-sectional nature of the study, it is difficult to make any inferences about causality. For instance, the relationship may be bi-directional since as studies point out, parents and children constantly shape and reshape each other through their mutual actions and reactions.[199,200] Third, measurement errors may have biased study results. MVPA and sedentary behaviour were assessed with both subjective (self-report) and objective (accelerometer) measures. Self-report measures are subject to reporting biases, such as recall and social desirability bias, since individuals are known to have poor recall of past PA levels and tend to overestimate these behaviours (biased reporting and low validity), respectively.[201,202] Therefore, inconsistency in our results may be due to these various forms of

measurement error. Additionally, self-reported dietary recall is subject to social desirability, which suggests that overweight or obese adolescents may not adequately report all the food they consume. Despite this challenge, the private and anonymous feature of the web-based dietary recall tool may have helped reduce such bias. Fourth, measurement issues were also apparent among the various parenting measures. The current study was limited to examining only two types of parenting styles while much of previous research has measured parenting styles according to the four prototypes developed by Baumrind (authoritative, permissive, authoritarian, and neglectful).[132] Given that the current study only examined two parenting styles on a continuum, it may be difficult to capture the true parenting style of the parent. Additionally, since authoritative parenting style was assessed on a continuum (low to high), we were unable to know the extent to which the high end of the authoritative style scale was measuring an unhealthy parenting style (very controlling style such as being authoritarian). Additionally, low reliability (low Cronbach's alphas) were apparent for some of the parenting practice scales. Although the measure has been validated, modifications were made, and the psychometric properties had to be re-examined. After modifications were made, a limited number of items captured each behaviour-specific parenting practice which may contribute to the low alpha. Finally, all parenting measures (practices, styles, and family functioning) were only administered to the parents and if these measures were administered to the adolescents, a different perspective might have emerged. The study would have benefited from considering the adolescents' perspective and investigating the similarities and differences between parent and child responses on the parenting measures.

5.7 Strengths

This study has a number of strengths. First, this is the first study to explore the moderating effects of both parenting styles and family functioning on adolescents' health behaviours. Understanding how parenting practices and modeling interact with styles and functioning on adolescents' health behaviours provides useful information for the development of interventions. Second, this is one of the only studies that examined these moderating effects in a sample of overweight or obese adolescents, which is essential when trying to design effective weight-management interventions. Third, this study is one of the few to use both accelerometers and self-report to directly measure and compare both parent and adolescents' PA levels and sedentary time. Finally, the study examined multiple health behaviours (PA, sedentary, and dietary behaviours), which provides a more complete picture and explores the similarities and differences across adolescent health behaviours.

5.8 Implications and Recommendations for Future Research

Due to the exploratory nature of this study, further research is required to look more closely at the important relationships that emerged in the present study. A number of improvements in design and measures should be considered in future studies.

First, obtaining a larger sample of parent-adolescent dyads is essential to obtain more power. Second, studies should consider targeting recruitment to obtain more diversity in family types with respect to family functioning and parenting styles. Third, future studies should administer the parenting measures to both parents and children, to examine concordance in child- and parent-reports of parenting and health behaviours. This is important, since the way children

perceive their parents' practices and styles, as well as family functioning, may differ from parents' views.

Future studies in this area may also benefit from different measures of parenting practices and parenting styles. Although the parenting practices measure used in the current study has been validated, future research should consider using a measure that assesses specific parenting practices (e.g., monitoring or restriction) rather than measuring practices on a continuum of more or less healthful. A more specific measure would provide a better sense of which parenting practices are most influential on adolescents' health behaviours as well as whether specific practices are moderated by parenting styles in different ways. Additionally, future research should use a measure that assesses all four parenting styles (authoritarian, authoritative, permissive, and neglectful), to provide a more complete profile of the styles that parents adopt. Finally, future studies should not only examine the effect of family-level mechanisms on overweight/obese adolescent health behaviours, but should be expanded to assess change in behaviours among adolescents over time.

Findings from this study offer implications for intervention development. First, interventionists (e.g., nurse practitioners) should consider parenting factors when counselling families with an overweight or obese adolescent. As part of family-based interventions, interventionists should encourage parents to not only provide support for their child's PA, dietary quality, and sedentary behaviours but modify their own health behaviours. Secondly, family context, specifically, parenting style, may help improve the efficacy of family-based interventions. For instance, it may be helpful for interventionists to educate parents on how different parenting styles can elicit

different health behaviours in conjunction with parenting practices and modeling to elicit healthful behaviours from their overweight/obese adolescents. Therefore, the practical implications of this study add to potential guidance for the development of future family-based interventions.

