AN EXAMINATION OF USER AND HOUSEHOLD CHARACTERISTICS ASSOCIATED WITH ADOLESCENTS' ADOPTION AND USAGE OF A LIFESTYLE BEHAVIOUR MODIFICATION APP

by

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BHSc (Hons.), University of Calgary, 2017

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Population and Public Health)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

June 2019

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An Examination of User and Household Characteristics Associated with Adolescents' Adoption and Usage of a Lifestyle Behaviour Modification App

submitted by Camilla Piatkowski in partial fulfillment of the requirements for

the degree of Master of Science

in Population & Public Health

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Abstract

Background: Adolescent obesity continues to be a major public health problem within Canada; therefore, effective solutions are required. E-health interventions can provide Canadian adolescents (13-17 years old) with personalized support to help them modify their obesogenic behaviours. However, predictors of app adoption and usage among adolescents have not been extensively examined.

Objective: This study aimed to examine user and household characteristics associated with adolescents' adoption and usage of the Aim2Be© app; a health behaviour modification intervention delivered through a smartphone app.

Methods: 371 adolescent-parent dyads completed baseline assessment and were provided with access to the Aim2Be© app. Mean adolescent age was 14.9 years and 50.1% were male (n=186). Mean adult age was 44.1 years and 34.7% were male (n=129). Multivariable logistic and linear regressions, along with path analyses, were used to determine characteristics that were significantly associated with app adoption and usage, respectively. Additionally, analyses were stratified by parent's sex. Univariable analyses were conducted in Stata (v.13.1), while path analyses were conducted in Mplus (v.8). All models were adjusted for adolescent's age and sex, and a significance level of 5% was used.

Results: 79.2% of adolescents (n=294) adopted the Aim2Be© app. When examining user characteristics, adolescent engagement in healthy behaviours was directly associated with increased odds of app adoption (OR=1.08; 95%CI=1.01-1.14). Autonomous motivation was

indirectly associated with app adoption (OR=1.02; 95%CI=1.00-1.04). When examining parenting practices, mediated through user characteristics, autonomy supportive practices were associated with increased app usage (β=0.21; 95%CI=0.07-0.36), while structure practices were indirectly associated with increased odds of app adoption (OR=1.02; 95%CI=1.00-1.04). When the analyses were stratified by parent's sex, differences in the associations emerged.

Conclusions: Both user characteristics and parenting practices were significantly associated with adolescents' app adoption and/or usage. The findings of this study will help inform future e-health interventions increase user engagement by identifying the characteristics of individuals who are not accessing the intervention, as well as identifying factors of the household environment that support long-term intervention use. This information will fill an important gap within the literature, as high attrition rates are commonly reported among e-health interventions and can consequently jeopardize program effectiveness.

Lay Summary

With 1 in every 3 Canadian youth classified as overweight or obese, effective solutions are greatly needed to tackle this childhood obesity epidemic. E-health interventions (i.e., interventions that are accessed through the internet) can provide Canadian teens with resources and personalized support to help them live a healthy and active lifestyle. However, very few studies have looked at the individual and household characteristics that influence teens' adoption and usage of a health promoting app.

Teen traits and parenting practices were associated with teen's adoption and/or usage of the Aim2Be© app. As well, these associations differed when mothers and fathers were examined separately. These results helped to identify teens who were not accessing the intervention, as well as identify key aspects of the household environment that support long-term use of the Aim2Be© app. Intervention planners should take these results into consideration and make appropriate modifications, in order to improve user engagement.

Preface

This thesis contains the original work completed by the author, Camilla Piatkowski, under the supervision of Dr. Louise Mâsse with guidance from Dr. Guy Faulkner and Dr. Martin Guhn. This thesis used data from the *Living Green and Health for Teens (LiGHT)* project which was conducted by Dr. Louise Mâsse, with the help of other research staff at BC Children's Hospital Research Institute. Sections of this thesis will be submitted for publication in peer-reviewed journals.

Living Green and Healthy for Teens (LiGHT) was approved by the University of British Columbia Children's and Women's Research Ethics Board (#H16-03090).

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Abbreviations

ACTS – Activity Support Scale

BMI – Body Mass Index

CFPQ – Comprehensive Feeding Practices Questionnaire

CFQ – Child Feeding Questionnaire

FLASHE – Family Life, Activity, Sun, Health, and Eating

IQR – Interquartile Range

LiGHT – Living Green and Healthy for Teens

Mins – Minutes

MVPA – Moderate-to-Vigorous Physical Activities

NYPANS – National Youth Physical Activity and Nutrition Study

OR – Odds Ratio

PAC-Q – Physical Activity Questionnaire for Older Children

PEAS – Parenting Eating and Activity Scale

PFSQ – Parental Feeding Style Questionnaire

REDCap – Research Electronic Data Capture

SCT – Social Cognitive Theory

SD – Standard Deviation

SDT – Self-Determination Theory

SRQs – Self-Regulation Questionnaires

24HrDRI – 24-Hour Dietary Recall Interviews

95%CI – 95% Confidence Interval

β – Standardized Coefficient

Acknowledgements

This thesis would not have been completed without the help, support, and encouragement of many individuals, some of whom I would like to acknowledge in this section.

Firstly, I would like to thank my supervisor, Dr. Louise Mâsse, for her support, guidance, and words of encouragement, as I completed my Master of Science degree. Thank you for providing me with countless opportunities to develop as an academic and for encouraging me to step outside of my comfort zone.

Additionally, I would like to express my sincerest gratitude to my committee members, Dr. Guy Faulkner & Dr. Matin Guhn, as they have generously provided their insights and expertise throughout the development of this thesis. Their feedback and thoughtful discussions have pushed me to think critically, encouraged me to consider other perspectives, and challenged my assumptions.

I also had the opportunity to meet and work with some amazing students and research staff over the last two years. Thus, I would like to thank Tomoko, Yingyi, Janae, Alysha, Jean, Jennifer, Nicole, and Angelica for welcoming me into the Mâsse Lab and for checking in on me, as I completed my analyses and proofread my thesis for the 100th time.

I would also like to thank my friends (aka the "Kerrisdale crew"), whom I had the pleasure of meeting during my first year and who have helped me make Vancouver my home away from home. Thank you to Areesha, Jessi, Chad, Shan, and Ernest for the many laughs and adventures that took place over the last two years. Thank you for teaching me the importance of taking breaks and celebrating my achievements, as well as guiding me through periods of extreme stress. These two years have gone by too quickly, but I look forward to see what the future holds for this special group of people!

Finally, I would like to thank the Canadian Institutes of Health Research, as well as the University of British Columbia for providing me with funding throughout the completion of my Master of Science degree.

Dedication

This thesis is dedicated to my parents.

Thank you for your support as I chase my dreams,

for teaching me the importance of hard work and perseverance,

for encouraging me to push my limits,

and for celebrating my accomplishments.

Chapter 1: Introduction

The burden of adolescent obesity within Canada remains a major public health concern, as over a third of Canadian adolescents are either overweight or obese (1). Consequently, this sub-population is faced with a greater risk of suffering from various acute and chronic comorbidities over the life-course (2-4), if their condition is left unmanaged.

Although the cause of adolescent obesity remains to be determined, obesogenic behaviours (e.g., physical activity, dietary behaviours, and sedentary behaviours) have been associated with childhood and adolescent obesity (5). Sadly, the large majority of Canadian adolescents do not meet the national recommendations. Specifically, only 9% of boys and 4% of girls partake in 60 minutes of daily physical activity (6). It has also been estimated that adolescents spend, on average, 8.6 hours per day in sedentary pursuits (6). Finally, only 30.5% of adolescents consume 5 or more daily servings of fruits and vegetables (7), while a large portion of adolescents' overall caloric intake is derived from nutrient-poor and energy-dense snacks, as well as sugar-sweetened beverages (8-10). Adolescents' health behaviours and their risk for becoming obese are influenced by various sources present within their social and physical environments (11-14). However, the household environment has been identified as one of the most important targets for adolescent obesity treatment, as evidence has shown that parents continue to act as socializing agents (15, 16) and influence adolescents' health behaviours through parenting practices (17, 18).

In order to effectively treat and manage adolescent obesity, lifestyle behaviour modification interventions need to be multifaceted, targeting the adolescent's diet, physical activity, and sedentary behaviours (19, 20). In addition, these interventions need to focus on promoting lifelong weight management; therefore, many are delivered within a family-based

context (i.e., where both the parent(s) and adolescent are present in the treatment session), which have been proven to be effective at improving adolescents' weight outcomes (21). However, family-based interventions are often resource intensive (22), thus new delivery processes need to be developed and evaluated, in order to reduce the overall cost and improve the reach of these programs.

E-health interventions refer to treatment or prevention interventions that have been specifically designed to be delivered through an internet platform (23). E-health interventions have many positive attributes that make them an attractive delivery option for paediatric obesity treatment interventions including cost-effectiveness and persuasive intervention design, where e-health interventions can provide users with tailored information and resources to help them engage in self-management (24, 25). Additionally, e-health interventions have the potential to be reached by many Canadian youth, as cell phone and internet penetration among this sub-population is high (26). However, poor user engagement remains to be a major issue among e-health lifestyle behaviour modification interventions (27, 28). Low levels of intervention use can jeopardize the effectiveness of the program (29); therefore, gaining a greater understanding of the factors associated with intervention adoption and usage can ultimately improve user engagement and effectiveness.

Though many studies have examined factors associated with use of e-health interventions aimed at modifying obesogenic behaviours (30-36), few studies have focused on adolescents (37). Therefore, more research is required to address this gap within the literature. As a result, this study examined individual and household characteristics associated with adolescents' adoption and usage of the Aim2Be© app; a health behaviour modification intervention program that is delivered through a smartphone app.

Chapter 2: Literature Review

2.1 The Burden of Childhood and Adolescent Obesity in Canada

Childhood and adolescent obesity continues to be a major public health epidemic in Canada. In 2012/2013, an estimated 36.8% of Canadian adolescents (aged 12-17 years) were classified as either overweight or obese, according to the Canadian Health Measures Survey (1). These statistics are alarming, as it has been noted that adolescents who are overweight or obese have a higher likelihood of remaining overweight during adulthood (38). Consequently, overweight or obese adolescents are placed at a higher risk of developing both short- and long-term negative health outcomes. Specifically, childhood and adolescent obesity is associated with sleep apnea, elevated blood pressure, glucose intolerance, and mental health problems (4). Childhood obesity is also associated with lifelong psychosocial consequences such as reduced quality of life (39), due to bullying, stigma, and discrimination (4, 40-42). Chronic disease incidences associated with obesity in adulthood include type II diabetes, cardiovascular disease, osteoarthritis, and many forms of cancers (2, 3). Additionally, obese adults also have a higher risk of developing depression, dementia, and premature mortality (43-45).

This public health crisis has major implications for the Canadian health care system, as the direct cost to treat co-morbidities associated with obesity at the population-level has been estimated at $3.9 billion CAD in 2006 (46). Given the extent of this evidence, it is imperative that immediate and effective actions are taken to resolve this epidemic. To develop effective interventions, researchers and program planners must consider a thorough understanding of the determinants of this health issue. Though the cause of the obesity epidemic remains to be determined, obesogenic behaviours are thought to be a leading contender and may be the key component to reduce and prevent future cases among the paediatric population (5).

2.2 Obesogenic Behaviours among Canadian Adolescents

To develop a holistic perspective of the health outcomes of Canadian adolescents, obesogenic behaviours, including: physical activity, healthy eating, sedentary behaviour, and sleep must be taken into account (47), especially since these behaviours have been associated with important health indicators (48). However, for the purposes of this study, the following obesogenic behaviours will be discussed in further detail: physical activity, sedentary behaviour, and dietary behaviours.

2.2.1 Physical Activity

Though the relationship between physical activity and obesity has been extensively examined within the paediatric population, results remain inconsistent (49); which may be a product of the different forms of measurements used to record physical activity (e.g., self-report, accelerometers, pedometers, etc.) (50). With that being said, moderate-to-strong correlations between physical activity and adolescent's weight status do exist within the literature (13, 49-52); where adolescents who are obese accumulate lower levels of physical activity, compared to non-obese adolescents. Additionally, dose-response relationships have been found in a handful of studies (50), indicating that adolescents can benefit from the health benefits associated with physical activity, even when exposed to small doses.

In order to achieve the health benefits associated with being physically active, the *Canadian 24-Hour Movement Guidelines* recommend that children and adolescents (5-17 years) accumulate a minimum of 60 minutes of moderate- to vigorous-levels of physical activity every day, as well as partake in strength training activities at least 3 days per week (53). However, Colley et al. (6) discovered that very few Canadian children and adolescents (only 9% boys and

4% girls) actually meet these recommendations. These statistics reflect a secular, decreasing trend that has been experienced by youth worldwide (54).

2.2.2 Sedentary Behaviours

Sedentary behaviours are defined as a class of behaviours characterized by low energy expenditure and minimal movement (55). These behaviours are often associated with work-related and recreational screen time, as well as prolonged periods of sitting (56). However, it is important to note that sedentary behaviour should not be misinterpreted as the inability to achieve the recommended amount of daily physical activity, as research has shown that individuals can exhibit prolonged periods of sedentary behaviour while still reaching the recommended physical activity guidelines (57).

Systematic reviews have demonstrated that excessive time spent engaged in sedentary behaviours is associated with many negative physical and psychosocial health effects, including increased risk of cardiovascular disease and lower self-esteem (55). Similarly to physical activity, a dose-response relationship has been identified (55), indicating that greater time spent being sedentary leads to decreased health. Additionally, it was found in many studies that a positive correlation existed between recreational screen time and adolescent's body mass index (BMI) (51, 52, 56).

The *Canadian 24-Hour Movement Guidelines* recommend that children and adolescents limit their recreational screen time for up to 2 hours per day, as well as to break up the time spent sitting (53). Using data from the Canadian Health Measures Survey, it was estimated that children and adolescents spend over 8.6 hours per day in sedentary pursuits (6). Though the proportion of sedentary pursuits being spent in front of a screen has not been recently measured

among adolescents, studies have estimated that youth spend anywhere from 2.3 to 6 hours per day in front of a screen (6, 58).

2.2.3 Dietary Behaviours

The quality of an adolescent's diet also plays a major role in his/her weight status, specifically in terms of adiposity (59, 60). Studies have reported that poor diets (characterized by high intake of low-nutrient/high-energy dense foods and fat; as well as low intake of fruits, vegetables, and dietary fiber) were associated with greater and excess levels of adiposity among children and adolescents (59, 60).

The 2019 *Canada's Food Guide* recommends that adolescents should eat a healthy diet that is comprised of vegetables, fruit, whole grains, and protein (with a particular focus on plant-based protein foods) (61). Additionally, in order to achieve the health benefits associated with healthy eating, *Canada's Food Guide* also recommends that adolescents limit their consumption of highly processed foods and drinks, as they contain excess levels of salt, sugar, and saturated fats (61). Finally, *Canada's Food Guide* recommends that adolescents replace their sugar-sweetened beverage intake with water (61).

Despite these recommendations, many children and adolescents consume unhealthy diets. Specifically in 2016, only 30.5% of Canadian adolescents (12-17 years) reported that they were consuming 5 or more daily servings of fruits and vegetables (7); a benchmark that was used in past research. Additionally, a large portion of adolescents' overall caloric intake is derived from nutrient-poor and energy-dense snacks, as well as sugar-sweetened beverages (8-10). Consequently, adolescents are placed at risk of not obtaining the essential vitamins and minerals that are required for healthy development (9).

In sum, the large majority of Canadian adolescents exhibit obesogenic behaviours. Thus, further examination of the environmental and social pressures that influence adolescents' health behaviour choices will provide critical insight into how this epidemic can be effectively treated and managed.

2.3 Determinants of Childhood and Adolescent Obesity

Due to its complex and multi-factorial nature, obesity is caused and influenced by a host of risk factors that interact with one another at various levels. For example, Davison & Birch's contextual model (62) conceptualizes a child's weight status as a product of the interaction of various characteristics at the individual-, household-, and societal-level. However, this section will specifically focus on the individual characteristics and parenting practices that are associated with childhood and adolescent obesity.

2.3.1 Individual Characteristics

Past studies have shown that a child's risk of developing obesity is associated with his/her demographics, including age, sex, and gender, as children's body composition and adiposity changes during puberty (63). However, for the purposes of this study, intrapersonal characteristics, specifically motivation, and its relationship to adolescent obesity will be discussed below.

Motivation is defined as the driving force that pushes an individual to act towards his/her goals and desires, as well as to develop and adapt when faced with adversity (64). In Self-Determination Theory (SDT), it has been argued that the type or quality of motivation that an

individual possesses, rather than the quantity, will better determine the outcome of his/her efforts (64). Furthermore, the type of motivation that an individual possesses can be influenced by whether the social environment supports and satisfies the individual's psychological needs (i.e., competence, autonomy, and relatedness). Failure to satisfy these innate needs hinders the individual's psychological growth and development (65). Thus, motivation is thought to lie on a continuum. Specifically, the spectrum ranges from amotivation (i.e., the lack of motivation to conduct a behaviour) to extrinsic motivation (where the behaviour is carried out to lead to a certain outcome, such as gaining a reward or avoiding punishment) to intrinsic motivation (where the behaviour is carried out because it is self-endorsed and done out of interest or enjoyment) (65). Additionally, different forms of regulation exist along the continuum, including introjected, identified, and integrated. This continuum can be split into two major groups. Specifically, identified, integrated, and intrinsic regulations are forms of autonomous motivation, where individuals act on their own volition and values (64). Extrinsic and introjected regulations, on the other hand, are forms of controlled motivation, where individuals act due to feelings of being pressured and/or a sense of obligation, due to a structured environment (e.g., maintaining one's self-image, avoiding a negative outcome) (64).

Within the current literature, there is evidence to suggest that adolescents' motivation plays an influential role on their health behaviours; however, results are inconsistent. With regards to healthy eating, past studies have found that autonomous and controlled motivation were both positively associated with adolescent's fruit and vegetable intake (66, 67), where one study found that controlled motivation had a stronger association compared to autonomous motivation (67). Among a sample of male adolescents, autonomous and controlled motivations were negatively associated with adolescents' screen time (68). Finally, with regards to physical

activity levels, one meta-analysis noted that among 46 studies that specifically examined children and adolescents, autonomous forms of motivation had moderate and positive associations with physical activity levels (69), while controlled forms of motivation and amotivation had weak and negative associations. However, in contrast to this meta-analysis, one study, which examined an adolescent treatment sub-population, found that both autonomous and controlled forms of motivation were positively associated with physical activity levels (70).

2.3.2 Parenting Practices

Though an individual's metabolism and adiposity may be influenced by his/her genetic make-up (71), studies have shown that the environment in which genes interact can ultimately alter an individual's risk for developing obesity (72). Additionally, recent research suggests that changes within the physical and social environment, rather than genetic susceptibility, have played a critical role in the drastic increase of obesity incidence over the past few decades (73). Adolescents, in particular, are subjected to various influences within their physical and social environments, including parents, friends, and peers. The family and household environment has been identified as one of the most important targets for childhood and adolescent obesity treatment and prevention interventions, as evidence has shown that parents continue to act as socializing agents (15, 16) and shape the health behaviours of youth, even during adolescence (74-76). Thus, further consideration of the household environment, specifically parenting practices, and its impact on adolescent health behaviours is discussed below.

Parenting practices are defined as the various strategies and techniques in which parents use during child rearing to influence their child's attitudes, beliefs, and/or behaviours (15, 77). Parenting practices are active, goal-directed actions or behaviours that can be adjusted according

to the familial context (15, 78). However, due to its diverse nature, there are currently no universally-accepted definitions nor well-defined categories within the literature (79-81), as practices can differ based on the situation that parents are addressing (e.g., increasing fruit and vegetable intake versus limiting recreational screen time). Consequently, this has led to major measurement discrepancies within the literature (82), making it extremely difficult to compare results between studies (83). However, despite these limitations, three higher-ordered parenting practice constructs emerged with regards to addressing health behaviours, including: a) control; b) structure; and c) autonomy support. Control includes parent-centred practices, where the parent attempts to impose their will on their child, without taking into account the child's needs or desires (84). Typically, controlling practices include the use of a coercive behaviour (e.g., threats, bribes, or punishments) or attempts to pressure the child into conforming to the parent's requests (e.g., pressure to eat or emotional regulation) (84). Structure practices, on the other hand, involve non-coercive practices where the parent attempts to structure or organize the environment to help facilitate their socialization goals (84). Depending on the parent's socialization goals, structure practices can be complementary to both autonomy supportive and controlling practices (84). Specifically, parents are required to provide sufficient levels of structure to help their child make guided choices; however, excessive levels of structure may limit the opportunities for the child to develop self-regulating skills. Some structure practices commonly used by parents include having rules and limits, modelling in front of the child, and guiding choices (84). Finally, autonomy supportive practices capture practices where the parent provides their adolescent with the opportunity to develop their own independence and support their volition to endorse the behaviours that the parent wants to instill (84). Examples of autonomy supportive practices include: child involvement, education, and the encouragement of

age-appropriate exploration, which provides parents the opportunity and environment to teach their children self-regulatory skills (84).

Research has demonstrated that significant associations between parenting practices and adolescent's obesogenic behaviours exist. The details regarding each specific health behaviour are described below:

Adolescents' Dietary Behaviours: Multiple systematic reviews have examined the associations between various parenting practices and children's dietary behaviours, where it was noted that parental support for healthy eating was positively associated with children's intake of fruits and vegetables (17). One literature review found that household availability and accessibility of fruits and vegetables were usually positively associated with children's and adolescents' fruit and vegetable intake (85); however, results are inconsistent, as some studies have reported null associations (17, 86). Parental intake of fruit and vegetables (17, 87), as well as intake of foods high in fat (86), were positively associated with adolescents' consumption of these foods. In addition, studies have found that household accessibility/availability of fruits and vegetables modified these associations (17). Parents' sugar-sweetened beverage intake was found to be positively associated with children's consumption of these drinks (86). Controlling strategies, such as restrictive and pressuring practices, tend to have the opposite effect with regards to the parents' goal and may prevent the child from self-regulating their eating (88). Observational and longitudinal studies have found that children whose parents placed higher levels of pressure during feeding were associated with lower dietary quality (85). Experimental studies also found that when children were rewarded for consuming a target food item, their consumption of the target food item would increase, however their preference for that food item would decrease

(85). Similar to pressure to eat, parents who reported using restrictive feeding practices were associated with higher child disinhibition (85). In contrast to pressure to eat, parental restrictions on processed treats were associated with higher child's preference for those foods.