Chapter 6: Conclusion

Research on family-level mechanisms that influence adolescents' health behaviours has been fairly limited among overweight or obese adolescents as most of the research has focused on younger children. Although the majority of the research has considered the effects of parenting practices and modeling independently,[12,13] study results suggest that when considered jointly, both parenting practices and parental modeling are important influences of overweight/obese adolescent health behaviours. Additionally, this study adds to the literature by providing support for the idea that the familial context, specifically parenting style, modifies these associations. However, since evidence of moderation was not consistent across all associations, it would be important to replicate these findings in a larger sample of overweight/obese adolescents and their parents. Furthermore, it would be helpful to further understand the mechanisms of these associations and how children's attributes (e.g., personality) can play a role in parenting style.

The theoretical model proposed in Figure 1 was not fully supported in this study. Although findings supported the moderating role of parenting style on the relationships between parenting practices, parental modeling, and adolescents' health behaviours, the effect of family functioning was not apparent. Given that the findings did not confirm the role of family functioning and the sample lacked variance with respect to family functioning, future research should use a more diverse sample of families to provide clearer insight as to how family functioning can influence these associations.

When it comes to examining the effectiveness of family-based interventions, mixed results have been reported.[92,107] One reason may be that interventions have not accounted for certain factors, such as parenting styles, which may alter the effectiveness of the parenting practices or modeling

targeted in the intervention. Therefore, the efficacy of obesity interventions may be improved if interventions not only target parenting practices and parental modeling, but also emphasize the importance of family context in shaping adolescents' health behaviours to ultimately manage weight outcomes.

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Appendix A

A.1 MySteps® Family Practices Survey[155]

MySteps Eating and Physical Activity Habits

Instructions: Read both statements in the middle of each row. Choose which one is most true for your family. Subsequently, select how true the statement is (sort of true or really true).

Really true for my child	Sort of true for my child			Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children eat breakfast on most days	Other children rarely eat breakfast	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children drink sodas or other sweetened drinks	Other children rarely drink sodas or other sweetened drinks	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children drink milk with their meals or snacks	Other children rarely drink milk with their meals or snacks	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children watch television	Other children rarely watch television	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children play on the computer or with video games	Other children rarely play on the computer or with video games	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children participate in organized sports or activities with a coach	Other children rarely participate in organized sports or activities with a coach	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some children spontaneously participate in physical activity in their free time	Other children rarely participate in physical activity in their free time	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families typically eat breakfast together	Other families rarely eat breakfast together	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families regularly eat at fast food restaurants	Other families rarely eat at fast food restaurants	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families typically eat while watching TV	Other families rarely eat while watching TV	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families usually eat fruits and vegetables with meals (or as snacks)	Other families rarely eat fruits and vegetables with meals (or as snacks)	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families use prepackaged foods for meals	Other families rarely use prepackaged foods for meals	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families regularly eat dessert after dinner	Other families rarely eat dessert after dinner	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families regularly eat dessert in the evening	Other families rarely eat dessert in the evening	Sort of true for my child	Really true for my child
Really true for my child	Sort of true for my child	Some families play games outside, ride bikes, or walk together often	Other families rarely play games outside, ride bikes, or walk together	Sort of true for my child	Really true for my child

A.2 Authoritative Parenting Scale Items from the MySteps® Parent Survey[159]

Please indicate the extent to which you never, sometimes, often, or always do the following:

	Never	Sometimes	Often	Always
1. I want to hear about my child's problems	☐	☐	☐	☐
2. I make sure my child tells me where he/she is going	☐	☐	☐	☐
3. I usually know where my child is after school	☐	☐	☐	☐
4. I tell my child when he/she does a good job on things	☐	☐	☐	☐
5. I am interested in my child's school work	☐	☐	☐	☐
6. I check to see if my child does his/her homework	☐	☐	☐	☐
7. I often ask my child what he/she does with friends	☐	☐	☐	☐
8. I make my child feel better when he/she is upset	☐	☐	☐	☐
9. I tell my child that I like my child just the way he/she is	☐	☐	☐	☐
10. I am usually pleased with how my child behaves	☐	☐	☐	☐
11. I tell my child times when he/she must come home	☐	☐	☐	☐
12. It is hard for me to say 'no' to my child	☐	☐	☐	☐
13. I am always telling my child what to do	☐	☐	☐	☐
14. I make rules without asking my child what he/she thinks	☐	☐	☐	☐
15. I forget the rules I make for my child	☐	☐	☐	☐
16. I can be talked into things easily	☐	☐	☐	☐