Adolescents' Physical Activity: Children's and adolescents' physical activity levels were positively associated with familial social support (18, 89-91) and instrumental behaviours (89, 92). One cross-sectional study found that gender-differences were present, as maternal logistic support (e.g., enrolling children in activities, providing transportation, etc.) was positively associated with girl's volume of physical activity, while paternal logistic support was positively associated with boy's daily moderate-to-vigorous physical activity levels (89). Additionally, studies and meta-analyses have found that parental participation in physical activity was positively associated with their child's moderate-to-vigorous physical activity levels (18, 91, 92), as well as their overall physical activity levels (90, 91). Interestingly, even though parental modelling of physical activity was extensively examined among adolescents, no significant associations were found (93). Finally, one review noted that encouragement was found to be positively associated with physical activity frequency among adolescents (91).

Adolescents' Sedentary Behaviours: With regards to sedentary behaviour, household rules were found to be negatively associated with adolescents' screen time use (18, 94). Jago et al. (95) demonstrated that children from low-restriction families had a 2.2 times greater risk of watching 2-4 hours of television per day, as well as a 3.3 times greater risk for watching more than four hours of television per day. Additionally, parental use of electronic devices was positively associated with children's electronic use (18). One cross-sectional study found that the presence

of a television and/or video game system within the adolescent's bedroom was associated with greater screen time usage (an additional 36 mins/day and 30 mins/day, respectively) (94).

Overall, the household environment is depicted as an important determinant of adolescents' weight status that has the potential to be modified within an intervention setting. Therefore, understanding how the household environment can influence adolescents' intervention use and treatment outcomes (through various modes of intervention delivery) merits further examination.

2.4 Adolescent Obesity Behavioural Interventions

Due to its complex nature, adolescent obesity treatment interventions require a multi-faceted approach, which tackle key aspects such as the adolescent's diet, physical activity, sedentary behaviour, and behavioural issues (96). Additionally, the primary goal of many treatment interventions for the overweight/obese paediatric population is to support lifelong change in health behaviours and thus, requires a life-course approach. The World Health Organization recommends the use of lifestyle behaviour modification interventions that combine dietary, physical activity, sedentary behaviour, and behavioural components as a form of obesity treatment among adolescents, in order to promote lifelong weight management (97), as strong evidence exists to suggest that these forms of intervention are effective among adolescents (19, 20). Two Cochrane systematic reviews found that multi-component behaviour modification interventions were effective at reducing BMI and/or overall weight among overweight and obese adolescents, both in a short- and long-term period (19, 20). Specifically, these reviews noted that overweight and obese adolescents attending multi-component lifestyle intervention programs

were able to maintain their weight/BMI loss at six, 12, and 18 months follow-up, as compared to adolescents who were on wait-lists or usual care groups (19, 20). Finally, the most recent Cochrane review found that there were no subgroup differences in long-term results with regards to the setting of the intervention (i.e., healthcare, community, school), nor by the mode of delivery (i.e., individual- vs. group-based interventions) (19).

Behavioural treatment strategies targeting adolescents' dietary, physical activity, and sedentary behaviours are often administered within family-based intervention (i.e., where both the parent(s) and adolescent are present within the treatment session), since parents act as important agents of change (15) and continue to influence their adolescent's environment (21); thereby influencing the adolescent's health behaviours (74, 87, 90). Therefore, it is not surprising to learn that one meta-analyses concluded that family-based obesity interventions were effective at improving children's and adolescents' weight outcomes, as compared with passive control groups (21). However, despite showcasing evidence of effectiveness, family-based, in-person interventions are resource-intensive and in 2009 the costs associated with operating these programs were estimated to run anywhere between $500-$800 USD per family, especially if these types of interventions are delivered in a rural setting (22). Thus, new delivery options for health behaviour modification interventions, such as e-health interventions, need to be developed and evaluated.

2.4.1 E-Health Obesity Interventions: Potential & Challenges

E-health interventions refer to treatment or prevention interventions that are specifically designed to be delivered through an internet platform or related networks (23). Typically, these interventions incorporate behavioural change techniques within the program content, along with

guidance or supportive feedback, to help address a health-related goal that the user wants to achieve (e.g., quitting smoking, losing weight, chronic disease management, etc.) (23, 98). E-health interventions provide many positive attributes that make it an attractive delivery option for paediatric obesity treatment interventions. E-health interventions can be cost-effective and provide participants with individually-tailored programs that are specific to the user's demographics, health problems, and other various characteristics (24, 25). E-health interventions have the potential to be reached and accessed by people from various demographics, thereby making it possible for these programs to be implemented at a provincial or national level (24, 25). Thus, e-health interventions present the opportunity to reach populations who are typically underserved due to geographical (e.g., rural settings), economic (e.g., low socioeconomic status), or social related (e.g., stigma) factors (28). In 2017, cell phone penetration among Canadians was recorded at 87%, additionally ~90% of Canadian households had internet access (99). Among adolescents specifically, Statistics Canada reported that nearly 100% of youths (15-24 years) used the Internet daily or owned their own smartphone (26). These statistics not only showcase how widely accepted this form of technology is with the adolescent population, but it also demonstrates the opportunity to reach Canadian youths. Not only is the potential for the use of e-health interventions present, but there is also preliminary evidence to suggest that e-health intervention can be effective at improving adolescents' health outcomes. Specifically, one systematic review found that e-health interventions were effective at treating obesity among adolescents, as positive weight and behaviour change outcomes (i.e., decreased adiposity, changes in dietary behaviours and physical activity levels) were reported in the intervention groups (100). Additionally, one meta-analysis reported that health behaviour modification interventions (targeting obesogenic behaviours, immunization, HIV prevention, or diabetes

management) that were delivered via mobile phones had a small but positive effect on youth's health outcomes, compared to the control groups (101). Finally, e-health interventions have the potential to address the weight stigma that may prevent individuals from accessing these resources (41).

Overall, e-health presents a viable mode of delivery for adolescent obesity treatment interventions. However, in order to improve program effectiveness, further research is required to evaluate the program's reach, characteristics associated with intervention adoption and use, as well as users' long-term health outcomes.

2.5 E-Health Intervention Adoption, Usage, and Its Implications

Due to the lack of consistency in terminology found within the literature, e-health intervention adoption and use has been operationalized in various ways, making it difficult to compare results between studies (102, 103). For example, adoption has been operationalized as whether the individual enrolled in the e-health intervention (32, 104), whether the intervention was used more than once (30), or whether the individual expressed willingness to use an e-health intervention (105). With regards to e-health intervention use, past studies have operationalized it as whether the individual initiated and/or completed all of the modules within the program (34-36, 104, 106), whether the individual returned to the e-health intervention website more than once (31, 33, 104), whether certain functionalities of the app were used or viewed (32, 37, 107), or how many times the individual logged into the intervention (30, 108). For this study, adoption refers specifically to an individual enrolling into the intervention, where those who are enrolled are defined as users, while those who do not enroll are defined as non-users. Intervention usage,

on the other hand, refers to an individual accessing the intervention and utilizing resources provided by the program, as defined by the number of minutes they were logged into the app.

The extent to which participants utilize lifestyle behaviour modification interventions as designed by program planners (29) (also known as adherence), continues to be a major issue with in-person programs, as highlighted by Pagoto and Appelhans (109); however, this issue also applies to the e-health context. Studies have noted that repeated or on-going intervention use is positively associated with program effectiveness (including both in-person and web-based programs) (29, 30, 109, 110), where users who are highly engaged with the intervention experience greater health benefits. However, e-health interventions are particularly vulnerable to poor intervention use and high attrition rates (27, 28, 111), with studies reporting only ~50% of its users sustaining long-term engagement to the program (27). Consequently, the effectiveness of the intervention can be potentially jeopardized. Thus, it is crucial that predictors of e-health intervention adoption and usage are identified and studied, in order to understand the differences between users who remain engaged within the program and those who dropout prematurely, as well as to identify intervention modifications to help promote user engagement for future e-health interventions (28).

2.5.1 Factors Associated with E-Health Intervention Adoption and Usage

Within the current literature, very few studies have examined characteristics associated with e-health interventions adoption (105) and use (37, 106, 107), among adolescent users (age range=11-19 years). Specifically, three health behaviour modification interventions were studied, including a smoking cessation program (107), binge drinking intervention (106), and a lifestyle behaviour management intervention for overweight and obese adolescents (37). One other study

examined user characteristics of an online smoking cessation program among a Norwegian population; however, information regarding the age of its users was not provided (108). Finally, one study examined adolescents' willingness to adopt e-health interventions for health promoting purposes (105). Among these five studies, various user characteristics were associated with intervention adoption or use, and these results can be sub-divided into the following categories: a) user's demographics and intrapersonal characteristics, b) user's health behaviours, and c) user's household environment. The details regarding each category are provided below.

User's Demographics and Intrapersonal Characteristics: With regards to user demographics, Jander et al. (106) and Wangberg et al. (108) noted that user's sex was associated with e-health intervention use. Specifically, female users were more engaged (i.e., completed more intervention sessions or had more logins), as compared to male users. Additionally, the same studies noted that users with higher education backgrounds were also associated with intervention engagement (106, 108). Among all four studies, age was found to be significantly associated with intervention engagement, however results varied. Specifically, three studies noted that younger adolescents were either more likely to exhibit higher engagement (i.e., responded to weekly text prompts or acquired more logins) to the e-health intervention (106, 107), or to certain aspects of the intervention (i.e., percentage of counselling calls completed) (37). In contrast, Wangberg et al. (108) noted that older users were associated with more logins to an online smoking cessation intervention.

With regards to user's intrapersonal characteristics, studies have found both positive and negative associations between intervention usage and user's motivation or perceived benefits. Specifically, among a sample of Swiss adolescents, it was found that users who perceived more

benefits from quitting smoking were more likely to exhibit stable engagement (i.e., respond to weekly text prompts) (OR=1.52; 95%CI:1.32-1.84) (107). Mâsse et al. (37) noted that among a sample of overweight and obese adolescents, autonomous motivation towards participating in the lifestyle management intervention "MySteps©" was positively associated with content viewed within the program.

User's Health Behaviours: With regards to the influence of user's health behaviours on their e-health intervention usage, only two studies examined whether adolescents who reported binge drinking one month prior to the baseline assessment were more or less likely to be engaged with the interventions. Jander et al. (106) noted that Dutch adolescents who reported binge drinking one month prior to the assessment were negatively associated with the number of completed program sessions of an online intervention aimed at reducing binge drinking behaviours. In contrast, Paz Castro et al. (107) noted that Swiss adolescents who reported binge drinking one month prior to the baseline assessment, had greater odds of exhibiting stable engagement (defined by the number of responses to text message prompts) within an online smoking cessation intervention, as compared to adolescents who did not report binge drinking (OR=1.54; 95%CI: 1.14-2.08). With regards to adoption of e-health interventions, Tercyak et al. (105) noted that adolescents who had markers of unhealthy behaviours, such as insufficient levels of moderate-to-vigorous levels of physical activity or high BMI levels, were positively associated with willingness to use e-health interventions.

User's Household Environment: Finally, one study (37) examined the influence of various aspects of the household environment (e.g., household income, parenting practices, and parenting

style) on adolescents' usage of a lifestyle management program. Specifically, among a sample of overweight and obese adolescents, it was noted that household income was significantly associated with program engagement, where adolescents from higher-income families viewed more website content (37). As well, adolescents who lived within a household that ate breakfast together every day viewed more of the intervention's content and utilized the tracking tools more often (37). Interestingly, higher availability of diet sugar-sweetened beverages was positively associated with greater usage of the intervention's tracking tools, as compared to adolescents from households with no sugar-sweetened beverages (37). Finally, the study also noted that authoritative parenting scale was negatively associated with adolescents' tracking tool usage (37).

Overall, very few studies have examined characteristics associated with adolescents' adoption or engagement towards web-based health behaviour modification interventions. Additionally, these associations have yet to be identified with regards to a behaviour modification intervention delivered within a smartphone app. Therefore, more research is required to address this gap within the literature.

2.6 Study Aims & Hypotheses

The purpose of this thesis was to examine the associations between adolescent-level characteristics and parenting practices with adolescents' adoption and usage of the Aim2Be© app; a health behaviour modification intervention program delivered through a smartphone app. The specific aims and hypotheses are:

Aim I: To examine whether adolescent characteristics (i.e., autonomous motivation, controlled motivation, and health behaviours) are associated with app adoption and/or app usage (Figure 2.1).

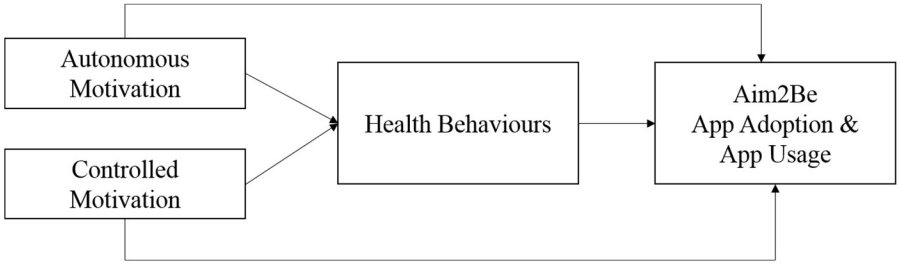


Figure 2.1: Theoretical model depicting the associations between adolescent characteristics on adolescents' adoption and usage of the Aim2Be© app.

Hypothesis I:

Adolescents with high levels of autonomous or controlled motivation and poor health behaviours will be more likely to adopt the Aim2Be© app and use the app more, compared to adolescents with low levels of autonomous and controlled motivation or adolescents who demonstrate healthy behaviours.

Aim II: To examine whether parenting practices are associated with adolescents' app adoption and/or app usage, as well as to explore whether these associations are confounded by parents' sex (Figure 2.2).

Figure 2.2: Theoretical model depicting the associations between parenting practices and adolescents' adoption and usage of the Aim2Be© app.

Hypothesis II:

Positive parenting practices (i.e., higher levels of autonomy supportive and structure parenting practices) will be associated with adolescents' app adoption and greater app usage, as compared to negative parenting practices (i.e., higher levels of control parenting practices).

Aim III: To examine whether the associations between adolescents' app adoption and/or app usage and parenting practices are mediated through adolescent characteristics, as well as to explore whether these associations are confounded by parents' sex (Figure 2.3).

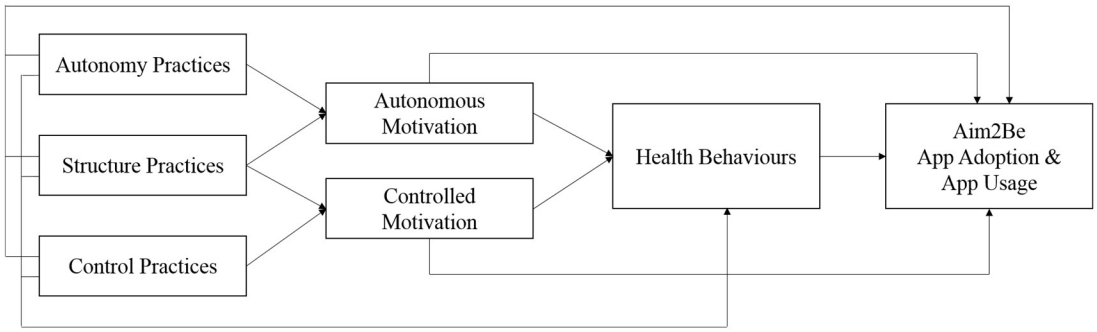


Figure 2.3: Theoretical model depicting the influence of adolescent characteristics and parenting practices on adolescents' adoption and adherence to the Aim2Be© app.

Hypothesis III:

The associations between parenting practices and adolescents' app adoption and/or usage, will be mediated by adolescents' motivation and health behaviours.

2.7 Theoretical Models

The theoretical models underlining the study hypotheses (Figures 2.1, 2.2, and 2.3) are guided by the principles of Self-Determination Theory (112) and Social Cognitive Theory (SCT) (113). In brief, the model outlines adolescents' app adoption and usage as a product that is directly influenced by individual characteristics. Additionally, adolescents' adoption and use of the Aim2Be© app is both directly influenced by parenting practices, as well as indirectly via adolescents' intrapersonal characteristics.

2.7.1 Self-Determination Theory (SDT)

SDT aims to understand how individual factors influence a person to acquire the motivation to self-regulate their behaviours, such as adopting and maintaining healthy behaviours (114). Deci and Ryan argue that in order for an adolescent to self-regulate and sustain a health behaviour, he/she must align their motivation to their personal values, in order to internalize it (115). Additionally, promotion of autonomous motivation is dependent on the fulfillment of the three innate psychological needs (65, 115, 116), which include: a) autonomy (i.e., the adolescent's need to express volition); b) competence (i.e., the adolescent's need to feel capable of achieving his/her desired goal); and c) relatedness (i.e., the adolescent's need to feel connected with others). Failure to satisfy these psychological needs hinders the adolescent's psychological growth and development and yields less optimal forms of motivation (i.e.,

controlled motivation) (65, 115).

In the literature, autonomous forms of motivation (e.g., intrinsic motivation) and other aspects from SDT (i.e., relatedness and autonomy support) were found to be significantly associated with intervention engagement (as defined by greater use of intervention functionalities) among adolescents (37). Additionally, studies have found that children and adolescents who demonstrated autonomous forms of motivation (i.e., intrinsic motivation and identified regulation) were positively associated with better health behaviours, including higher levels of physical activity (69, 70, 117, 118), as well as fruit and vegetable intake (66). Therefore, within this study, adolescent's motivation was examined to determine whether it was associated with adolescents' Aim2Be© app adoption and usage directly or indirectly via adolescents' health behaviours.

2.7.2 Social Cognitive Theory (SCT)

SCT aims to describe how social and cognitive factors allow or impede an adolescent from adopting a health behaviour (119). Specifically, this theory takes into account how the social context, as well as internal and external reinforcements (e.g., modelling, self-efficacy, and expectations) influence an adolescent to self-regulate and change his/her behaviour (120, 121). An important feature of SCT is the construct of reciprocal determinism, which suggests that individuals do not operate as independent agents (122), rather individuals' behaviours are influenced by their social factors, environment, and personal factors.

Within the literature, there is strong evidence to suggest that the household environment plays a role in shaping adolescents' health behaviours (74-76). One mechanism includes parental modelling of healthy behaviours, as studies have found that children's health behaviours tend to

mirror those to their parents (76, 87, 123, 124). Therefore, parenting practices were examined to determine whether they were associated with adolescents' adoption and/or usage to the Aim2Be© app indirectly via the adolescent's intrapersonal characteristics.

2.8 Study Rationale

Very little research has examined and identified predictors of adolescents' adoption and use of e-health interventions, especially those targeting obesogenic behaviours. Moreover, predictors of app adoption and usage of a lifestyle modification intervention delivered through a smartphone app have yet to be identified among an adolescent study population. Further examination into this sub-population is critical, as adolescence is a sensitive period for the development and maintenance of health behaviours, as research has found that these behaviours track into adulthood (125). Additionally, these results will help inform program planners develop effective interventions that promote stable user engagement, as high attrition rates and low user engagement are commonly reported (27, 28). Therefore, this study examined the association between individual characteristics and parenting practices with adolescents' adoption and usage of the Aim2Be© app.

Chapter 3: Methods

3.1 Living Green and Healthy for Teens (LiGHT) Project

The data source for this study came from the Living Green and Healthy for Teens (LiGHT) project, which aims to promote healthy behaviours among Canadian youth and their families through the delivery of an innovative lifestyle management program called Aim2Be©. Aim2Be© is a gamified mobile phone app and website that helps and supports children and adolescents (10-17 years), as well as their families in adopting and maintaining healthy lifestyle behaviours. Specifically, through the use of behaviour change techniques, the app aids users to adopt health behaviours that are in line with the current Canadian lifestyle recommendations on nutrition, physical activity, sedentary behaviour, and sleep. The app has been designed to provide adolescents with an engaging and non-judgemental platform, in order to support healthy growth and development.

This study examined the baseline data collected during the pre-post evaluation of the LiGHT version 2.1, which was conducted from March 2018 – October 2018. Ethics approval was granted by the University of British Columbia research ethics board.

3.1.1 Aim2Be© App

Aim2Be© is a free lifestyle management program that is delivered via the iOS (i.e., Apple App Store) and Android (i.e., Google Play) platforms. A complimentary website was also designed and contained the same features of the app, in order to reach users who lacked access to a compatible smartphone or related devices. The program was designed to provide all Canadian families with health promotion resources to help address the Canadian adolescent obesity epidemic. Specifically, the purpose of the app was to promote and guide long-term behaviour

change with regards to physical activity, sedentary behaviours, healthy eating, and sleep. Additionally, the app aimed to promote healthy body image and increase the self-esteem of users. Contrary to interventions that are prescriptive in nature, Aim2Be© provided adolescents with control over their health journey, as adolescents choose the behaviours they would like to change based on reflection and self-discovery.

Based on the principles of SDT (65) & SCT (113), Aim2Be© was developed to improve adolescents' self-efficacy and intrinsic motivation, as the intrapersonal factors to trigger change in their self-regulatory processes. Activation of these self-regulatory skills will allow adolescents to be better prepared to adopt and maintain their behaviour changes, especially when faced with perceived barriers or limitations. Specifically, the app addresses three types of mediators, including: gamified, behavioural, and environmental mediators. To target gamified mediators, the app was developed using Ayogo Health Inc.'s Empower Platform, which combines elements of social interaction and gamification (e.g., quizzes, interactive stories, daily bonuses), in order to increase user enjoyment and intrinsic motivation; a key element in user engagement, as described by the Player Experience of Need Satisfactions model (126, 127). The app provides adolescents with the opportunity to customize their app so that it better suits their personality and style, thereby making it more personal and relatable to them. The behavioural mediator is targeted through the development and activation of self-regulatory skills (e.g., goal setting and self-monitoring). The app empowers adolescents to adopt and maintain behaviour changes by increasing their intrinsic motivation and self-efficacy levels through the use of a variety of behaviour change techniques, which are provided in the form of aims, tasks, and articles found within the app. Finally, to target environmental mediators, the app provides adolescents with emotional and social support from peers through the app's social wall, as well as support from a

Live Coach which users can access directly through the app. The Live Coach is a health professional who has expertise in healthy living (e.g., dietician) and training in motivational interviewing, and he/she provides users with the option to schedule phone or text meetings where adolescents can discuss their goals and ask for guidance, if they find themselves struggling to achieve their goal(s). Additionally, the program targets the familial environment through the implementation of a parent companion Aim2Be© app, which was specifically designed to help parents carry-out positive behaviour changes within their household environment and help support their adolescent (e.g., positive modeling, physical and social support).

The contents of the app were developed and reviewed by experts in the field of medicine, nutrition, physical activity, and psychology to ensure that the information aligns with the Canadian health recommendations, as well as paediatric management clinical guidelines. The app was also developed with the intention to meet the needs of the target population (i.e., adolescents and their families). This was done through a series of focus group discussions, one-on-one interviews, and advisory committees during the app development phase, as well as beta testing of the initial prototype.

3.2 Study Participants

A sample of web panel members from InSights West (a Canadian market research company) were recruited for the pre-post evaluation of the LiGHT project. InSights West recruits its members through web advertisements and random digit dialing to ensure that hard to reach Canadians are also included within their samples.

At the beginning of the recruitment process, 1418 parents were screened electronically to ensure that their family (i.e., parent and adolescent) met the following study criteria:

Participant Inclusion Criteria: Parents had to be the primary caregiver of an adolescent that is 13-17 years of age. In addition, both parent and adolescent had to agree to participate in the study, be literate in English, able to read at the grade 5 level or higher, as well as had access to a computer or smartphone that was connected to the internet within their household.

Participant Exclusion Criteria: For the adolescent participants specifically, they were excluded if they had any health condition that severely restricted their physical activities and/or diet, had a type I diabetes diagnosis, or suffered from any cognitive, psychological, or physical limitations that prevented them from spending 20-30 minutes on a computer program that was written at a grade 5 reading level.

InSights West assessed the eligibility of their web-panel members to participate in the LiGHT project. Once deemed eligible, parents were introduced to the full study and were asked to provide consent electronically via the web-based platform Research Electronic Data Capture (REDCap) (128) to be contacted by research staff from the University of British Columbia. Afterwards, parents and adolescents were asked to provide consent and assent, respectively, in order to participate in the study. At the end of the recruitment process, a total of 371 adolescents and 369 parents completed the baselines questionnaires, while 294 adolescents enrolled in the Aim2Be© app.

3.3 Study Protocol

Once families were recruited and both parent and adolescent participants consented/assented to participate in the study online, participants were redirected to the baseline questionnaire which was administered online through REDCap (128). Once completed, participants were provided with access to their respective version of the Aim2Be© app and were

asked to enroll, login, and use the app as they see fit. At 1-month follow-up, adolescents completed a short online questionnaire, and at 4½-months follow-up, both the parent and adolescent were asked to complete a final assessment. At the end of the study, families were provided with an honorarium of a maximum of $100 ($20 for completing both parent and adolescent baseline questionnaires, $20 for completing the 1-month intermediate questionnaire, and $60 for completing the 4½-months follow-up questionnaires).

The following table (Table 3.1) summarizes all of the constructs and variables that were collected from the study participants. For this study specifically, the data collected from the baseline questionnaires will only be examined.

Table 3.1: Questionnaires and time points of administration during the pre-post evaluation of the LiGHT project.

Evaluation Questionnaires	**Baseline**		**1 Month Follow-up**		**4½ Months Follow-up**		**Responses Used in this Thesis**	
	Adolescent	Parent	Adolescent	Parent	Adolescent	Parent	Adolescent	Parent
Socio-Demographic Questionnaire	✓	✓			✓	✓	✓	✓
Knowledge of Canadian Health Recommendations	✓				✓			
Lifestyle Behaviour Questionnaires	✓	✓			✓	✓	✓	
Anthropometric Measurements	✓	✓			✓	✓		
Weight Concern Questionnaire	✓	✓			✓	✓		
Mediators of Behaviour Change (i.e., Motivation and Self-Efficacy)	✓		✓		✓		✓	
Family Functioning, Support, & Parenting Questionnaire		✓				✓		✓
App Web-Analytics	*Continuously Collected*						✓	

3.4 Measures

Adolescent characteristics (i.e., health behaviours and motivation) and parenting practices were assessed using various self-reported measurements. Adolescents' adoption and use of the

Aim2Be© app was measured objectively using web-analytic data, which was provided by the app developers, Ayogo Health Inc. Further details regarding each measure and how they were used are provided below. A full list of all of the measures and survey items is outlined within Appendix A.

3.4.1 Adolescents' Adoption & Use of the Aim2Be© App

Using the web-analytics data collected from the Aim2Be© app, adolescent's adoption of the Aim2Be© app was operationalized as a dichotomous variable, where adolescents who enrolled and logged into the app after they downloaded it, were defined as participants who successfully adopted the app. Conversely, adolescents who did not download the app nor enrolled in the app were defined as participants who did not adopt the app.

Adolescent's usage of the Aim2Be© app was operationalized as a continuous variable. Specifically, the total number of minutes in which the adolescent was logged into the app during the intervention period (i.e., 135 days after app enrollment) was used to measure the adolescent's app usage. Due to its heavily right-skewed distribution, the outcome variable was log-transformed, in order to conduct parametric analysis.

3.4.2 Adolescents' Current Health Behaviours

The health behaviours of adolescents were measured based on the participant's physical activity levels, dietary behaviours, and screen time using validated questionnaires. The details of each measurements and the overall health behaviour index score are described in this section.

Physical Activity Levels: Adolescents' physical activity levels were measured using the Physical

Activity Questionnaire for Older Children (PAQ-C), a self-administered seven day recall questionnaire which was validated among a sample of grade 4-8 elementary students (129). One-week test-retest reliability of the questionnaire was determined to be r=0.82 and r=0.75 for female and male students, respectively (129). The PAQ-C was originally designed to be administrated through a paper-and-pencil method, however for this study, the questionnaire was modified to be administered online. Specifically, adolescents were asked to recall the amount of physical activity that they completed over the last seven days, with responses varying from "None" to "More than 2 hours". If adolescents reported completing any amount of physical activity within the last seven days, they were then asked to indicate which activities they completed from a pre-determined list, which was modified from the original questionnaire (shorten to include moderate-to-vigorous physical activities (MVPA) typically reported by adolescents). Adolescents were also provided with the option to list any activities which were not previously listed. For the analyses, the amount of physical activity that participants reported over the last seven days was summated and divided by seven, in order to calculate the adolescent's average daily MVPA levels.

Dietary Behaviours: Adolescents' fruit and vegetable, as well as sugar-sweetened beverages intake, was measured using items taken from the National Youth Physical Activity and Nutrition Study (NYPANS) (130). Validity has been assessed against 24-hour dietary recall interviews (24HrDRI) among a sample of high school students (131, 132). Additionally, survey items for soda/pop and 100% fruit juices servings significantly correlated with the mean servings reported within the 24HrDRI (ρ=0.44 and ρ=0.28, respectively) (132).

The NYPANS was originally administered through a paper-and-pencil method, however

the survey items were modified to be administered online. Specifically, participants were asked to recall the amount of fruit and vegetable servings that they consumed in the previous day (without including 100% fruit or vegetable juices, as well as fried potatoes). Responses to the survey items included a range of "None" to "4 or more servings" in ½ serving increments. Additionally, participants were asked to recall how many times they consumed the following beverages over a 7-day period: i) 100% fruit juices; ii) regular soda/pop (not including diet drinks); as well as iii) other sugar-sweetened beverages (including fruit-flavoured drinks, sports or high energy drinks, blended sweetened tea or coffee drinks, as well as other sweetened drinks; which have all been combined into one survey item). Responses for these three items included the following: "None"; "1-3 times in the past 7 days"; "4-6 times in the past 7 days"; "1 time per day"; "2 times per day"; "3 times per day"; "4 or more times per day". For the analyses, the number of servings of both fruits and vegetables reported by the adolescent on the two survey items were summated to calculate an estimated daily intake of fruits and vegetables. With regards to the sugar-sweetened beverages, if adolescents responded with "1-3 times in the past 7 days" or "4-6 times in the past 7 days" for any of the survey items, the mean number (2 times in the past 7 days; 5 times in the past 7 days, respectively) was used in the calculations. However, if participants selected any of the following responses: "1 time per day", "2 times per day", "3 times per day", or "4 or more times per day", then the responses were multiplied by seven, in order to determine the adolescent's average weekly intake. Finally, in order to calculate the adolescent's average daily sugar-sweetened beverage intake, the total amount of weekly sugar-sweetened beverages intake reported among the three survey items was summated and then divided by seven.

Sedentary Behaviour/Recreational Screen Time: Adolescents' screen time was assessed using Rosenberg et al.'s Sedentary Behaviour Questionnaire for adults (133), which measured the amount of time participants were sedentary on their most recent weekday and weekend day (including: watching television, playing computer/video games, sitting while listening to music, sitting and talking on the phone, doing paperwork or office work, sitting and reading, playing a musical instrument, doing arts and crafts, sitting and driving/riding in a car, bus, or train). Though the questionnaire was validated among an overweight adult sample (133), the questionnaire itself was found to be sensitive to changes in an obesity intervention among adolescents (134).

For this study, the questionnaire was modified to specifically measure the following four sedentary behaviours: watching TV; playing computer or videos game; using a computer, tablet, or mobile device outside of school work or paid work; and talking or texting on a cell phone. Therefore, participants were asked to report the length of time that they typically spent completing each of the activities on the most recent weekday and weekend day (8 survey items in total). Responses for the survey items included: "None", "15 minutes", "30 minutes", "1 hour", "1.5 hours", "2 hours", "2.5 hours", "3 hours", "3.5 hours", and "4 or more hours". For the analyses, adolescents' weekday sedentary time reported among all four behaviours within the most recent weekday were summated and then multiplied by five, in order to estimate participants' sedentary hours on weekdays. Similarly, adolescents' weekend sedentary time within the most recent weekend was estimated by summating the total sedentary time among all four behaviours and then multiplied by two. Afterwards, the weekday and weekend sedentary hours were added and then divided by seven, in order to estimate adolescents' average daily sedentary hours.

Adolescents' Health Behaviours Indicator: Since this study focussed on determining whether adolescents who have an overall healthy versus unhealthy lifestyle would be more or less willing to adopt and to use the Aim2Be© app, an indicator of participants' current health behaviours was computed. To compute an indicator of current health behaviours, each behaviour was first dichotomized through median split (high was coded as 1, while low was coded as 0 for physical activity and fruit and vegetable intake; reverse coding was applied for sugar-sweetened beverage intake and sedentary behaviours). An overall health behaviour score was calculated by adding the index score for all four health behaviours. This resulted in a total score ranging from 0 to 4, where "4/4" indicated that the adolescent was living a healthy lifestyle relative to the study sample, while "0/4" indicated that the adolescent was living an unhealthy lifestyle relative to the study sample.

3.4.3 Adolescents' Autonomous and Controlled Motivation

Adolescents' motivation was measured using 16 items that were adapted from the Family Life, Activity, Sun, Health, and Eating (FLASHE) study (135), which were originally taken and modelled after the Self-Regulation Questionnaires (SRQs) (136). The SRQs were developed using SDT, in order to help differentiate an individual's motivation or regulation with regards to various domain-specific behaviours, such as treatment, academic, or exercise self-regulation. Internal consistency of the subscales found within the Treatment Self-Regulation Questionnaire were found to be adequate across three different health behaviours (exercise, diet, and tobacco use) among various adult populations (α range=0.73-0.93) (137). The FLASHE motivation scale includes four items for each health behaviour (4 items x 4 health behaviours = 16 items), where

two of the items measured controlled motivation (i.e., external and introject regulation) and two items measured autonomous motivation (i.e., integrated regulation and intrinsic motivation). These four items were then repeated for each behaviour (i.e., physical activity, fruits and vegetables intake, consumption of sugar-sweetened beverages, and screen time). In this study, the response scale was modified from a four-point to a five-point Likert scale, where 1 indicated "Strongly Disagree" and 5 indicated "Strongly Agree".

Autonomous & Controlled Motivation Indicators: Similar to the health behaviour index, this study was interested in determining whether adolescents with high or low levels of autonomous and controlled motivation were more or less likely to adopt and use the Aim2Be© app. Therefore, an indicator of both adolescents' autonomous and controlled motivation was computed. For each behaviour, autonomous motivation was dichotomized by first summing the two items that assessed autonomous motivation and recoding those who had a score from 2 to 6, as 0 (indicating low autonomous motivation), and those who had a score of 7 to 10, as 1 (indicating high autonomous motivation). This scoring was then applied to all four behaviours and an autonomous indicator variable was computed by summing all four behaviour indicators. This resulted in an overall score that ranged from 0 to 4, where "4/4" indicated that the individual was autonomously motivated among all health behaviours, while "0/4" indicated that the individual was not autonomously motivated. The same scoring process was then used to compute an indicator variable for controlled motivation.

3.4.4 Parenting Practices

Parenting practices were assessed using the questionnaires drawn from the FLASHE

study (135). A total of 27 items were used to assess parents' level of control, structure, and autonomy-supportive practices that they implement with regards to their adolescent's health behaviours, including: i) fruit and vegetable intake; ii) sugar-sweetened beverages and junk food intake; iii) physical activity; and iv) screen time. A full description of the items is provided below. A five-point Likert response scale was used for each survey item, where 1 indicated "Strongly Disagree" and 5 indicated "Strongly Agree".

Parenting Practices around Healthy Eating: Within this study, the FLASHE study questionnaire regarding parenting practices around healthy eating was used. The survey included 14-items, which were modeled after the Child Feeding Questionnaire (CFQ; α range=0.70-0.73) (138), Comprehensive Feeding Practices Questionnaire (CFPQ; α range=0.75-0.80) (139), Parental Feeding Style Questionnaire (PFSQ; α range=0.65-0.77) (140), and Legitimacy of Parental Authority (141), in order to assess the parenting practices surrounding their adolescent's fruits and vegetables intake, as well as their sugar-sweetened beverages and junk food intake. Specifically, two items assessed parents' use of modelling, seven items assessed parents' use of controlling and restrictive practices, structure practices were measured using two items, parents' use of encouragement for eating fruits and vegetables was assessed using one item, and two items (not taken from previous sources) assessed whether parents used autonomy supportive practices with regards to their adolescent's dietary intake.

Parenting Practices around Physical Activity: Within this study, the FLASHE study questionnaire regarding parenting practices around physical activity was used. The survey included six-items, which were modelled after the Parenting Eating and Activity Scale (PEAS; α

range=0.81-0.82) (142), Activity Support Scale (ACTS; α range=0.71-0.83) (143), CFPQ (139), and Legitimacy of Parental Authority (141), in order to assess the parenting practices surrounding their adolescent's physical activity. Specifically, one item assessed parents' use of modelling, controlling practices were measured with three items, structure/support practice was assessed using one item, and one item (not taken from previous sources) assessed whether parents used autonomy supportive practices with regards to their adolescent's physical activity.

Parenting Practices around Screen Time: Within this study, the FLASHE study questionnaire regarding parenting practices around screen time were used. The survey included seven-items, which were modelled after the PEAS (142), ACTS (143), PFSQ (140), and Legitimacy of Parental Authority (141), in order to assess the parenting practices surrounding their adolescent's screen time. Specifically, one item assessed parents' use of modelling, four items assessed parents' use of controlling/restrictive practices, structure practice was assessed using one item, and one item (not taken from previous sources) assessed whether parents used autonomy supportive practices with regards to their adolescent's recreational screen time.

Upon further examination of the survey items, the item that assessed structure practices was removed from the structure indicator and final analysis, as it was determined that the wording of the question was not clearly written for the participants.

Control, Structure, and Autonomy Supportive Parenting Practices Indicators: To determine whether the use of various parenting practices were significantly associated with adolescents' adoption and use of the Aim2Be© app, indicators for control, structure, and autonomy supportive parenting practices was computed. Specifically, an index score for each parenting

practice (control, structure, and autonomy support) was computed by averaging the survey items associated with each parenting practice within every health behaviour (i.e., adolescent's fruit and vegetable intake, sugar-sweetened beverages and junk food intake, physical activity, and sedentary behaviours). The scores were then dichotomized by recoding those who had an average score from 1 to 3, as 0 (indicating low use of that parenting practice), and those who had an average score of 4 to 5, as 1 (indicating high use of that parenting practice). The index scores for each parenting practice was then summated from all four health behaviours, resulting in a control, structure, and autonomy supportive parenting score that ranged from 0 to 4. A score of "4/4" indicated that the parent utilized that specific subtype of parenting practices throughout all of their adolescent's health behaviours, while a score of "0/4" indicated that the parent did not use that subtype of parenting practices in any of their adolescent's health behaviours.

3.5 Data Analysis

To address the study aims, univariable logistic and linear regressions, along with path analyses were used. Specifically, six models were analyzed to determine whether adolescent characteristics or parenting practices were associated with adolescents' adoption and/or usage of the Aim2Be© app. Additionally, stratified analyses by the sex of the parent respondent were completed to determine whether the effects of parenting practices were the same if the survey was completed by the mother or father samples. Stratified analyses were only conducted for aims II and III. Finally, to determine whether the demographic characteristics of the samples used for the app adoption and usage models differed significantly, two-sample t-tests and chi-squared tests were conducted for continuous and categorical variables, respectively. Descriptive and univariate statistical analyses, as well as regression diagnostics were conducted in Stata version

13.1 (144), while path analyses were conducted with Mplus version 8 (145). All models were adjusted for adolescent's age and sex, and a significance level of 5% was used. Scatterplots, bar plots, and residual plots were evaluated to ensure that regression assumptions were not violated.

3.6 Missing Data

At the end of the data cleaning process, 28 parent-adolescent dyads (7.5% of the total sample) contained missing information; specifically, dyads were missing a motivation or parenting practice indicator.

To address this issue, Monte Carlo integration was first applied in Mplus. However, only 8 cases with missing endogenous variables (i.e., autonomous and controlled motivations) were recovered using this strategy, leaving 20 cases (5.4% of the total sample) with missing data on the exogenous variables (i.e., control, structure, and autonomy practices). Since this strategy did not recover the majority of the missing cases, a different solution was implemented. Specifically, index scores were recoded to reflect the response of the answered survey items – this was completed for all 28 dyads. Afterwards, the indicator score was adjusted accordingly (as previously mentioned). If, however, the index score was based on the response of one survey item (e.g., autonomy support parenting practices regarding adolescent's physical activity) that the participant did not answer, the indicator was not adjusted and remained missing. At the end of the data recoding process, 23 dyads were recovered and only 5 parent-adolescent dyads (1.3% of the total sample) contained missing information.

Changes to the study results that occurred after the missing cases were included in the study analyses have been noted in the result tables found in Chapter 4. When the 23 recovered cases were included in the study analyses, a handful of minor changes were observed.

Specifically, associations that were borderline significant gained significance, while other associations that were near the p-value=0.05 cut-off point lost statistical significance. Only one major change to the study results was observed. Specifically, the association between controlled motivation and app adoption within the full sample (Table 4.6) lost statistical significance when the missing cases were added to the model.

Chapter 4: Results

4.1 Sample Demographic Characteristics

Table 4.1 presents the demographic characteristics of the study sample (n=371). Among the adolescent sample, the mean age was 14.9 years, the sample was equally split based on sex, and the majority were of white ethnicity. Among the parent sample, the mean age was 46.5 years and approximately 2/3 of the sample were female (65.2%). The majority of the parents were married or living with a common-law, were educated, and had a household income of >$50,000. Note that the distribution of the sample demographics did not significantly differ between the families included within the app adoption models and those included in the app usage models.

Table 4.1: Study sample demographic characteristics.

		N	%	Mean ± SD	Range
Adolescent Sample					
Age		371	100	14.9 years ± 1.5	13 – 17
Sex	Male	187	50.4		
	Female	184	49.6		
Ethnicity	White	258	69.5		
	Chinese	21	5.7		
	South East Asian/South Asian/Japanese	19	5.1		
	Aboriginal/White & Aboriginal	22	5.9		
	Other	51	13.8		
Parent Sample					
Age		368	99.2	46.6 years ± 6.6	27 – 66
	Missing	3	0.8		
Sex	Male	129	34.8		
	Female	242	65.2		
Marital Status	Married/Common-Law	311	83.8		
	Single/Divorced/Widowed	60	16.2		
Household Income	Less than $50,000	53	14.3		
	$50,000 - $99,999	134	36.1		
	$100,000 - $150,000+	148	39.9		
	Missing	36	9.7		
Highest Level of Education Attained	High School or Less	86	23.2		
	College Diploma or Trade Certificate	98	26.4		
	Bachelor's Degree	140	37.7		
	Above Bachelor's Degree	47	12.7		

Note: N = Number; % = Percentage; SD = Standard Deviation

4.2 Descriptive Statistics of Adolescent Characteristics and Parenting Practices

The mean, standard deviation, median, and interquartile range for the dependent variables, independent variables, mediators, and covariates are presented in Table 4.2. A correlation matrix is provided in Appendix B. With regards to the dependent variables, the majority of adolescents adopted the Aim2Be© app (79.2%). The mean number of minutes of app usage was 83.6 minutes, while the median was 34.4 minutes. The total number of minutes of app usage ranged from 0.9 – 1335.9 minutes.

For all of the independent and mediating variables, the scores ranged from 0 – 4. The mean score for all of the mediators was approximately 2, meaning that adolescents scored above the 50th percentile for about two out of four health behaviours and were autonomously motivated and externally motivated to engage in two out of four health behaviours. With regards to parenting practices, control practices had a mean score of 2.2, meaning that parents on average, used controlling practices for about two out of the four health behaviours measured in this study. Means scores for autonomy support and structure practices were 1.6 and 2.6, respectively.

Table 4.2: Descriptive statistics for dependent variables, independent variables, and mediators.

		N	%	Mean ± SD	Median (IQR)	Range
Dependent Variables						
Minutes of App Usage		294		83.6 ± 156.5	34.4 (65.33)	0.9 – 1335.9
App Adoption	*Yes*	294	79.2			
	No	77	20.8			
Independent Variables						
Autonomy Practices		367		1.6 ± 1.2	1 (2)	0 – 4
Structure Practices		368		2.6 ± 1.1	3 (2)	0 – 4
Control Practices		369		2.1 ± 1.4	2 (2)	0 – 4
Mediators						
Health Behaviours		371		2.0 ± 1.1	2 (2)	0 – 4
Autonomous Motivation		371		2.2 ± 1.1	2 (2)	0 – 4
Controlled Motivation		371		2.2 ± 1.4	2 (2)	0 – 4

Note: N = Number; % = Percentage; SD = Standard Deviation; IQR = Interquartile Range

4.3 Associations between Adolescent Characteristics, Parenting Practices, and Adolescent's App Adoption and Usage

Table 4.3 highlights the univariable linear and logistic analyses, respectively, between the independent and mediating variables with the dependent variables. All univariate analyses were adjusted for adolescent's age and sex.

Univariately, health behaviours (β=0.17) was the only variable that was positively associated with app adoption, meaning that adolescents' odds of adopting the app increased if they reported engaging in more healthier behaviours. In contrast, when examining app usage, all forms of parenting practices, including control (β=0.17), structure (β=0.13), and autonomy (β=0.23) were univariately positively associated. These results indicate that app usage increased if parents were more controlling, provided more structure, or provided autonomy through their parenting practices on the health behaviours examined in this study.

Table 4.3: Univariable linear and logistic regression analysis, adjusted for adolescent's sex and age.

	Dependent Variables					
	App Adoption			**Minutes of App Usage**		
	β	**95%CI**	**p-value**	**β**	**95%CI**	**p-value**
Independent Variables						
Autonomy Practices	-0.03	(-0.17, 0.11)	p=0.66	**0.23**	**(0.12, 0.34)**	**p=0.00**
Structure Practices	-0.06	(-0.20, 0.08)	p=0.40	**0.13**	**(0.02, 0.24)**	**p=0.03**
Control Practices	-0.06	(-0.21, 0.08)	p=0.39	**0.17**	**(0.06, 0.29)**	**p=0.01**
Mediators						
Health Behaviours	**0.17**	**(0.03, 0.31)**	**p=0.02**	0.03	(-0.08, 0.15)	p=0.60
Autonomous Motivation	0.01	(-0.13, 0.15)	p=0.90	-0.05	(-0.16, 0.07)	p=0.43
Controlled Motivation	0.09	(-0.05, 0.22)	p=0.22	0.04	(-0.07, 0.16)	p=0.46
Covariates						
Adolescent Age	-0.11	(-0.25, 0.03)	p=0.11	-0.05	(-0.16, 0.07)	p=0.41
Adolescent Sex[†]	0.07	(-0.07, 0.21)	p=0.32	0.08	(-0.04, 0.19)	p=0.19

Note: β = Standardized Estimate; 95%CI = 95% Confidence Interval; Bold = $p<0.05$; [†]Reference = Male

4.4 Characteristics Associated with Adolescents' Adoption of Aim2Be©

4.4.1 Adolescent Characteristics Associated with Adoption of Aim2Be© (Aim IA)

Table 4.4 and Figure 4.1 display the associations between the characteristics of adolescents (i.e., autonomous motivation, controlled motivation, and health behaviours) and their adoption of Aim2Be© - adjusted for adolescent's age and sex.

As shown in Table 4.4, two adolescent characteristics had an effect on Aim2Be© adoption, namely health behaviours and autonomous motivation. Health behaviours had a significant and positive direct effect on adoption, where a one standard deviation increase in adolescent's health behaviours was associated with an 8% increase in the odds of adopting the Aim2Be© app. Autonomous motivation had a significant and positive indirect effect on app adoption via health behaviours, where one standard deviation increase in adolescent's autonomous motivation was associated with a 2% increase in the odds of adopting the Aim2Be© app. With regards to the mediators, both autonomous (β=0.30) and controlled motivation (β=0.12) were all positively associated with health behaviours, meaning that increases in both autonomous and controlled motivations were associated with greater engagement in healthy behaviours. Finally, adolescent's age was negatively associated with health behaviours (β=-0.11), meaning that older adolescents engaged in poorer health behaviours compared to younger adolescents.

Table 4.4: Associations between adolescent characteristics and app adoption, adjusted for adolescent's sex and age (n=371).

	Dependent Variable		**Mediator**
	App Adoption		**Health Behaviours**
	Direct Effect	*Indirect Effect*	*Direct Effect*
	OR (95%CI)	**OR (95%CI)**	**β (95%CI)**
Mediators			
Health Behaviours	**1.08 (1.01, 1.14)**		
Autonomous Motivation	0.96 (0.90, 1.03)	**1.02 (1.00, 1.04)[1]**	**0.30 (0.20, 0.40)**
Controlled Motivation	1.04 (0.97, 1.10)	1.01 (1.00, 1.02)	**0.12 (0.02, 0.22)**
Covariates			
Adolescent Age	0.96 (0.91, 1.02)		**-0.11 (-0.20, -0.01)**
Adolescent Sex[†]	1.03 (0.98, 1.09)		-0.04 (-0.13, 0.06)

Note: OR = Odds Ratio; 95%CI = 95% Confidence Interval; β = Standardized Estimate; Bold = p<0.05; [†]Reference = Male
Indirect Path: 1) The indirect effect of autonomous motivation occurs via health behaviours.

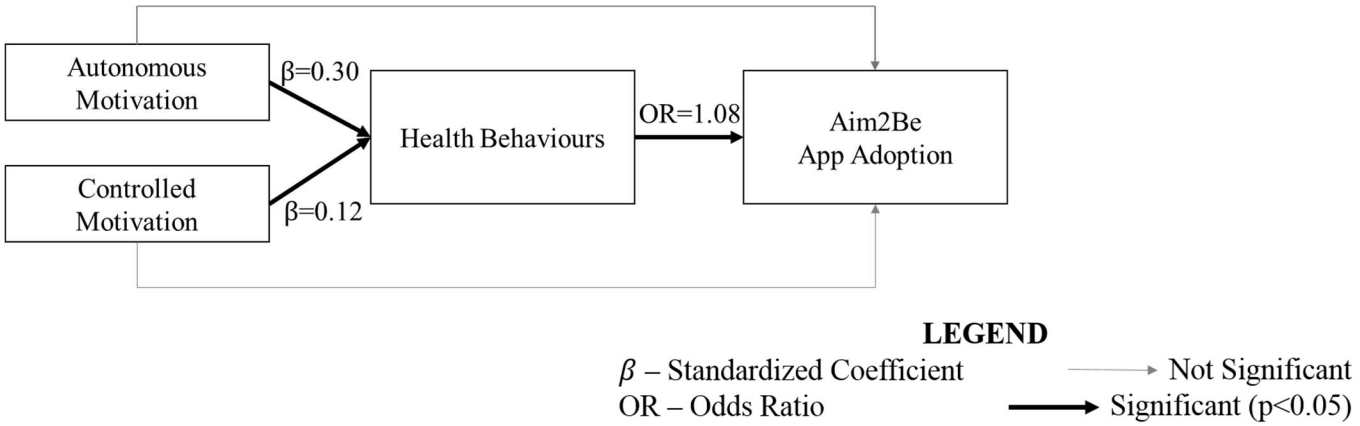


Figure 4.1: Graphical summary of the associations between adolescent characteristics and app adoption, adjusted for adolescent's age and sex (n=371).

4.4.2 Parenting Practices Associated with Adoption of Aim2Be© (Aim IIA)

Table 4.5 and Figure 4.2 display the associations between autonomy support, structure, and control practices, with adolescents' adoption of the Aim2Be© app - adjusted for adolescent's age and sex. Table 4.5 also displays the results of the parent sex stratified analyses.

Full Sample

As shown in Table 4.5, no direct effects were observed between parenting practices and app adoption among the full sample. Additionally, none of the covariates were significantly associated with app adoption.

Mother and Father Samples

In Table 4.5, no direct effects were observed among the mother and father samples. As well, none of the covariates were significantly associated with app adoption among both samples.

Table 4.5: Total direct effects of parenting practices on adolescents' app adoption, adjusted for adolescent's sex and age.

	Dependent Variable		
	App Adoption		
	Total Sample *(n=366)*	**Mothers** *(n=239)*	**Fathers** *(n=127)*
	OR (95%CI)	**OR (95%CI)**	**OR (95%CI)**
Independent Variables			
Autonomy Practices	1.00 (0.93, 1.08)	0.97 (0.88, 1.06)	1.08 (0.95, 1.22)
Structure Practices	0.98 (0.92, 1.05)	1.00 (0.92, 1.08)	0.98 (0.87, 1.09)
Control Practices	0.98 (0.91, 1.05)	1.00 (0.91, 1.10)	0.94 (0.83, 1.06)
Covariates			
Adolescent Age	0.95 (0.90, 1.01)	0.98 (0.90, 1.05)	0.91 (0.82, 1.01)
Adolescent Sex†	1.02 (0.96, 1.08)	1.01 (0.94, 1.08)	1.03 (0.94, 1.14)

Note: OR = Odds Ratio; 95%CI = 95% Confidence Interval; Bold = p<0.05; †Reference = Male

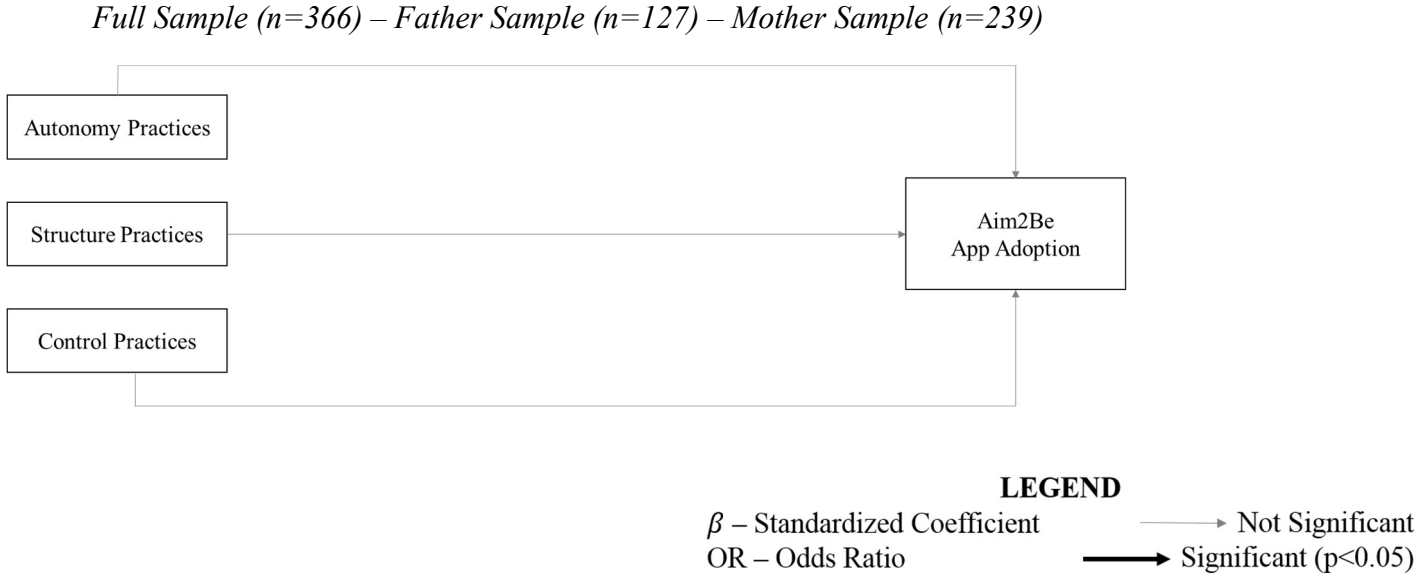


Figure 4.2: Graphical summary of the associations between parenting practices and app adoption, adjusted for adolescent's age and sex.

4.4.3 Mediated Effects Associated with Adoption of Aim2Be© (Aim IIIA)

Table 4.6 displays the associations between parenting practices and adoption of Aim2Be©, mediated by adolescent characteristics and adjusted for adolescent's age and sex. Table 4.7 displays the results of the parent sex stratified analyses. Finally, Figure 4.3 summarizes the results from Tables 4.6 and 4.7.

Full Sample

As shown in Table 4.6, two adolescent characteristics and one parenting practice had direct or indirect effects on Aim2Be© adoption, specifically health behaviours, autonomous motivation, and use of structure parenting practices. Health behaviours had a positive direct effect on adoption (OR=1.08; $p<0.05$), where a one standard deviation increase in adolescent's health behaviours score was associated with an 8% increase in the odds of adopting the Aim2Be© app. Autonomous motivation had a positive indirect effect on adoption of Aim2Be© via adolescent's health behaviours (OR=1.02; $p<0.05$), where one standard deviation increase in adolescent's autonomous motivation score was associated with a 2% increase in the odds of adopting the Aim2Be© app. Use of structure parenting practices also had an overall positive indirect effect on adoption (OR=1.02; $p<0.05$). However, since none of the specific indirect paths were significant, the results suggest that it was the combined effect of structure practices on autonomous and controlled motivation that resulted in an increase in app adoption. Specifically, one standard deviation increase in structure practices was associated with a 2% increase in the adolescent's odds of adopting the Aim2Be© app.

With regards to the mediators, autonomy parenting practices was positively associated with autonomous motivation ($\beta=0.18$; $p<0.05$) and had a positive indirect association with health

behaviours (β=0.06; p<0.05). Autonomous motivation was positively associated with health behaviours (β=0.32; p<0.05). Control parenting practices was positively associated with controlled motivation (β=0.20; p<0.05), meaning that increased use of controlling practices was associated with greater controlled motivation. Finally, adolescent's age was negatively associated with health behaviours (β=-0.12; p<0.05), which indicated that older adolescents engaged in poorer health behaviours, as compared to younger adolescents.

Mother and Father Samples

When the analyses were stratified by parent's sex, difference in the associations emerged (see Table 4.7 and Figure 4.3). Specifically, among the mother subgroup, the associations between health behaviours, autonomous motivation, and app adoption remained significant (ORs=1.11 and 1.01, respectively). These results suggest that adolescents who engaged in healthy behaviours and had higher levels of autonomous motivation had greater odds of adopting the Aim2Be© app. The indirect effect between structure parenting practices and adolescent's app adoption no longer remained significant. Among the father subgroup, the direct and indirect associations between health behaviours, autonomous motivation, and structure practices to app adoption were not significant. Instead, controlled motivation was the only variable that was positively associated with app adoption (OR=1.13; p<0.05). Specifically, one standard deviation increase in the adolescent's controlled motivation score was associated with a 13% increase in the adolescent's odds of adoption the app.

Table 4.6: Associations between parenting practices and adolescent's app adoption, mediated by adolescent characteristics and adjusted for adolescent's sex and age (n=366).

	Dependent Variable		**Mediators**			
	App Adoption		**Autonomous Motivation**	**Controlled Motivation**	**Health Behaviours**	
	Direct Effect	*Indirect Effect*	*Direct Effect*	*Direct Effect*	*Direct Effect*	*Indirect Effect*
	OR (95%CI)	**OR (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**
Independent Variables						
Autonomy Practices	1.01 (0.94, 1.08)	1.00 (0.98, 1.01)	**0.18 (0.06, 0.29)**		-0.04 (-0.17, 0.08)	**0.06 (0.02, 0.10)**[3]
Structure Practices	0.97 (0.90, 1.03)	**1.02 (1.00, 1.04)**[1]	0.03 (-0.08, 0.15)	**0.22 (0.11, 0.32)**	-0.03 (0.00, 0.22)	0.03 (-0.01, 0.08)
Control Practices	0.98 (0.90, 1.05)	1.01 (0.99, 1.03)		**0.20 (0.10, 0.31)**	0.11 (-0.16, 0.09)	0.02 (-0.00, 0.05)
Mediators						
Health Behaviours	**1.08 (1.02, 1.15)**[a]					
Autonomous Motivation	0.96 (0.90, 1.03)	**1.02 (1.00, 1.05)**[2]			**0.32 (0.22, 0.42)**	
Controlled Motivation	1.05 (0.99, 1.13)[b]	1.01 (1.00, 1.02)			0.11 (0.00, 0.22)	
Covariates						
Adolescent Age	0.96 (0.90, 1.02)		0.02 (-0.80, 0.12)	0.05 (-0.05, 0.15)	**-0.12 (-0.22, -0.02)**	
Adolescent Sex†	1.02 (0.96, 1.08)		0.10 (-0.00, 0.20)	0.04 (-0.06, 0.13)	-0.03 (-0.13, 0.07)	

Note: OR = Odds Ratio; 95%CI = 95% Confidence Interval; β = Standardized Estimate; Bold = $p<0.05$; †Reference = Male; [a]= Gained statistical significance when missing cases were included in the model; [b]= Lost statistical significance when missing cases were included in the model

Indirect Path: 1) Structure parenting practices had an indirect effect on app adoption but no specific indirect paths were identified. **2)** The indirect effect between autonomous motivation and app adoption occurs via health behaviours. **3)** The indirect effect between autonomy parenting practices and health behaviours occurs via autonomous motivation.

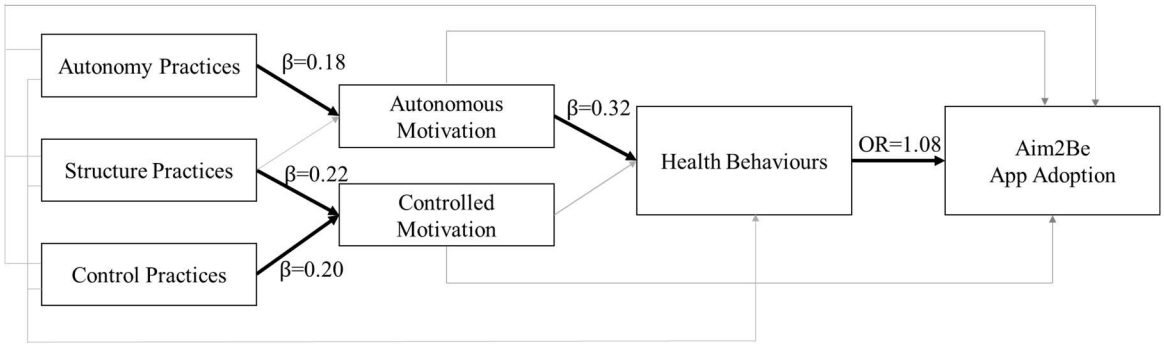
Table 4.7: Associations between parenting practices and adolescent's app adoption, among mothers and fathers - mediated by adolescent characteristics and adjusted for adolescent's sex and age.

	Dependent Variable		**Mediators**			
	App Adoption		**Autonomous Motivation**	**Controlled Motivation**	**Health Behaviours**	
	Direct Effect	*Indirect Effect*	*Direct Effect*	*Direct Effect*	*Direct Effect*	*Indirect Effect*
	OR (95%CI)	**OR (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**
MOTHER SAMPLE (n=239)						
Independent Variables						
Autonomy Practices	0.98 (0.89, 1.07)	0.99 (0.98, 1.01)	0.14 (-0.01, 0.28)		-0.04 (-0.20, 0.12)	0.04 (-0.01, 0.09)
Structure Practices	0.99 (0.91, 1.07)	1.01 (0.99, 1.04)	0.05 (-0.10, 0.19)	**0.25 (0.13, 0.38)**	0.07 (-0.08, 0.21)	0.05 (-0.01, 0.11)[b]
Control Practices	1.00 (0.91, 1.09)	1.01 (0.98, 1.03)		**0.20 (0.07, 0.33)**	0.01 (-0.15, 0.16)	0.03 (-0.00, 0.06)
Mediators						
Health Behaviours	**1.11 (1.03, 1.19)**					
Autonomous Motivation	0.95 (0.88, 1.03)	**1.01 (1.00, 1.06)[a1]**			**0.31 (0.19, 0.43)**	
Controlled Motivation	1.01 (0.94, 1.10)	1.02 (1.00, 1.03)			**0.15 (0.01, 0.28)**	
Covariates						
Adolescent Age	0.98 (0.91, 1.06)		0.04 (-0.09, 0.17)	**0.13 (0.01, 0.26)**	-0.10 (-0.22, -0.02)	
Adolescent Sex[1]	1.01 (0.94, 1.08)		0.10 (-0.02, 0.23)	0.02 (-0.10, 0.14)	0.04 (-0.13, 0.07)	
FATHER SAMPLE (n=127)						
Independent Variables						
Autonomy Practices	1.08 (0.95, 1.23)	0.99 (0.96, 1.03)	**0.27 (0.08, 0.45)**		-0.09 (-0.29, 0.12)	**0.09 (0.01, 0.17)[2]**
Structure Practices	0.95 (0.84, 1.07)	1.03 (0.99, 1.07)	0.01 (-0.18, 0.20)	0.17 (-0.01, 0.35)	**0.26 (0.08, 0.43)**	0.01 (-0.06, 0.08)
Control Practices	0.92 (0.86, 1.04)	1.02 (0.99, 1.06)		**0.21 (0.03, 0.39)**	-0.10 (-0.31, 0.11)	0.01 (-0.03, 0.05)
Mediators						
Health Behaviours	1.04 (0.93, 1.16)					
Autonomous Motivation	0.98 (0.87, 1.10)	1.01 (0.98, 1.05)			**0.34 (0.17, 0.52)**	
Controlled Motivation	**1.13 (1.01, 1.25)**	1.00 (0.99, 1.01)			0.04 (-0.14, 0.22)	
Covariates						
Adolescent Age	0.93 (0.84, 1.04)		-0.02 (-0.19, 0.15)	-0.10 (-0.28, 0.07)	**-0.21 (-0.38, -0.05)**	
Adolescent Sex[†]	1.02 (0.93, 1.13)		0.12 (-0.05, 0.29)	0.10 (-0.06, 0.27)	**-0.20 (-0.35, -0.04)**	

Note: OR = Odds Ratio; 95%CI = 95% Confidence Interval; β = Standardized Estimate; Bold = $p<0.05$; [†]Reference = Male; [a]= Gained statistical significance when missing cases were included in the model; [b]= Lost statistical significance when missing cases were included in the model

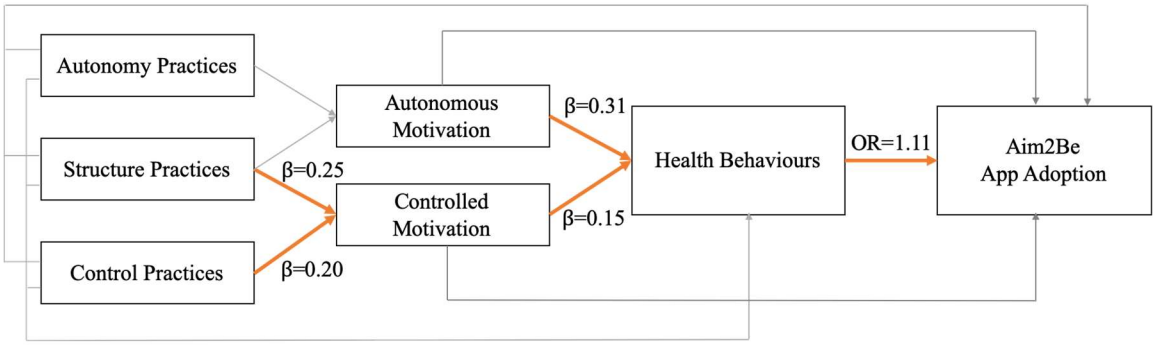
Indirect Paths: 1) Among mothers, the indirect effect between autonomous motivation and Aim2Be© app adoption occurs via the health behaviours. **2)** Among fathers, the indirect effect between autonomy practices and health behaviours occurs via autonomous motivation.

Full Sample (n=366)



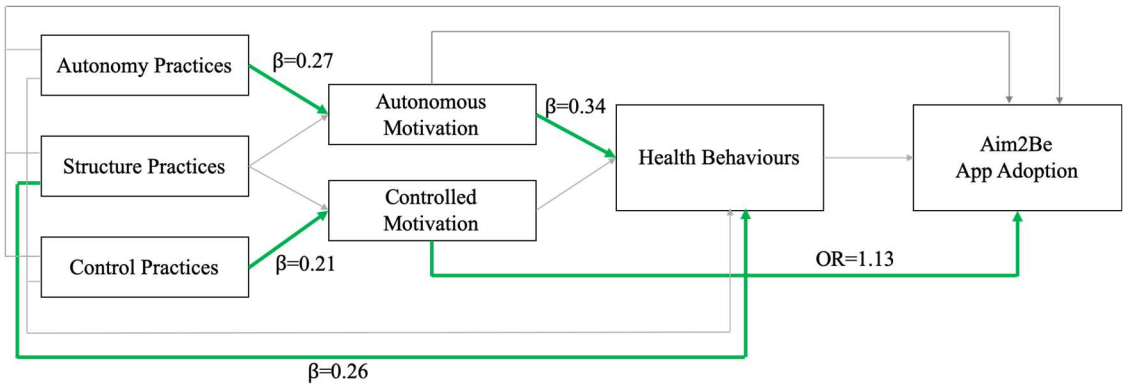
Indirect Path: 1) Structure parenting practices had an indirect effect on app adoption but no specific indirect paths were identified (OR=1.02). **2)** Autonomous motivation was indirectly associated with app adoption via health behaviours (OR=1.02). **3)** Autonomy parenting practices was indirectly associated with health behaviours via autonomous motivation (β=0.06).

Mother Sample (n=239)



Indirect Paths: 1) Autonomous motivation had an indirect effect on app adoption via health behaviours (OR=1.01).

Father Sample (n=127)



Indirect Path: 1) Autonomy practices had an indirect effect on health behaviours via autonomous motivation (β=0.09).

LEGEND

β – Standardized Coefficient
OR – Odds Ratio
Not Significant
Significant (p<0.05)

Figure 4.3: Graphical summaries of the associations between parenting practices and app adoption, mediated by adolescent characteristics and adjusted for adolescent's age and sex.

4.5 Characteristics Associated with Usage of Aim2Be©

4.5.1 Characteristics of Adolescents Associated with Usage of Aim2Be© (Aim IB)

Table 4.8 and Figure 4.4 display the associations between adolescent's characteristics and their use of the Aim2Be© app - adjusted for adolescent's age and sex. As shown in Table 4.8, none of the individual-level characteristics had an effect (both directly and indirectly) on app usage. However, autonomous ($\beta=0.28$; $p<0.05$) and controlled ($\beta=0.15$; $p<0.05$) motivations were both positively associated with health behaviours, meaning that higher autonomous and controlled motivation levels were associated with greater engagement in healthy behaviours.

Table 4.8: Associations between adolescent characteristics and minutes of app usage, adjusted for adolescent's sex and age (n=294).

	Dependent Variable		**Mediator**
	Mins of App Usage		**Health Behaviours**
	Direct Effect	*Indirect Effect*	*Direct Effect*
	β (95%CI)	**β (95%CI)**	**β (95%CI)**
Mediators			
Health Behaviours	0.04 (-0.08, 0.16)		
Autonomous Motivation	-0.08 (-0.21, 0.04)	0.01 (-0.02, 0.05)	**0.28 (0.17, 0.40)**
Controlled Motivation	0.06 (-0.06, 0.18)	0.01 (-0.01, 0.03)	**0.15 (0.04, 0.26)**
Covariates			
Adolescent Age	-0.05 (-0.16, 0.07)		-0.06 (-0.17, 0.05)
Adolescent Sex†	0.09 (-0.03, 0.20)		-0.08 (-0.18, 0.03)

Note: β = Standardized Estimate; 95%CI = 95% Confidence Interval; Bold = p<0.05; †Reference = Male

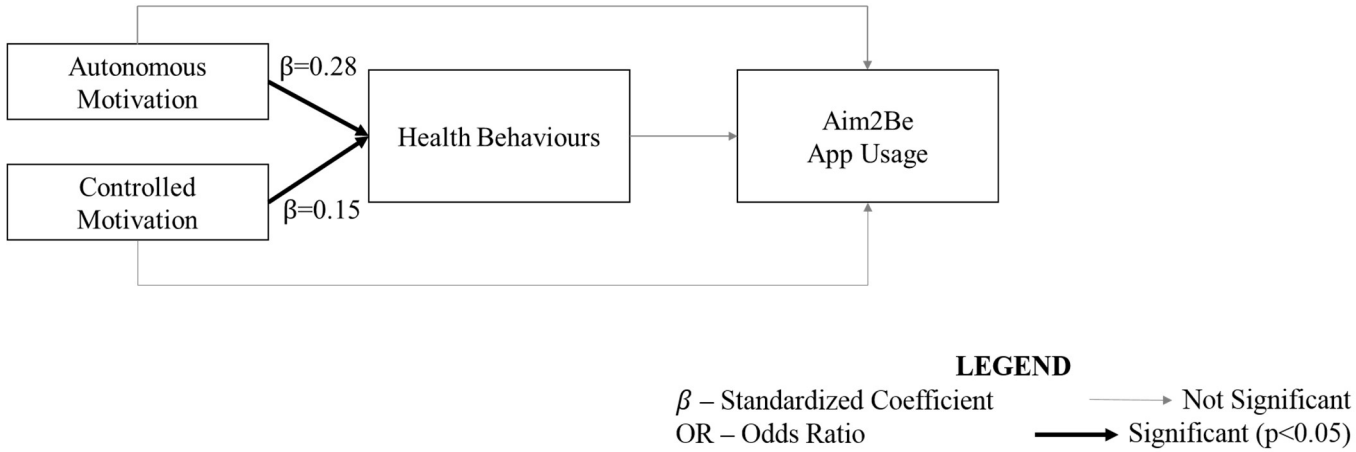


Figure 4.4: Graphical summary of the associations between adolescent characteristics and app usage, adjusted for adolescent's age and sex (n=294).

4.5.2 Parenting Practices Associated with Usage of Aim2Be© (Aim IIB)

Table 4.9 and Figure 4.5 display the associations between autonomy support, structure, and control practices, with Aim2Be© app usage - adjusted for adolescent's age and sex. Table 4.10 and Figure 4.5 also display the results of the stratified parent sex analyses.

Full sample

As shown in Table 4.9, one parenting practice, namely autonomy support, had a positive direct effect on app usage ($\beta=0.20$; $p<0.05$). Specifically, one standard deviation increase in autonomy supportive parenting practices was associated with a 2.30 minute increase in the adolescent's use of the Aim2Be© app.

Mother and Father Sample

When the analysis was stratified by parent's sex, differences in the associations emerged. In the mother sample, the association between autonomy practices and app usage remained positive ($\beta=0.24$; $p<0.05$), where one standard deviation increase in autonomy practices was associated with a 2.72 minute increase in the adolescent's use of the Aim2Be© app (see Table 4.10 and Figure 4.5). In contrast, among the father subgroup, no significant associations were observed between parenting practices and adolescent's app usage.

Table 4.9: Total direct effects of parenting practices on adolescent's minutes of app usage, adjusted for adolescent's sex and age.

	Dependent Variable		
	Mins of App Usage		
	Total Sample *(n=292)*	**Mothers** *(n=190)*	**Fathers** *(n=102)*
	β (95%CI)	**β (95%CI)**	**β (95%CI)**
Independent Variables			
Autonomy Practices	**0.20 (0.06, 0.34)**	**0.24 (0.06, 0.41)**	0.09 (-0.17, 0.34)
Structure Practices	0.01 (-0.12, 0.14)	0.01 (-0.14, 0.17)	0.03 (-0.19, 0.25)
Control Practices	0.06 (-0.09, 0.20)	0.03 (-0.15, 0.20)	0.15 (-0.10, 0.40)
Covariates			
Adolescent Age	-0.02 (-0.13, 0.10)	-0.01 (-0.15, 0.14)	-0.05 (-0.24, 0.15)
Adolescent Sex†	0.11 (-0.00, 0.22)	0.13 (-0.01, 0.27)	0.01 (-0.18, 0.20)

Note: β = Standardized Estimate; 95%CI = 95% Confidence Interval; Bold = $p<0.05$; †Reference = Male

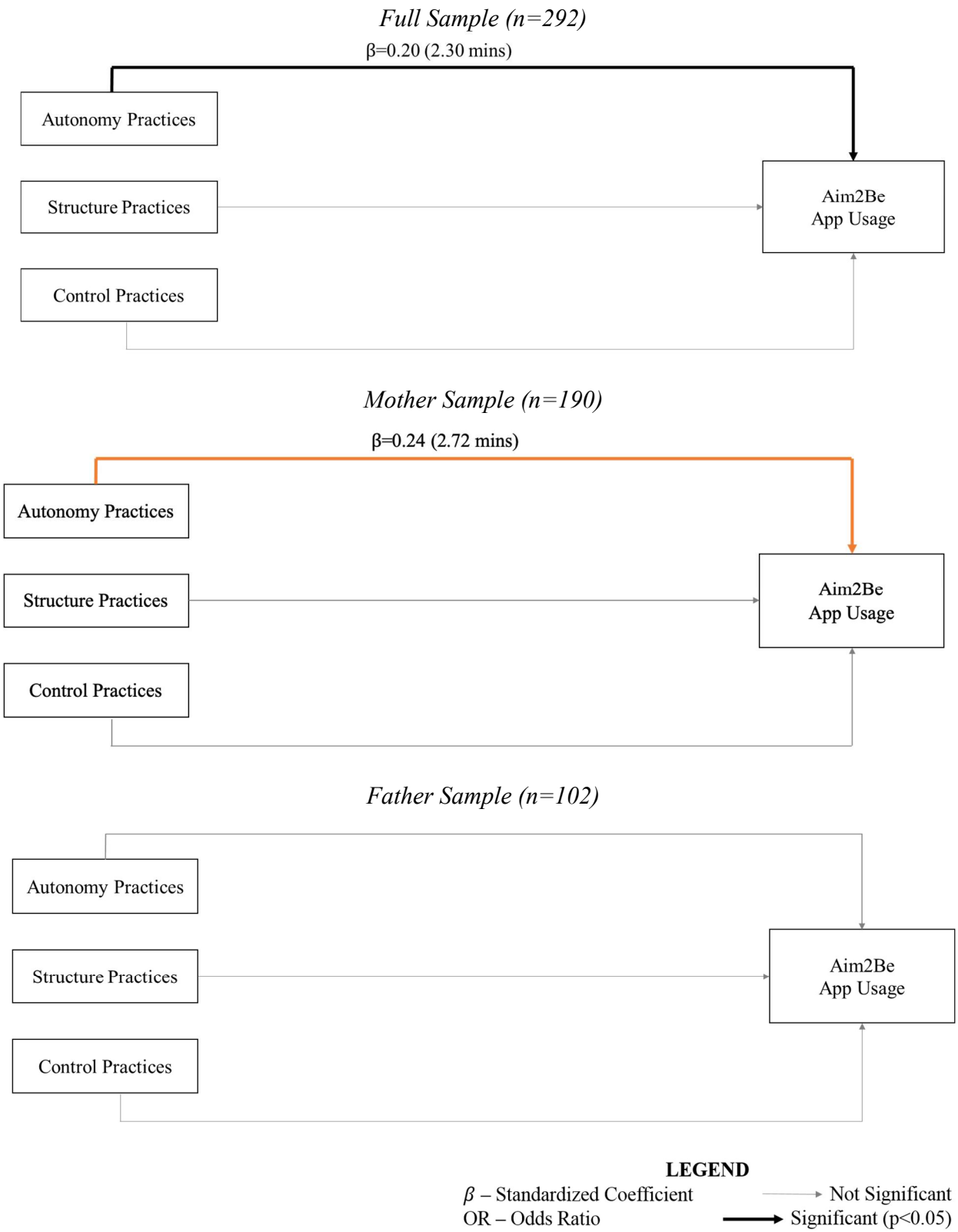


Figure 4.5: Graphical summary of the associations between parenting practices and app usage, adjusted for adolescent's age and sex.

4.5.3 Mediated Effects Associated with Usage of Aim2Be© (Aim IIIB)

Table 4.10 displays the associations between parenting practices and Aim2Be© app usage – mediated by adolescent-level characteristics and adjusted for adolescent's age and sex. Table 4.11 also displays the results of the parent sex stratified analyses. Finally, Figure 4.6 summarizes the results of Tables 4.10 and 4.11.

Full Sample

As shown in Table 4.10, one parenting practice and one covariate had positive effects on app usage, namely autonomy practices ($\beta=0.21$; $p<0.05$) and adolescent's sex ($\beta=0.12$; $p<0.05$). Specifically, one standard deviation increase in autonomy parenting practices was associated with a 2.40 minute increase in the adolescent's use of the Aim2Be© app. At the same time, female adolescents used the app for 1.24 minutes more, as compared to male adolescents. No indirect effects were observed.

With regards to the mediators, autonomy practices ($\beta=0.14$; $p<0.05$) and adolescent's sex ($\beta=0.12$; $p<0.05$) were positively associated with autonomous motivation. Structure ($\beta=0.25$; $p<0.05$) and control practices ($\beta=0.23$; $p<0.05$) were positively associated with controlled motivation, meaning that increased use of structure and controlling practices were associated with higher levels of controlled motivation. Finally, both structure practices ($\beta=0.15$; $p<0.05$) and autonomous motivation ($\beta=0.30$; $p<0.05$) were positively associated with adolescents' health behaviours.

Mother and Father Sample

When the analyses were stratified by parent's sex, differences in the associations

emerged (see Table 4.11 and Figure 4.6). Within the mother sample, the positive associations between autonomy practices ($\beta=0.25$; $p<0.05$), adolescent's sex ($\beta=0.14$; $p<0.05$), and app usage remained significant. Specifically, one standard deviation increase in autonomy parenting practices was associated with a 2.83 minute increase in app usage. Additionally, female adolescents were associated with a 1.79 minutes increase in total app usage, compared to male adolescents. In contrast, within the father subgroup, no direct or indirect effects were observed with regards to app usage.

Table 4.10: Associations between parenting practices and minutes of app usage, mediated through adolescent characteristics and adjusted for adolescent's sex and age (n=292).

	Dependent Variable		**Mediators**			
	Minutes of App Usage		**Autonomous Motivation**	**Controlled Motivation**	**Health Behaviours**	
	Direct Effect	*Indirect Effect*	*Direct Effect*	*Direct Effect*	*Direct Effect*	*Indirect Effect*
	β (95%CI)	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**
Independent Variables						
Autonomy Practices	**0.21 (0.07, 0.36)**	-0.01 (-0.03, 0.01)	**0.14 (0.01, 0.27)**		-0.03 (-0.17, 0.11)	0.04 (0.00, 0.08)
Structure Practices	0.02 (-0.12, 0.15)	-0.00 (-0.04, 0.03)	0.07 (-0.06, 0.20)	**0.25 (0.13, 0.36)**	**0.15 (0.03, 0.27)**	0.05 (-0.00, 0.10)[b]
Control Practices	0.06 (-0.09, 0.20)	0.00 (-0.03, 0.03)		**0.23 (0.11, 0.35)**	0.01 (-0.13, 0.15)	0.03 (-0.01, 0.06)
Mediators						
Health Behaviours	0.03 (-0.09, 0.15)					
Autonomous Motivation	-0.10 (-0.22, 0.03)	0.01 (-0.03, 0.04)			**0.30 (0.19, 0.41)**	
Controlled Motivation	-0.01 (-0.13, 0.12)	0.00 (-0.01, 0.02)			0.11 (-0.01, 0.23)	
Covariates						
Adolescent Age	-0.02 (-0.13, 0.10)		-0.02 (-0.14, 0.09)	0.06 (-0.06, 0.17)	-0.06 (-0.17, 0.05)	
Adolescent Sex[†]	**0.12 (0.01, 0.24)**		**0.12 (-0.14, 0.09)**	0.06 (-0.05, 0.17)	-0.06 (-0.17, 0.05)	

Note: β = Standardized Estimate; 95%CI = 95% Confidence Interval; Bold = p<0.05; [†]Reference = Male; [b]= Lost statistical significance when missing cases were included in the model

Table 4.11: Associations between parenting practices and minutes of app usage among mothers and fathers - mediated through adolescent characteristics and adjusted for adolescent's sex and age.

	Dependent Variable		**Mediators**			
	Minutes of App Usage		**Autonomous Motivation**	**Controlled Motivation**	**Health Behaviours**	
	Direct Effect	*Indirect Effect*	*Direct Effect*	*Direct Effect*	*Direct Effect*	*Indirect Effect*
	β (95%CI)	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**	**β (95%CI)**
MOTHER SAMPLE (n=190)						
Independent Variables						
Autonomy Practices	**0.25 (0.07, 0.42)**	-0.01 (-0.03, 0.01)	0.11 (-0.05, 0.27)		0.03 (-0.14, 0.19)	0.03 (-0.02, 0.09)
Structure Practices	0.02 (-0.14, 0.18)	-0.01 (-0.05, 0.04)	0.06 (-0.11, 0.22)	**0.27 (0.13, 0.41)**	0.12 (-0.03, 0.27)	0.06 (-0.01, 0.12)[b]
Control Practices	0.03 (-0.14, 0.21)	-0.00 (-0.03, 0.03)		**0.20 (0.05, 0.35)**	0.06 (-0.11, 0.22)	0.03 (-0.01, 0.07)
Mediators						
Health Behaviours	-0.02 (-0.17, 0.13)					
Autonomous Motivation	-0.09 (-0.24, 0.07)	-0.01 (-0.05, 0.04)			**0.31 (0.18, 0.44)**	
Controlled Motivation	-0.00 (-0.16, 0.15)	-0.00 (-0.02, 0.02)			0.15 (-0.00, 0.29)	
Covariates						
Adolescent Age	-0.01 (-0.16, 0.14)		-0.04 (-0.18, 0.11)	0.10 (-0.04, 0.24)	0.00 (-0.14, 0.14)	
Adolescent Sex[†]	**0.14 (0.00, 0.28)**		0.11 (-0.03, 0.25)	0.02 (-0.11, 0.16)	0.02 (-0.11, 0.15)	
FATHER SAMPLE (n=102)						
Independent Variables						
Autonomy Practices	0.10 (-0.16, 0.36)	-0.01 (-0.07, 0.04)	0.20 (-0.00, 0.41)		-0.14 (-0.38, 0.09)	0.06 (-0.01, 0.14)
Structure Practices	0.02 (-0.21, 0.25)	0.01 (-0.06, 0.08)	0.08 (-0.13, 0.29)	**0.19 (0.00, 0.48)**[a]	**0.24 (0.04, 0.43)**	0.04 (-0.04, 0.12)
Control Practices	0.14 (-0.12, 0.40)	0.01 (-0.06, 0.08)		**0.31 (0.09, 0.43)**	-0.05 (-0.29, 0.20)	0.02 (-0.04, 0.09)
Mediators						
Health Behaviours	0.03 (-0.18, 0.24)					
Autonomous Motivation	-0.05 (-0.27, 0.17)	0.01 (-0.06, 0.08)			**0.32 (0.13, 0.50)**	
Controlled Motivation	0.03 (-0.19, 0.25)	0.00 (-0.01, 0.02)			0.07 (-0.13, 0.27)	
Covariates						
Adolescent Age	-0.04 (-0.24, 0.16)		0.02 (-0.17, 0.21)	-0.01 (-0.19, 0.17)	**-0.19 (-0.37, -0.01)**	
Adolescent Sex[†]	0.02 (-0.18, 0.22)		0.17 (-0.02, 0.35)	0.17 (-0.00, 0.35)	**-0.25 (-0.43, -0.08)**	

Note: β = Standardized Estimate; 95%CI = 95% Confidence Interval; Bold = p<0.05; [†]Reference = Male; [a]= Gained statistical significance when missing cases were included in the model; [b]= Lost statistical significance when missing cases were included in the model

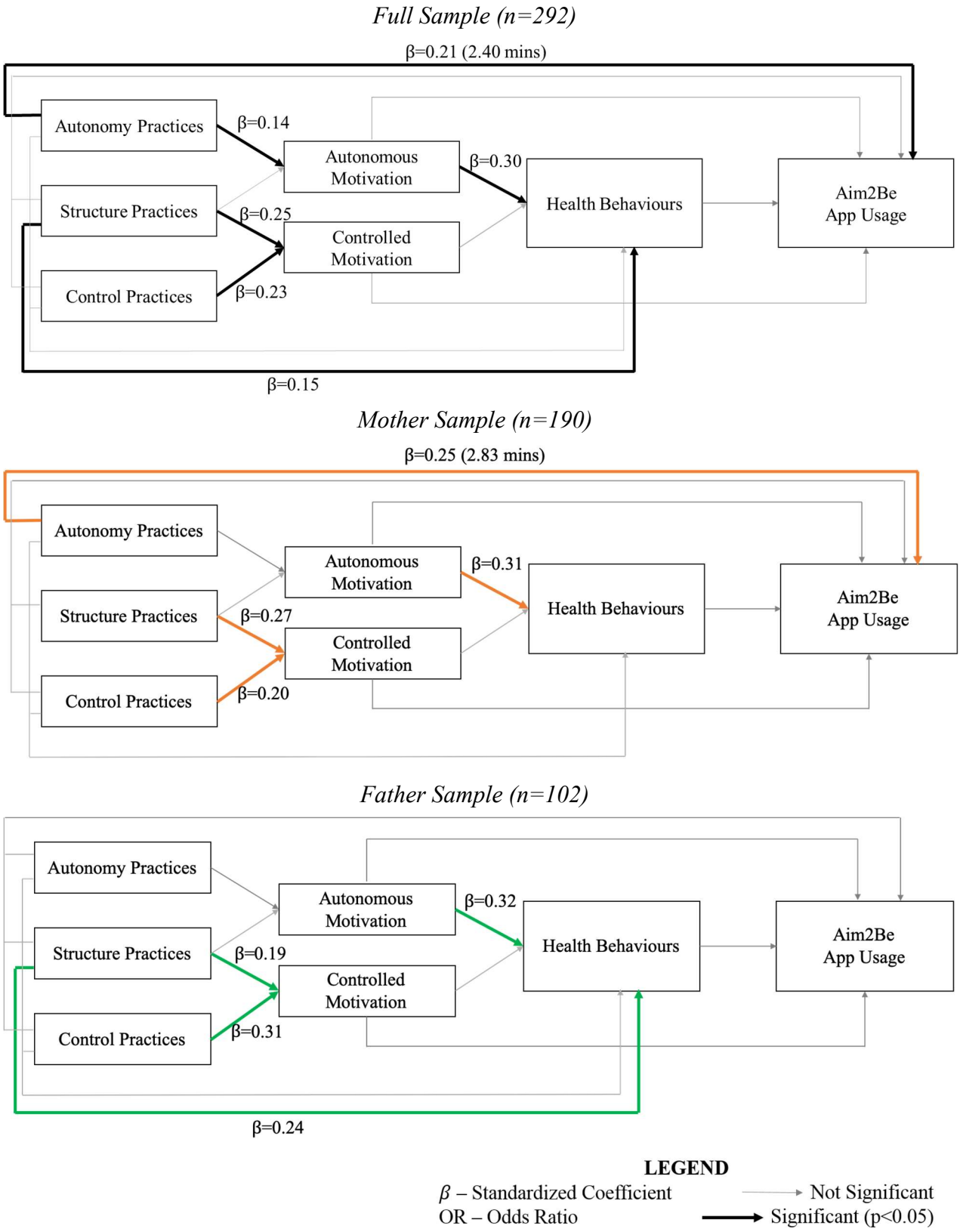


Figure 4.6: Graphical summaries of the associations between parenting practices and app usage, mediated by adolescent characteristics and adjusted for adolescent's age and sex.

Chapter 5: Discussion

The purpose of this study was to examine the associations between adolescent-level characteristics and parenting practices with adolescents' adoption and usage of the Aim2Be© app. A novel aspect of this study was that differences in the effects of parenting practices were examined between mothers and fathers through stratified analyses. Results indicated that not only are adolescent characteristics associated with app adoption, but parenting practices also had an indirect and direct effect on app adoption and usage, respectively. Furthermore, the mechanisms through which parenting practices influenced adolescents' adoption and usage of the Aim2Be© app were not the same in the mother and father samples. Overall these findings provide evidence to suggest that both individual-level characteristics and parenting practices influenced app adoption and usage. Importantly, these results highlight that to increase user engagement, intervention planners should take these characteristics into consideration when developing e-health interventions aimed at changing obesity-related behaviours.

5.1 The Associations of Adolescent Characteristics with Adoption & Usage of the Aim2Be© App

Within this study, adolescent characteristics (i.e., autonomous motivation, controlled motivation, and health behaviours) were examined to determine whether they were directly or indirectly associated with app adoption and usage. It was hypothesized that high levels of autonomous or controlled motivation, along with poor health behaviours, would be associated with adoption and greater app usage; the study results however, only partially supported these hypotheses. Specifically, autonomous motivation and health behaviours were found to be indirectly and directly associated with app adoption, respectively. Though controlled motivation

did not have a direct effect on app adoption in this model (Aim IA), it was implicated in the indirect effect between structure practices and app adoption, when parenting practices were included (Aim IIIA). In contrast, no associations were observed between adolescent characteristics and app usage (Aim IB & Aim IIIB). Overall, these findings provided greater insight into the characteristics of Aim2Be© app users, details of which are explained in further detail below.

One major finding of this study was that adolescents who had better health behaviours and were more autonomously motivated were more likely to adopt the Aim2Be© app. Predictors of app adoption have mainly been examined among adults (30, 32, 146) with the exception of one study that examined willingness to use e-health interventions among adolescents (105). Studies conducted in adults have found that individuals with better health behaviours (30, 32) and higher motivation (146) were more likely to adopt e-health interventions. These associations were also observed in this thesis, indicating that adolescents who may have benefited the most from this program (i.e., adolescents with poor health behaviours and/or low motivation to engage in healthy behaviours) were not accessing the app. However, the one study conducted in adolescents contradicted the results of this thesis, as they reported that poorer health behaviours and high BMI levels were associated with increased willingness to use e-health interventions (105). Importantly, the study with contradicting findings differed in the following ways from this thesis: 1) it focused on willingness to use e-health interventions for health promoting purposes, rather than examining actual adoption, and 2) it also recruited adolescents in the healthcare context and not from the general population. Consequently, sampling from a healthcare context may have biased the responses of the adolescents towards increased willingness to use an e-health lifestyle behaviour modification, which may or may not have translated into actual

adoption. Based on the findings of the study, it appears that gaining a greater understanding of how individual-level characteristics are associated with app adoption is important to ensure that the sub-population of adolescents who may have benefited the most from using the Aim2Be© app are in fact, accessing the app.

Another key finding of this study was that adolescents' characteristics were associated with app adoption, but they were not associated with app usage. One possible reason for this might be because those who are not motivated have already opted to not adopt the app; as a result, other factors likely explain app usage. One possible reason may be that while those who adopted the app were more motivated and had healthier lifestyle behaviors, their continued use of the app may be determined, in part, by app features. Meaning the extent to which the app aligns with their personal values would explain their continued use. Perski et al. (146) noted that among a handful of studies, lack of personal relevance was a deterring factor for participants to use e-health interventions. Therefore, it has been suggested that to improve user engagement, e-health interventions need to include persuasive design techniques, in order to better accommodate and match the needs and preferences of the target population (147-149). Another plausible explanation as to why adolescents' characteristics were not associated with app usage, may be related to how app usage was operationalized. In this study, app usage was measured as the total number of minutes that the adolescent spent using the app, which provided an overview of the adolescent's total exposure to the intervention. However, one major limitation of this methodology is that patterns of app usage cannot be differentiated among the study sample. Specifically, while the results provided some insight about the quantity of usage, little information was provided regarding the quality of that usage. Patterns of usage better reflect the time, frequency, and intensity of a user's engagement with the intervention (103), thereby

providing researchers with the opportunity to differentiate users based on engagement profiles and identify predictors of app engagement (150). Overall, identifying factors that are associated with long-term intervention use can provide indication as to whether the intervention is best suited to the target population and if modifications are necessary to promote long-term use.

With regards to the study covariates, adolescent's age and sex were not significantly associated with app adoption. In contrast however, adolescent sex was a significant covariate for app usage, when parenting practices were mediated by adolescent characteristics. Similar to past studies among both adolescents (106, 108) and adults (32, 34, 36, 104, 151), these findings indicated that female adolescents used the Aim2Be© app more than male adolescents. One possible reason for why female adolescents used the app more may be because they found the app more personally relevant, as past studies have found that females are more likely to seek out health information online, compared to males (152, 153). Age was not found to be significantly associated with app adoption nor usage, which is inconsistent with past studies (37, 106, 107). One possible reason as to why no associations were observed, may be due to the age range of the study sample. This study included adolescents between the ages of 13-17 years, while past studies have examined adolescents from a wider range (11-16 years) (37) or older adolescents (15-19 years) (106, 107). Therefore, variability in maturity levels may not have been captured in this study. Overall, understanding the influence of age and sex can provide greater insight into determining whether the app is engaging for adolescents of various demographics.

5.2 The Associations of Parenting Practices with Adoption and Usage of the Aim2Be© App

Autonomy supportive, structure, and control parenting practices were examined in this

study to determine whether they were directly or indirectly (via adolescent characteristics) associated with app adoption and usage. It was hypothesized that positive parenting practices, namely autonomy supportive and structure practices, would be directly and indirectly associated with app adoption, as well as usage. Results partially supported these hypotheses; specifically, among the full study sample, structure parenting practices were indirectly associated with app adoption. With regards to app usage, autonomy supportive parenting practices were found to be directly associated and this effect was only present within the mother sample, when stratified analyses were completed. Overall these findings provide evidence to support the idea that parenting practices had a partial effect on adolescent's adoption and usage of the Aim2Be© app.

The social and physical environments play an influential role in e-health intervention (146, 154) and treatment contexts (21, 155), the household environment is a key target and necessary to support behaviour change among adolescents. However, the extent to which the household environment influences adolescents' adoption and/or use of e-health interventions has received little attention, except in one study (37). Mâsse et al. (37) found that overweight and obese adolescents who lived in a household environment that had better family breakfast practices or had greater access to sugar-sweetened beverages, were more likely to use certain functionalities of the "MySteps©" e-health intervention. Consistent with Mâsse et al. (37), it appears that parenting practices or being in an environment that supports healthy behaviours motivated adolescents to adopt the Aim2Be© app. However, structure parenting practices unexpectedly had an indirect effect on app adoption via both autonomous and controlled motivation. Based on SDT, one would expect that parenting practices would influence app adoption through autonomous motivation, by facilitating satisfaction of the adolescent's basic psychological needs (64). However, results indicate that controlled motivation is also implicated

in the mechanism. While this appears inconsistent, past studies have found that both autonomous and controlled motivation were positively associated with adolescent's health behaviours (67, 68, 70). Thus, there is evidence to suggest that both forms of motivation have the potential to influence adolescent's adoption of the Aim2Be© app via health behaviours. Additionally, the mechanisms of app adoption were evaluated during a transitional period of the adolescent's development, where autonomous motivation is likely emerging. Specifically, adolescents can become autonomously motivated when their identity and values of living a healthy lifestyle have matured; thereby allowing the adolescent to fully internalize these values (156). However, while the process through which adolescents become autonomously motivated is unclear, adolescents may transition from controlled to autonomous motivation in a structured household environment, where their innate need of competence is satisfied (156) and their values and identity mature. This may explain why structure parenting practices had an indirect effect on app adoption via both autonomous and controlled motivation. Overall, these findings provide indication that understanding how the physical and social environments influence app adoption can provide greater insight into the types of supportive environments that are needed to help adolescents engage with e-health interventions.

In contrast to app adoption, parenting practices had a direct effect on app usage; specifically, autonomy supportive parenting practices were positively associated. This is a new finding within the literature, as the direct association between parenting practices and intervention use have not been previously examined. One possible reason why this association was observed in this study, may be due to the fact that parents who utilize more autonomy supportive parenting practices may have created an environment that supported and primed adolescents to modify their health behaviours. Specifically, autonomy supportive practices, such

as education and encouragement of self-exploration, provide opportunities for both the parent and adolescent to engage in discussions concerning healthy living. Thus, if adolescents feel that they are supported by their parents and have the autonomy to change their health behaviours, they may be more likely to use the app, in order to facilitate and guide these behaviour changes. These claims are consistent with the literature, as one study in particular, found that adolescents' perceived autonomy support from parents was associated with their perceived behavioural control to eat healthy (157). In contrast, household environments that are controlling in nature, may not provide adolescents with leeway or the opportunity to express their values and needs with regards to changes of their lifestyle behaviours. Thus, adolescents may be deterred from using the app, as the household environment is not conducive towards supporting the adolescent's behaviour changes. Overall, these results indicate that future studies should look into addressing the issues of the household environment, such as providing behaviour change strategies that parents can easily implement in their family to help support their adolescents, as a means to promote long-term engagement with the Aim2Be© app.

The results from the stratified analyses indicated that the mechanisms of association changed in the mother sample versus the father sample. The key difference being that autonomous processes drove the relationship in the mother sample, whereas controlled processes drove the relationship in the father sample. Specifically, among the mother sample, app adoption was associated with adolescent's health behaviours and autonomous motivation, while app usage was associated by autonomy supportive practices. Among the father sample however, only app adoption was associated with adolescents' controlled motivation. These results may, in part, be reflective of the differences in how mothers and fathers rear their adolescents with respect to obesogenic behaviours. Specifically, parental expectations with regards to obesogenic

behaviours may differ based on parents' gender. Within the literature, studies has found that fathers used more controlling practices with regards to adolescent's physical activity and dietary behaviours (158). Mothers, on the other hand, were more inclined to use different supportive practices (158, 159), which have been found to support autonomous processes. Additionally, these changes in associations may stem from differences in the parent-adolescent relationships, where differences in the strength of the relationship may affect how adolescents integrate their parent's values. For example, past studies found that interpersonal factors (e.g., parent's motivation, attitudes, and expectations) were positively associated with adolescent's motivation and obesogenic behaviours (66, 160, 161). Moreover, one study found that the influence of the interpersonal factors on adolescent's sugar-sweetened beverage intake differed between mothers-adolescent and father-adolescents dyads (161). Specifically, mothers' autonomous motivation was significantly associated with adolescents' sugar-sweetened beverage intake, while no significant associations were observed among the father-adolescent dyads. These results suggest that mothers and fathers not only have different influences over adolescent's health behaviours, but these differences also vary depending on the health behaviour being examined. Overall, the findings of this study indicate that more research is required to better understand the role and influence of dyadic relationships with regards to app adoption and usage.

Lastly, though the results of the stratified analyses indicated that the mechanisms differed when the mother sample was compared to the father sample, there was limited evidence to suggest that the influence of parenting practices was mediated by adolescents' characteristics; as was hypothesized in this study. Specifically, autonomy supportive practices did not influence app adoption and/or usage via the adolescent's autonomous motivation, while controlling parenting practices did not influence app adoption and/or usage via the adolescent's controlled motivation.

One possible explanation as to why no mediating effects were observed, may be that the household context cannot be fully explained by parenting practices alone; rather indicators of the quality of the parent-adolescent relationship may need to be taken into account. For example, the emotional climate of the household environment (e.g., parenting style) was not taken into consideration. Consequently, these contextual variables may better explain how adolescents interpret the parenting practices employed by their parents. Within the literature, parenting styles have been found to influence adolescent's obesogenic behaviours (87, 89, 162-165), where authoritative parenting style (define by high levels of demandingness and responsiveness) are often associated with adolescent engagement in positive health behaviours. Additionally, evidence from past studies suggest that parenting styles significantly moderate the effects of parenting practices on adolescent's dietary behaviours and physical activity levels (166, 167). Thus, future studies may consider measuring other aspects of the household environment, such as parenting style, to further elucidate the mechanisms through which the household environment influences intervention usage.

5.3 Study Limitations & Strengths

5.3.1 Limitations

Though this study provided novel findings, several limitations need to be taken into consideration. First, the drop off rate within the Aim2Be© app was high among our study sample; a commonly reported issue for many e-health interventions (27, 28, 111). Specifically, only 60% of the adolescents who adopted the app (n=176) were using it after the first week of the intervention. Moreover, the majority of the time adolescents spent using the app was completed within the first few days after they downloaded the app. Due to the sharp decline in

app usage, this study may have faced a lack of statistical power, which would have made it difficult to detect any statistically significant differences between short- and long-term app users. Additionally, these results provide indication that other unmeasured factors may have influenced adolescents' adoption and usage of the Aim2Be© app. For example, during beta testing of the Aim2Be© apps (versions 2.1 and 2.2), adolescents were split on whether they viewed the app to be engaging. Specifically, about half of the sample enjoyed the app and wanted to continue using it, while the other half of the sample did not enjoy the app and could not see themselves using it (168, 169). In addition, adolescents who enjoyed the app tended to be younger and female (168, 169). Therefore, due to the sample used in this study, lack of app enjoyment may explain the sharp decline in app usage, as it can be difficult to create an app that is engaging for a broad sample. Finally, since a preliminary version of the app was evaluated, the contents and resources of the program were not fully developed to accommodate families from diverse cultural backgrounds or individuals who do not read or speak English. Consequently, some adolescents may not have been able to understand or relate to the app, which may have also influenced the results of the study.

Additionally, it is highly likely that adolescents' app usage may have been influenced by whether they encountered any app glitches, where adolescents may have dropped out prematurely due to these technical difficulties. Unfortunately, this study was unable to determine how many individuals were affected by these issues.

Within this study, adolescent's sex was controlled for within the analyses, while stratified analyses were conducted based on parent's sex. However, it is likely that gender may better explain the individual and parenting differences between adolescents who adopted and used the app, as parenting practices and adolescent's health behaviours are both influenced by parent's

and adolescent's gender (164, 170, 171). However, since parent's gender was not collected within the baseline assessment, and there were a handful of adolescents who did not report their gender, sex was used as a proxy measure.

Finally, the baseline questionnaire data used in this study may have been subjected to social desirability and recall bias, thereby threatening the study's internal validity due to inaccurate responses. Specifically, if adolescents lacked insight into their health behaviours, they may have overestimated their physical activity levels and fruit and vegetable intake, while underestimating their sedentary behaviours and sugar-sweetened beverages intake. Though validated questionnaires were used, many had to be modified and/or shortened for the purposes of this study; consequently, the sensitivity of these questionnaires may have been reduced. Additionally, the data acquired from the baseline assessment was cross-sectional. Since health behaviours, motivation, and parenting practices are dynamic and may change over time, the study analyses were unable to take this into account.

5.3.2 Strengths

This study provides a unique perspective of app usage and adoption predictors to the existing e-health literature. Firstly, this study examined individual and household associations with app adoption and usage among adolescents. Though past studies have identified characteristics of e-health intervention users, the overwhelmingly large majority of these studies examined this among adult populations (30-34, 36, 104, 172), with only a handful of studies examining an adolescent population (37, 106, 107). Additionally, among health promoting interventions, predictors of e-health intervention uptake has also not been extensively examined among adolescents (105), therefore the findings of this study helped to fill an important gap

within the literature. Secondly, this study not only examined the influence of the household environment on app adoption and usage, but it was one of the first to examine whether the mechanisms differed within a mother and father sample.

One major strength of this study was that the outcome variables were measured objectively using web-analytics data, rather than relying on self-reported measurements. This provided a more accurate depiction of the time adolescents used the Aim2Be© app and mitigated against measurement bias, where participants may have overestimated the time they spent using the app.

Another strength of the study was the study sample itself. Specifically, the adolescent sample was evenly split based on sex – unlike in many past studies, where females were overrepresented (33, 34, 36, 104). Thus, the risk of sampling bias was mitigated against, as the sample demographics were fairly representative of the general Canadian population, as the distribution of adolescent ethnicity, household structure, and household income among the study sample were similar to the distribution reported in the 2016 Canadian Census (173-176). Therefore, these results may be generalized to other Canadian families.

5.4 Study Implications and Future Directions

By analyzing patterns of app adoption and usage, the findings of this study provided greater insight into the individual-level and household-level characteristics of adolescents who are accessing and using the Aim2Be© app. Thus, these results can inform future intervention modifications, in order to improve user engagement by ensuring the app is well designed and suited to the target audience. Examples of intervention modifications that have been found to be efficacious within the literature include: increasing interactivity of the app (e.g., prompting users

to track their behaviours within the app and providing feedback and recommendations based on their inputs) (148, 177), tailoring the contents of the app based on user's profiles (e.g., current health behaviours and motivation-styles, health knowledge, or parenting practices) (177), as well as making the app more engaging to adolescents (e.g., ensuring that the app design is appealing and rewards are meaningful to adolescents) (178-180). These results also fill a critical gap within the literature, as adolescents are the ideal target audience for health promotion interventions. Therefore, by understanding how the household environment and intrapersonal characteristics can influence intervention uptake and use, future e-health interventions can plan to mitigate against potential barriers, as a means to improve intervention effectiveness.

Based on these implications, the following recommendations are made for future studies. First, future studies should look into determining whether the findings presented in this study are similar among other study populations. Since a general population sample was used in this study, it would be beneficial to determine whether different predictors are found among a treatment population (i.e., adolescents who are overweight or obese), since it has been argued that overweight/obese individuals who perceive their BMI as a health risk, may be more prepared to take action and change their behaviours to better manage their weight (33, 181).

Second, future studies should look into differentiating users based on their engagement profiles, in order to determine: i) whether individual and household characteristics differ between user profiles; and ii) identify app characteristics and/or functionalities that are associated with long term use and user engagement. By examining whether certain components of the program were engaging, researchers will gain a better understanding of why certain adolescents did not adopt nor use the app for an extended period of time; a research area of high priority as stated by Pagoto and Appelhans (109). Specifically, these results will help to determine whether the design

of the app or other potential factors that would better explain adolescents' adoption and usage of the Aim2Be© app. Additionally, by examining the breadth and depth of use completed by participants, researchers will have the opportunity to determine whether app design moderates the relationship between individual- and household-level predictors and app usage. Finally, by examining engagement profiles, researchers can also identify which app characteristics and/or functionalities are associated with effective behaviour change, and determine whether a dose-response relationship exists within the intervention (103).

Chapter 6: Conclusion

Predictors of e-health intervention use have been extensively examined among adults within the literature (30-36, 104, 172). Among adolescents, however, only a few studies have identified predictors of intervention use (37, 106, 107). Thus, to address this gap within the literature, this study identified both individual- and household-level characteristics that were associated with app adoption and usage, among a sample of Canadian adolescents. Aspects of this study that provided novel contributions to the existing literature include: i) the examination of the influence of the household environment, as well as ii) determining whether associations were similar in a sample of mothers and fathers.

Highlights of the study findings include: i) adolescents who were autonomously motivated and engaged in healthier behaviours had greater odds of adopting Aim2Be©; ii) the household environment, specifically autonomy supportive parenting practices, was positively associated with app usage; and iii) different mechanisms exist in the mother versus father samples, with regards to the associations between parenting practices and adolescents' adoption and usage of the Aim2Be© app.

Identifying patterns of intervention adoption and use can help program developers make informed decisions with regards to intervention modifications as a means to improve user engagement and program reach. Thus, the findings of this study suggest that future e-health interventions need to ensure that the app is designed to reach and engage users, especially potential users who may benefit the most from using the program. As well, the influence of the household environment also needs to be taken into consideration to ensure that the program satisfies the needs of the target audience. Due to the limitations of this study, future research is required to further elucidate the mechanisms through which the household environment

influences app usage, as well as to determine whether modifying the intervention to a specific sub-population of adolescents (i.e., overweight and obese adolescents) would results in higher rates of app adoption and usage.

References

1. Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. Health Promot Chronic Dis Prev Can. 2016;36(9):194-8.

2. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. BMC Public Health. 2009;9(1):88.

3. Bray GA. Medical consequences of obesity. J Clin Endocrinol Metab. 2004;89(6):2583-9.

4. Dietz WH. Health consequences of obesity in youth: Childhood predictors of adult disease. Pediatrics. 1998;101(Supplement 2):518-25.

5. Campbell MK. Biological, environmental, and social influences on childhood obesity. Pediatric Research. 2015;79:205.

6. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. Health Reports. 2011;22(1):15-23.

7. Statistics Canada. Health fact sheet: Fruit and vegetable consumption, 2016 [Internet]. Ottawa: Statistics Canada; 2017 Sept [cited 2018 Nov 10]. Available from: https://www150.statcan.gc.ca/n1/en/pub/82-625-x/2017001/article/54860-eng.pdf?st=wfX_6lk8

8. Phillips S, Starkey LJ, Gray-Donald K. Food habits of Canadians: Food sources of nutrients for the adolescent sample. Can J Diet Pract Res. 2004;65(2):81-4.

9. Hanning RM, Woodruff SJ, Lambraki I, Jessup L, Driezen P, Murphy CC. Nutrient intakes and food consumption patterns among Ontario students in grades six, seven, and eight. Can J Public Health. 2007;98(1):12-6.

10. Garriguet D. Canadians' eating habits. Health Rep. 2007;18(2):17-32.

11. Ritchie LD, Welk G, Styne D, Gerstein DE, Crawford PB. Family environment and pediatric overweight: What is a parent to do? J Am Diet Assoc. 2005;105(5, Supplement):70-9.

12. Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M. The association of the school food environment with dietary behaviors of young adolescents. Am J Public Health. 2003;93(7):1168-73.

13. Finnerty T, Reeves S, Dabinett J, Jeanes YM, Vögele C. Effects of peer influence on dietary intake and physical activity in school children. Public Health Nutr. 2009;13(3):376-83.

14. Ornelas IJ, Perreira KM, Ayala GX. Parental influences on adolescent physical activity: A longitudinal study. Int J Behav Nutr Phys Act. 2007;4(1):3.

15. Darling N, Steinberg L. Parenting style as context: An integrative model. Psychol Bull. 1993;113(3):487-96.

16. McCoby EE, Martin JA. Socialization in the context of the family: Parent-child interaction. In: Mussen PH, Hetherington EM, editors. Handbook of child psychology: Vol. 4. Socialization, personality, and social development. New York: Wiley; 1983. p. 1-101.

17. Rasmussen M, Krølner R, Klepp K-I, Lytle L, Brug J, Bere E, et al. Determinants of fruit and vegetable consumption among children and adolescents: A review of the literature. Part I: Quantitative studies. Int J Behav Nutr Phys Act. 2006;3(1):22.

18. Maitland C, Stratton G, Foster S, Braham R, Rosenberg M. A place for play? The influence of the home physical environment on children's physical activity and sedentary behaviour. Int J Behav Nutr Phys Act. 2013;10(1):99.

19. Al-Khudairy L, Loveman E, Colquitt JL, Mead E, Johnson RE, Fraser H, et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese adolescents aged 12 to 17 years. Cochrane Database Syst Rev. 2017(6).

20. Oude Luttikhuis H, Baur L, Jansen H, Shrewsbury VA, O'Malley C, Stolk RP, et al. Cochrane review: Interventions for treating obesity in children. Evid Based Child Health. 2009;4(4):1571-729.

21. Janicke DM, Steele RG, Gayes LA, Lim CS, Clifford LM, Schneider EM, et al. Systematic review and meta-analysis of comprehensive behavioral family lifestyle interventions addressing pediatric obesity. J Pediatr Psychol. 2014;39(8):809-25.

22. Janicke DM, Sallinen BJ, Perri MG, Lutes LD, Silverstein JH, Brumback B. Comparison of program costs for parent-only and family-based interventions for pediatric obesity in medically underserved rural settings. J Rural Health. 2009;25(3):326-30.

23. Eysenbach G. CONSORT-EHEALTH: Improving and standardizing evaluation reports of web-based and mobile health interventions. J Med Internet Res. 2011;13(4):e126.

24. Ahern DK. Challenges and opportunities of eHealth research. Am J Prev Med. 2007;32(5, Supplement):S75-S82.

25. Bennett GG, Glasgow RE. The delivery of public health interventions via the Internet: Actualizing their potential. Annual review of public health. 2009;30:273-92.

26. Statistics Canada. A portrait of Canadian youth. Ottawa, Ontario, Canada; 2018.

27. Kelders SM, Kok RN, Ossebaard HC, Van Gemert-Pijnen JEWC. Persuasive system design does matter: A systematic review of adherence to web-based interventions. J Med Internet Res. 2012;14(6):e152-e.

28. Vandelanotte C, Müller AM, Short CE, Hingle M, Nathan N, Williams SL, et al. Past, present, and future of eHealth and mHealth research to improve physical activity and dietary behaviors. J Nutr Educ Behav. 2016;48(3):219-28.e1.

29. Donkin L, Christensen H, Naismith SL, Neal B, Hickie IB, Glozier N. A systematic review of the impact of adherence on the effectiveness of e-therapies. J Med Internet Res. 2011;13(3):e52-e.

30. Kelders SM, Van Gemert-Pijnen JEWC, Werkman A, Nijland N, Seydel ER. Effectiveness of a web-based intervention aimed at healthy dietary and physical activity behavior: A randomized controlled trial about users and usage. J Med Internet Res. 2011;13(2):e32-e.

31. Wanner M, Martin-Diener E, Bauer G, Braun-Fahrländer C, Martin BW. Comparison of trial participants and open access users of a web-based physical activity intervention regarding adherence, attrition, and repeated participation. J Med Internet Res. 2010;12(1):e3-e.

32. Glasgow RE, Nelson CC, Kearney KA, Reid R, Ritzwoller DP, Strecher VJ, et al. Reach, engagement, and retention in an Internet-based weight loss program in a multi-site randomized controlled trial. J Med Internet Res. 2007;9(2):e11.

33. Verheijden MW, Jans MP, Hildebrandt VH, Hopman-Rock M. Rates and determinants of repeated participation in a web-based behavior change program for healthy body weight and healthy lifestyle. J Med Internet Res. 2007;9(1):e1-e.

34. Gomez Quiñonez S, Walthouwer MJL, Schulz DN, de Vries H. mHealth or eHealth? Efficacy, use, and appreciation of a web-based computer-tailored physical activity intervention for dutch adults: A randomized controlled trial. J Med Internet Res. 2016;18(11):e278-e.

35. Walthouwer MJL, Oenema A, Lechner L, de Vries H. Use and effectiveness of a video- and text-driven web-based computer-tailored intervention: Randomized controlled trial. J Med Internet Res. 2015;17(9):e222-e.

36. Van der Mispel C, Poppe L, Crombez G, Verloigne M, De Bourdeaudhuij I. A self-regulation-based eHealth intervention to promote a healthy lifestyle: Investigating user and website characteristics related to attrition. J Med Internet Res. 2017;19(7):e241-e.

37. Mâsse LC, Watts AW, Barr SI, Tu AW, Panagiotopoulos C, Geller J, et al. Individual and household predictors of adolescents' adherence to a web-based intervention. Annals of behavioral medicine : a publication of the Society of Behavioral Medicine. 2015;49(3):371-83.

38. Singh AS, Mulder C, Twisk JWR, Van Mechelen W, Chinapaw MJM. Tracking of childhood overweight into adulthood: A systematic review of the literature. Obes Rev. 2008;9(5):474-88.

39. Kolotkin RL, Meter K, Williams GR. Quality of life and obesity. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2001;2(4):219-29.

40. Puhl RM, Heuer CA. The stigma of obesity: A review and update. Obesity. 2009;17(5):941-64.

41. Puhl RM, Heuer CA. Obesity stigma: Important considerations for public health. Am J Public Health. 2010;100(6):1019-28.

42. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med. 1993;329(14):1008-12.

43. Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression: A systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010;67(3):220-9.

44. Beydoun MA, Beydoun HA, Wang Y. Obesity and central obesity as risk factors for incident dementia and its subtypes: A systematic review and meta-analysis. Obes Rev. 2008;9(3):204-18.

45. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. JAMA. 2003;289(2):187-93.

46. Anis AH, Zhang W, Bansback N, Guh DP, Amarsi Z, Birmingham CL. Obesity and overweight in Canada: An updated cost-of-illness study. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2010;11(1):31-40.

47. Chaput J-P, Carson V, Gray CE, Tremblay MS. Importance of all movement behaviors in a 24 hour period for overall health. Int J Environ Res Public Health. 2014;11(12):12575-81.

48. Saunders TJ, Gray CE, Poitras VJ, Chaput J-P, Janssen I, Katzmarzyk PT, et al. Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016;41(6 (Suppl. 3)):S283-S93.

49. Prentice-Dunn H, Prentice-Dunn S. Physical activity, sedentary behavior, and childhood obesity: A review of cross-sectional studies. Psychol Health Med. 2012;17(3):255-73.

50. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7(1):40.

51. Janssen I, Katzmarzyk PT, Boyce WF, King MA, Pickett W. Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. J Adolesc Health. 2004;35(5):360-7.

52. Tremblay MS, Willms JD. Is the Canadian childhood obesity epidemic related to physical inactivity? Int J Obes. 2003;27:1100.

53. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. Appl Physiol Nutr Metab. 2016;41(6 (Suppl. 3)):S311-S27.

54. Dollman J, Norton K, Norton L. Evidence for secular trends in children's physical activity behaviour. Br J Sports Med. 2005;39(12):892-7.

55. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011;8(1):98.

56. Pate RR, Mitchell JA, Byun W, Dowda M. Sedentary behaviour in youth. Br J Sports Med. 2011;45(11):906-13.

57. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". Exerc Sport Sci Rev. 2008;36(4):173-8.

58. ParticipACTION. The Brain + Body Equation: Canadian kids need active bodies to build their best brains. The 2018 ParticipACTION report card on physical activity for children and youth [Internet]. Toronto: ParticipACTION; 2018 [cited 2019 Feb 03]. Available from: https://www.participaction.com/en-ca/resources/report-card

59. Ambrosini GL, Emmett PM, Northstone K, Howe LD, Tilling K, Jebb SA. Identification of a dietary pattern prospectively associated with increased adiposity during childhood and adolescence. Int J Obes. 2012;36:1299.

60. Ritchie LD, Spector P, Stevens MJ, Schmidt MM, Schreiber GB, Striegel-Moore RH, et al. Dietary patterns in adolescence are related to adiposity in young adulthood in black and white females. J Nutr. 2007;137(2):399-406.

61. Health Canada. Canada's dietary guidelines for health professionals and policy makers [Internet]. Ottawa: Health Canada; 2019 [cited 2019 Feb 15]. Available from: https://food-guide.canada.ca/static/assets/pdf/CDG-EN-2018.pdf

62. Davison KK, Birch LL. Childhood overweight: A contextual model and recommendations for future research. Obes Rev. 2001;2(3):159-71.

63. Wang Y, Beydoun MA. The obesity epidemic in the United States — Gender, age, socioeconomic, racial/ethnic, and geographic characteristics: A systematic review and meta-regression analysis. Epidemiol Rev. 2007;29(1):6-28.

64. Deci EL, Ryan RM. Facilitating optimal motivation and psychological well-being across life's domains. Can Psychol. 2008;49(1):14-23.

65. Deci EL, Ryan RM. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychol Inq. 2000;11(4):227-68.

66. Dwyer LA, Bolger N, Laurenceau J-P, Patrick H, Oh AY, Nebeling LC, et al. Autonomous motivation and fruit/vegetable intake in parent–adolescent dyads. Am J Prev Med. 2017;52(6):863-71.

67. Parks CA, Blaser C, Smith TM, Calloway EE, Oh AY, Dwyer LA, et al. Correlates of fruit and vegetable intake among parents and adolescents: Findings from the Family Life, Activity, Sun, Health, and Eating (FLASHE) study. Public Health Nutr. 2018;21(11):2079-87.

68. Lubans DR, Lonsdale C, Plotnikoff RC, Smith J, Dally K, Morgan PJ. Development and evaluation of the Motivation to Limit Screen-time Questionnaire (MLSQ) for adolescents. Prev Med. 2013;57(5):561-6.

69. Owen KB, Smith J, Lubans DR, Ng JYY, Lonsdale C. Self-determined motivation and physical activity in children and adolescents: A systematic review and meta-analysis. Prev Med. 2014;67:270-9.

70. Verloigne M, De Bourdeaudhuij I, Tanghe A, D'Hondt E, Theuwis L, Vansteenkiste M, et al. Self-determined motivation towards physical activity in adolescents treated for obesity: an observational study. Int J Behav Nutr Phys Act. 2011;8(1):97.

71. Speakman JR. Obesity: The integrated roles of environment and genetics. J Nutr. 2004;134(8):2090S-105S.

72. Bouchard C. Gene–environment interactions in the etiology of obesity: Defining the fundamentals. Obesity. 2008;16(S3):S5-S10.

73. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: Public-health crisis, common sense cure. Lancet. 2002;360(9331):473-82.

74. Pedersen S, Grønhøj A, Thøgersen J. Following family or friends. Social norms in adolescent healthy eating. Appetite. 2015;86:54-60.

75. Lindsay AC, Sussner KM, Kim J, Gortmaker S. The role of parents in preventing childhood obesity. Future Child. 2006;16(1):169-86.

76. Gustafson SL, Rhodes RE. Parental Correlates of Physical Activity in Children and Early Adolescents. Sports Medicine. 2006;36(1):79-97.

77. Patrick H, Hennessy E, McSpadden K, Oh A. Parenting styles and practices in children's obesogenic behaviors: Scientific gaps and future research directions. Childhood obesity (Print). 2013;9:S73-S86.

78. Costanzo PR, Woody EZ. Domain-specific parenting styles and their impact on the child's development of particular deviance: The example of obesity proneness. J Soc Clin Psychol. 1985;3(4):425-45.

79. Gevers DWM, Kremers SPJ, de Vries NK, van Assema P. Clarifying concepts of food parenting practices. A Delphi study with an application to snacking behavior. Appetite. 2014;79:51-7.

80. O'Connor TM, Mâsse LC, Tu AW, Watts AW, Hughes SO, Beauchamp MR, et al. Food parenting practices for 5 to 12 year old children: A concept map analysis of parenting and nutrition experts input. Int J Behav Nutr Phys Act. 2017;14(1):122.

81. Mâsse LC, O'Connor TM, Tu AW, Hughes SO, Beauchamp MR, Baranowski T, et al. Conceptualizing physical activity parenting practices using expert informed concept mapping analysis. BMC Public Health. 2017;17(1):574.

82. Mâsse LC, Watts AW. Stimulating innovations in the measurement of parenting constructs. Child Obes. 2013;9(s1):S-5-S-13.

83. Baranowski T, O'Connor T, Hughes S, Sleddens E, Beltran A, Frankel L, et al. Houston... We have a problem! Measurement of parenting. Child Obes. 2013;9 Suppl:S1-4.

84. Vaughn AE, Ward DS, Fisher JO, Faith MS, Hughes SO, Kremers SPJ, et al. Fundamental constructs in food parenting practices: a content map to guide future research. Nutr Rev. 2016;74(2):98-117.

85. Ventura AK, Birch LL. Does parenting affect children's eating and weight status? Int J Behav Nutr Phys Act. 2008;5(1):15.

86. van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, et al. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. Health Educ Res. 2007;22(2):203-26.

87. Pearson N, Biddle SJH, Gorely T. Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. Public Health Nutr. 2009;12(2):267-83.

88. Johnson SL, Birch LL. Parents' and children's adiposity and eating style. Pediatrics. 1994;94(5):653-61.

89. Jago R, Davison KK, Brockman R, Page AS, Thompson JL, Fox KR. Parenting styles, parenting practices, and physical activity in 10- to 11-year olds. Prev Med. 2011;52(1):44-7.

90. Gustafson SL, Rhodes RE. Parental correlates of physical activity in children and early adolescents. Sports Med. 2006;36(1):79-97.

91. Edwardson CL, Gorely T. Parental influences on different types and intensities of physical activity in youth: A systematic review. Psychol Sport Exerc. 2010;11(6):522-35.

92. Pugliese J, Tinsley B. Parental socialization of child and adolescent physical activity: A meta-analysis. J Fam Psychol. 2007;21(3):331.

93. Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth - a review and update. Obes Rev. 2007;8(2):129-54.

94. Ramirez ER, Norman GJ, Rosenberg DE, Kerr J, Saelens BE, Durant N, et al. Adolescent screen time and rules to limit screen time in the home. J Adolesc Health. 2011;48(4):379-85.

95. Jago R, Davison KK, Thompson JL, Page AS, Brockman R, Fox KR. Parental sedentary restriction, maternal parenting style, and television viewing among 10- to 11-year-olds. Pediatrics. 2011.

96. Kumar S, Kelly AS. Review of childhood obesity: From epidemiology, etiology, and comorbidities to clinical assessment and treatment. Mayo Clin Proc. 2017;92(2):251-65.

97. World Health Organization. Interim report of the commission on ending childhood obesity [Internet]. Geneva: World Health Organization; 2015 [cited 2018 Nov 28]. Available from: https://www.who.int/end-childhood-obesity/commission-ending-childhood-obesity-interim-report.pdf?ua=1

98. Barak A, Klein B, Proudfoot JG. Defining internet-supported therapeutic interventions. Ann Behav Med. 2009;38(1):4-17.

99. Canadian Radio-Television and Telecommunications Comission. Communicatins monitoring report 2017. Ottawa: Canadian Radio-Television and Telecommunications Commision; 2017 [cited 2018 Nov 03]. Available from: https://crtc.gc.ca/eng/publications/reports/policymonitoring/2017/cmr2017.pdf

100. Nguyen B, Kornman KP, Baur LA. A review of electronic interventions for prevention and treatment of overweight and obesity in young people. Obes Rev. 2011;12(5):e298-e314.

101. Fedele DA, Cushing CC, Fritz A, Amaro CM, Ortega A. Mobile health interventions for improving health outcomes in youth: A meta-analysis. JAMA pediatrics. 2017;171(5):461-9.

102. Sieverink F, Kelders SM, Gemert-Pijnen JEWCv, van Gemert-Pijnen JE. Clarifying the concept of adherence to eHealth technology: Systematic review on when usage becomes adherence. J Med Internet Res. 2017;19(12):e402.

103. Short CE, DeSmet A, Woods C, Williams SL, Maher C, Middelweerd A, et al. Measuring engagement in eHealth and mHealth behavior change interventions: Viewpoint of methodologies. J Med Internet Res. 2018;20(11):e292-e.

104. Brouwer W, Oenema A, Raat H, Crutzen R, de Nooijer J, de Vries NK, et al. Characteristics of visitors and revisitors to an Internet-delivered computer-tailored lifestyle intervention implemented for use by the general public. Health Educ Res. 2010;25(4):585-95.

105. Wilson LD, Walker LR, Abraham AA, Graham AL, Tercyak KP. Association of multiple behavioral risk factors with adolescents' willingness to engage in eHealth promotion. J Pediatr Psychol. 2008;34(5):457-69.

106. Jander A, Crutzen R, Mercken L, Candel M, de Vries H. Effects of a web-based computer-tailored game to reduce binge drinking among dutch adolescents: A cluster randomized controlled trial. J Med Internet Res. 2016;18(2):e29.

107. Paz Castro R, Haug S, Filler A, Kowatsch T, Schaub MP. Engagement within a mobile phone-based smoking cessation intervention for adolescents and its association with participant characteristics and outcomes. J Med Internet Res. 2017;19(11):e356.

108. Wangberg SC, Bergmo TS, Johnsen J-AK. Adherence in Internet-based interventions. Patient Prefer Adherence. 2008;2:57-65.

109. Pagoto SL, Appelhans BM. A call for an end to the diet debates. JAMA. 2013;310(7):687-8.

110. Denzer C, Reithofer E, Wabitsch M, Widhalm K. The outcome of childhood obesity management depends highly upon patient compliance. Eur J Pediatr. 2004;163(2):99-104.

111. Eysenbach G. The law of attrition. J Med Internet Res. 2005;7(1):e11.

112. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000;55(1):68-78.

113. Bandura A. Social cognitive theory: An agentic perspective. Ann Rev Psychol. 2001;52(1):1-26.

114. Deci EL, Ryan RM, editors. Instrinsic motivation and self-determination in human behavior [Internet]. New York: Prenum Press; 1985 [cited 2018 Nov 10].

115. Ryan RM, Patrick H, Deci EL, Williams GC. Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. Health Psychol Rev. 2008;10(1):2-5.

116. Deci EL, Ryan RM. Facilitating optimal motivation and psychological well-being across life's domains. Can Psychol. 2008;49(1):14-34.

117. Gillison FB, Standage M, Skevington SM. Relationships among adolescents' weight perceptions, exercise goals, exercise motivation, quality of life and leisure-time exercise behaviour: A self-determination theory approach. Health Educ Res. 2006;21(6):836-47.

118. Chatzisarantis NLD, Hagger MS. Effects of an intervention based on self-determination theory on self-reported leisure-time physical activity participation. Psychol Health. 2009;24(1):29-48.

119. Bandura A. Health promotion from the perspective of social cognitive theory. Psychol Health. 1998;13(4):623-49.

120. Bandura A. Social cognitive theory of self-regulation. Organ Behav Hum Decis Process. 1991;50(2):248-87.

121. Bandura A. Human agency in social cognitive theory. Am Psychol. 1989;44(9):1175-84.

122. Bandura A. The self system in reciprocal determinism. Am Psychol. 1978;33(4):344-58.

123. Jago R, Fox KR, Page AS, Brockman R, Thompson JL. Parent and child physical activity and sedentary time: Do active parents foster active children? BMC Public Health. 2010;10(1):194.

124. Blanchette L, Brug J. Determinants of fruit and vegetable consumption among 6–12-year-old children and effective interventions to increase consumption. Hum Nutr Appl Nutr. 2005;18(6):431-43.

125. Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. Maturitas. 2011;70(3):266-84.

126. Przybylski AK, Rigby CS, Ryan RM. A motivational model of video game engagement. Rev Gen Psychol. 2010;14(2):154-66.

127. Ryan RM, Rigby CS, Przybylski A. The motivational pull of video games: A self-determination theory approach. Motiv Emot. 2006;30(4):344-60.

128. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81.

129. Kowalski KC, Crocker PR, Donen RM. The physical activity questionnaire for older children (PAQ-C) and adolescents (PAQ-A) manual. College of Kinesiology, University of Saskatchewan. 2004;87(1):1-38.

130. Centers for Disease Control and Prevention. National Youth Physical Activity and Nutritional Study (NYPANS) Updated: June 14, 2018. Available from: https://www.cdc.gov/healthyyouth/data/yrbs/nypans.htm.

131. Eaton DK, Olsen EOM, Brener ND, Scanlon KS, Kim SA, Demissie Z, et al. A comparison of fruit and vegetable intake estimates from three survey question sets to estimates from 24-hour dietary recall interviews. J Acad Nutr Diet. 2013;113(9):1165-74.

132. Olsen EOM, Eaton DK, Sohyun P, Brener ND, Blanck HM. Comparing methods for assessing beverage intake among high school students. Am J Health Behav. 2014;38(1):114-23.

133. Rosenberg DE, Norman GJ, Wagner N, Patrick K, Calfas KJ, Sallis JF. Reliability and validity of the Sedentary Behavior Questionnaire (SBQ) for adults. J Phys Act Health. 2010;7(6):697-705.

134. French SA, Gerlach AF, Mitchell NR, Hannan PJ, Welsh EM. Household obesity prevention: Take Action--a group-randomized trial. Obesity. 2011;19(10):2082-8.

135. Nebeling LC, Hennessy E, Oh AY, Dwyer LA, Patrick H, Blanck HM, et al. The FLASHE study: Survey development, dyadic perspectives, and participant characteristics. Am J Prev Med. 2017;52(6):839-48.

136. Self-Determination Theory. Self-Regulation Questionnaires (SRQ). Available from: http://selfdeterminationtheory.org/self-regulation-questionnaires/.

137. Levesque CS, Williams GC, Elliot D, Pickering MA, Bodenhamer B, Finley PJ. Validating the theoretical structure of the Treatment Self-Regulation Questionnaire (TSRQ) across three different health behaviors. Health Educ Res. 2007;22(5):691-702.

138. Birch LL, Fisher JO, Grimm-Thomas K, Markey CN, Sawyer R, Johnson SL. Confirmatory factor analysis of the Child Feeding Questionnaire: a measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. Appetite. 2001;36(3):201-10.

139. Musher-Eizenman D, Holub S. Comprehensive Feeding Practices Questionnaire: Validation of a new measure of parental feeding practices. J Pediatr Psychol. 2007;32(8):960-72.

140. Wardle J, Sanderson S, Guthrie CA, Rapoport L, Plomin R. Parental feeding style and the inter-generational transmission of obesity risk. Obes Res. 2002;10(6):453-62.

141. Darling N, Cumsille P, Martínez ML. Individual differences in adolescents' beliefs about the legitimacy of parental authority and their own obligation to obey: A longitudinal investigation. Child Dev. 2008;79(4):1103-18.

142. Larios SE, Ayala GX, Arredondo EM, Baquero B, Elder JP. Development and validation of a scale to measure Latino parenting strategies related to children's obesigenic behaviors. The parenting strategies for eating and activity scale (PEAS). Appetite. 2009;52(1):166-72.

143. Davison KK, Li K, Baskin ML, Cox T, Affuso O. Measuring parental support for children's physical activity in white and African American parents: The Activity Support Scale for Multiple Groups (ACTS-MG). Prev Med. 2011;52(1):39-43.

144. STATA Corp. Statistical Software: Release 13. College Station, TX: StatCorp LP; 2013.

145. Muthén L, Muthén B. Mplus User's Guide. Los Angeles, CA: Muthén & Muthén; 1998-2017.

146. Michie S, Perski O, Blandford A, West R. Conceptualising engagement with digital behaviour change interventions: A systematic review using principles from critical interpretive synthesis. Transl Behav Med. 2016;7(2):254-67.

147. van Gemert-Pijnen JEWC, Nijland N, van Limburg M, Ossebaard HC, Kelders SM, Eysenbach G, et al. A holistic framework to improve the uptake and impact of eHealth technologies. J Med Internet Res. 2011;13(4):e111.

148. Danaher BG, Boles SM, Akers L, Gordon JS, Severson HH. Defining participant exposure measures in Web-based health behavior change programs. J Med Internet Res. 2006;8(3):e15.

149. Mohr DC, Schueller SM, Montague E, Burns MN, Rashidi P. The behavioral intervention technology model: An integrated conceptual and technological framework for eHealth and mHealth interventions. J Med Internet Res. 2014;16(6):e146.

150. Couper MP, Alexander GL, Zhang N, Little RJA, Maddy N, Nowak MA, et al. Engagement and retention: Measuring breadth and depth of participant use of an online intervention. J Med Internet Res. 2010;12(4):e52.

151. Geraghty AWA, Torres LD, Leykin Y, Pérez-Stable EJ, Muñoz RF. Understanding attrition from international Internet health interventions: A step towards global eHealth. Health Promot Int. 2013;28(3):442-52.

152. Hallyburton A, Evarts LA. Gender and online health information seeking: A five survey meta-analysis. J Consum Health Internet. 2014;18(2):128-42.

153. Atkinson NL, Saperstein SL, Pleis J. Using the internet for health-related activities: Findings from a national probability sample. J Med Internet Res. 2009;11(1):e4.

154. Ritterband LM, Thorndike FP, Cox DJ, Kovatchev BP, Gonder-Frederick LA. A behavior change model for internet interventions. Annals of behavioral medicine : a publication of the Society of Behavioral Medicine. 2009;38(1):18-27.

155. Gruber KJ, Haldeman LA. Using the family to combat childhood and adult obesity. Prev Chronic Dis. 2009;6(3):A106-A.

156. Deci EL, Ryan RM. Motivation, personality, and development within embedded social contexts: An overview of self-determination theory [Internet]. In: Ryan RM, editor. The Oxford handbook of human motivation. Oxford: Oxford University Press; 2012. p. 85-107.

157. Girelli L, Hagger M, Mallia L, Lucidi F. From perceived autonomy support to intentional behaviour: Testing an integrated model in three healthy-eating behaviours. Appetite. 2016;96:280-92.

158. Lloyd AB, Lubans DR, Plotnikoff RC, Collins CE, Morgan PJ. Maternal and paternal parenting practices and their influence on children's adiposity, screen-time, diet and physical activity. Appetite. 2014;79:149-57.

159. Davison KK, Cutting TM, Birch LL. Parents' activity-related parenting practices predict girls' physical activity. Med Sci Sports Exerc. 2003;35(9):1589-95.

160. Joyal-Desmarais K, Lenne RL, Panos ME, Huelsnitz CO, Jones RE, Auster-Gussman LA, et al. Interpersonal effects of parents and adolescents on each other's health behaviours: A dyadic extension of the theory of planned behaviour. Psychol Health. 2019:1-21.

161. Figueroa R, Kalyoncu ZB, Saltzman JA, Davison KK. Autonomous motivation, sugar-sweetened beverage consumption and healthy beverage intake in US families: Differences between mother-adolescent and father-adolescent dyads. Public Health Nutr. 2019:1-9.

162. Kremers SPJ, Brug J, de Vries H, Engels RC. Parenting style and adolescent fruit consumption. Appetite. 2003;41(1):43-50.

163. Sleddens EFC, Gerards SMPL, Thijs C, De Vries NK, Kremers SPJ. General parenting, childhood overweight and obesity-inducing behaviors: A review. Pediatr Obes. 2011;6:e12-e27.

164. Vollmer RL, Mobley AR. Parenting styles, feeding styles, and their influence on child obesogenic behaviors and body weight. A review. Appetite. 2013;71:232-41.

165. Lohaus A, Vierhaus M, Ball J. Parenting styles and health-related behavior in childhood and early adolescence: Results of a longitudinal study. J Early Adolesc. 2009;29(4):449-75.

166. Carbert NS, Brussoni M, Geller J, Mâsse LC. Moderating effects of family environment on overweight/obese adolescents' dietary behaviours. Appetite. 2019;134:69-77.

167. Carbert NS. Everything in moderation: Are adolescents' obesity-related health behaviours moderated by parenting styles and family functioning? [master's thesis]. [Vancouver (BC)]: The University of British Columbia; 2017. 122 p.

168. Vlaar J, Lin Y, Mâsse L. Living Green and Healthy for Teens (LiGHT): Aim2Be© v2.1 pre-post evaluation. Vancouver: The University of British Columbia; 2019 Apr [cited 2019 Apr 26].

169. Vlaar J, Mâsse L. Living Green and Healthy for Teens (LiGHT): Aim2Be© v2.2 beta testing. Vancouver: The University of British Columbia; 2019 Jan [cited 2019 Apr 26].

170. Leech RM, McNaughton SA, Timperio A. The clustering of diet, physical activity and sedentary behavior in children and adolescents: A review. Int J Behav Nutr Phys Act. 2014;11(1):4.

171. Vollrath ME, Hampson SE, Júlíusson PB. Children and eating. Personality and gender are associated with obesogenic food consumption and overweight in 6- to 12-year-olds. Appetite. 2012;58(3):1113-7.

172. Van 't Riet J, Crutzen R, De Vries H. Investigating predictors of visiting, using, and revisiting an online health-communication program: A longitudinal study. J Med Internet Res. 2010;12(3):e37.

173. Statistics Canada. Canadian demographics at a glance: Second edition [Internet]. Ottawa: Statistics Canada; 2016 [cited 2019 Apr 2]. Avaiable from: https://www150.statcan.gc.ca/n1/en/pub/91-003-x/91-003-x2014001-eng.pdf?st=AQmc0PUQ

174. Statistics Canada. Immigration and ethnocultural diversity: Key results from the 2016 Census [Internet]. Ottawa: Statistics Canada; 2017 [cited 2019 Apr 2]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/171025/dq171025b-eng.htm.

175. Statistics Canada. Income highlight tables, 2016 Census [Internet]. Ottawa: Statistics Canada; 2017 [cited 2019 Apr 2]. Available from: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/inc-rev/index-eng.cfm

176. Statistics Canada. Household income in Canada: Key results from the 2016 Census [Internet]. Ottawa: Statistics Canada; 2017 [cited 2019 Apr 2]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/170913/dq170913a-eng.htm

177. Morrison L, Moss-Morris R, Michie S, Yardley L. Optimizing engagement with Internet-based health behaviour change interventions: Comparison of self-assessment with and without tailored feedback using a mixed methods approach. Br J Health Psychol. 2014;19(4):839-55.

178. Brouwer W, Kroeze W, Crutzen R, de Nooijer J, de Vries NK, Brug J, et al. Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review. J Med Internet Res. 2011;13(1):e2.

179. McClure JB, Shortreed SM, Bogart A, Derry H, Riggs K, St John J, et al. The effect of program design on engagement with an internet-based smoking intervention: Randomized factorial trial. J Med Internet Res. 2013;15(3):e69.

180. Khadjesari Z, Murray E, Kalaitzaki E, White IR, McCambridge J, Thompson SG, et al. Impact and costs of incentives to reduce attrition in online trials: Two randomized controlled trials. J Med Internet Res. 2011;13(1):e26.

181. Wee CC, Davis RB, Phillips RS. Stage of readiness to control weight and adopt weight control behaviors in primary care. J Gen Intern Med. 2005;20(5):410-5.

Appendices

Appendix A

Table A.1: Evaluation questionnaires administered to the study participants through Research Electronic Data Capture (REDCap) at baseline. Only the questions in which the responses were analyzed in this study are displayed below.

Construct	Survey Items
Motivation for healthy eating (eating fruits and vegetables and limiting sugary drinks and junk food)	There are many reasons why people eat fruits and vegetables every day. Select how much you agree or disagree with each statement: **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) I simply enjoy eating a variety of fruits and vegetables b) I would feel bad about myself if I didn't eat enough fruits and vegetables c) Others would be upset with me if I didn't eat enough fruits and vegetables d) It is personally important to me to eat enough fruits and vegetables There are many reasons why people limit how much junk food and sugary drinks they have. Select how much you agree or disagree with each statement: **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) I simply don't like the taste of many junk food items or sugary drinks b) I would feel bad about myself if I didn't limit junk food and sugary drinks c) Others would be upset with me if I didn't limit junk food and sugary drinks d) It is personally important to me to limit junk food and sugary drinks
Motivation for limiting electronic device usage	There are many reasons why people limit the amount of time they spend using electronic devices (e.g., computer, phone, tablet, TV, video games) in their free time. Select how much you agree or disagree with each statement: **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) I simply don't enjoy spending too much time using electronic devices b) I would feel bad about myself if I didn't limit the time I spend using electronic devices c) Other would be upset with me if I didn't limit the time I spend using electronic devices d) It is personally important to me that I limit the time I spend using electronic devices
Motivation for being physically active	There are many reasons why people are physically active. Select how much you agree or disagree with each statement: **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) I simply enjoy being physically active b) I would feel bad about myself if I wasn't physically active c) Others would be upset with me if I wasn't physically active d) It is personally important to me to be physically active
Physical activity behaviours	*Physical activity is any activity that increases your heart rate and makes you get out of breath at least some of the time. Physical activity can be done in sports, school activities, playing with friends, or walking to school or other places. Examples of physical activity are running, brisk walking, skating, biking, dancing, skating, skateboarding, swimming, soccer, basketball, football among others.* *For the next questions, we would like to know about the physical activity you have done over the past 7 days. Remember:* • *There are no right or wrong answers – this is NOT a test!* • *Please answer all questions as honestly and accurately as you can – this is very important*

Construct	Survey Items
	Think about the physical activity that you did on each of the past 7 days. For each of the questions below, mark how many minutes of physical activity you did on each day, and which activitie(s) you did… **[None, 1 to 14 minutes, 15 to 29 minutes, 30 to 59 minutes, 1 to 2 hours, More than 2 hours]** a) Monday b) Tuesday c) Wednesday d) Thursday e) Friday f) Saturday g) Sunday *Physical activity can be done in sports, school activities, playing with friends, or walking to school or other places. Physical activities include running, brisk walking, skating, biking, dancing, skateboarding, swimming, soccer, basketball, football or any other activities that increase your heart rate and makes you get out of breath at least some of the time.* **[Following questions are linked to responses from the previous question]** a) [Ask if 4a is > than none] Which activitie(s) did you do on Monday? b) [Ask if 4b is > than none] Which activitie(s) did you do on Tuesday? c) [Ask if 4c is > than none] Which activitie(s) did you do on Wednesday? d) [Ask if 4d is > than none] Which activitie(s) did you do on Thursday? e) [Ask if 4e is > than none] Which activitie(s) did you do on Friday? f) [Ask if 4f is > than none] Which activitie(s) did you do on Saturday? g) [Ask if 4f is > than none] Which activitie(s) did you do on Sunday? ***RESPONSE FORMAT: (select all that apply)*** o Active games: chase tag, hopscotch, hide and seek o Active video games (dance-dance revolution) o Ball playing: four square, dodge ball, kickball o Basketball o Baseball/Softball o Bicycling o Bicycling to or from school o Cross-country skiing o Dance: ballet, hip hop o Exercise: push-ups, sit-ups, weight lifting o Golf o Gymnastics: bars, beam, tumbling, trampoline o Hockey: ice, floor, field, ringette o Jogging/Running o Martial arts: karate, tae kwon do o Racket sports: badminton, tennis, paddleball o Skateboarding/scooter (non-motorized)

Construct	Survey Items
	○ Skating: ice, inline ○ Soccer/Football ○ Skiing / snowboarding ○ Swimming ○ Volleyball ○ Yoga / Pilates ○ Walking ○ Walking to or from school ○ Other specify_____
Sedentary behaviours	To help set-up the next questions, please indicate what day today is: **[Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday]** The next questions will ask about your time spent resting and sitting and we want you think only about what you did this past SATURDAY. How much time did you spend: **[None, 15 min, 30 min, 1 hour, 1.5 hours, 2 hours, 2.5 hours, 3 hours, 3.5 hours, 4 or more hours]** a) Watching movies, TV shows or sports on any screens this past SATURDAY (such as TV, computer, tablet, mobile devices) b) Playing computer or video games this past SATURDAY c) Using a computer, tablet or mobile device outside of [ADOLESCENT = school work / PARENT = paid work or school work**]** this past SATURDAY (such as surfing the internet, Facebook) Do NOT count activities you already reported on. d) Talking or texting on a cell phone this past SATURDAY Now, we will ask the same questions except we want you to think about the activities you did on <*last weekday – pre-filled based on question 1 from health behaviours set-up construct. For example, if today is Monday we want the participant to think about last Friday. Or if today is Tuesday, think about Monday*>. How much time did you spend: **[None, 15 min, 30 min, 1 hour, 1.5 hours, 2 hours, 2.5 hours, 3 hours, 3.5 hours, 4 or more hours]** a) Watching movies, TV shows or sports on any screens on <*last weekday*> (such as TV, computer, tablet, mobile devices) b) Playing computer or video games *on* <*last weekday*> c) Using a computer, tablet or mobile device outside of [ADOLESCENT = school work / PARENT = paid work or school work**]** on <*last weekday*> (such as surfing the internet, Facebook – Do NOT count activities you already reported on) d) Talking or texting on a cell phone on <*last weekday*>
Dietary behaviours	*The next questions will ask about the foods you ate or drank in the past 7 days.* In the last 7 days, how often did you drink 100% fruit juice such as apple or orange juice? DO NOT count punch, Kool-Aid, sports drinks, fruit cocktails or fruit-flavored drinks. **[None, 1-3 times in the past 7 days, 4-6 times in the past 7 days, 1 time per day, 2 times per day, 3 times per day, 4 or more times per day]** In the last 7 days, how many times did you drink a regular soda or pop that contains sugar? DO NOT count diet sodas or diet drinks. **[None, 1-3 times in the past 7 days, 4-6 times in the past 7 days, 1 time per day, 2 times per day, 3 times per day, 4 or more times per day]**

<table>
<tr><th>Construct</th><th>Survey Items</th></tr>
<tr><td></td><td>In the last 7 days, how many times did you drink fruit-flavored drink (such as Kool-aid®, Sunny D®, or lemonade), sports or high energy drinks (such as Gatorade®, Red Bull®), blended sweetened tea or coffee drinks (such as iced tea, Starbucks® latte or frappucino®, Chai tea), or other sweetened drinks? DO NOT count 100% fruit juices and diet drinks.
[None, 1-3 times in the past 7 days, 4-6 times in the past 7 days, 1 time per day, 2 times per day, 3 times per day, 4 or more times per day]

The next questions ask about how many servings of fruits and vegetables you ate yesterday. Use the examples below as a guide when you answer these questions.
<table><tr><td>1 serving of FRUIT could be:
1 medium apple or orange
1 medium banana
1 large plum
½ cup of berries
20 cherries
20 grapes
¼ cup of dried fruit</td><td>1 serving of VEGETABLES could be:
½ cup of broccoli
1 large carrot
1 cup of raw spinach
1 cup of raw lettuce
½ cup of sweet potatoes
½ cup of green beans
4 Brussels sprouts</td></tr></table>
Yesterday how many servings of fruit (including fresh, frozen, canned, and dried fruit) did you eat? Do not count 100% fruit juice.
[None – 4 or more servings (in 0.5 serving increments)]

Yesterday how many servings of vegetables (including fresh, frozen or canned) did you eat? Do not count 100% vegetable juice or fried potatoes.
[None – 4 or more servings (in 0.5 serving increments)]</td></tr>
<tr><td>Parenting practices surrounding healthy eating</td><td>The next part of the survey asks you to think about your teen’s eating habits.
[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]
a) I have to make sure that my teenager eats enough fruits and vegetables
b) I buy fruits and vegetables for my teenager
c) I try to eat fruits and vegetables when my teenager is around
d) I encourage my teenager to try different kinds of fruits and vegetables
e) My teenager and I decide together how many fruits and vegetables he/she has to eat
f) I make my teenager eat fruits and vegetables
g) It’s okay for me to make rules about how many fruits and vegetables my teenager can have

These questions ask about junk food and sugary drinks that your teenager may eat or drink. Remember that JUNK FOODS are foods that are high in calories and usually added sugars and fat and include candy, cookies, potato chips, French Fries, etc. SUGARY DRINKS include regular soda or pop, sports drinks, fruit drinks, sweetened iced teas, and other drinks with added sugar.
[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]
a) If my teenager has had a bad day, I let him/her have junk food and sugary drinks to feel better
b) I don’t buy a lot of junk food or sugary drinks for my teenager
c) I try to avoid eating junk food or drinking sugary drinks when my teenager is around
d) My teenager and I decide together how much junk food or sugary drinks he/she can have</td></tr>
</table>

Construct	Survey Items
	e) I have to make sure that my teenager doesn't eat too much junk food or drink too many sugary drinks f) I decide how much junk food or sugary drinks my teenager can have g) It's okay for me to make rules about how much junk food or sugary drinks my teenager can have
Parenting practices surrounding physical activity	Now think about your teen's time being physically active. **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) I have to make sure my teenager gets enough physical activity b) I take my teenager places where he/she can be physically active c) My teenager and I decide together how much physical activity he/she has to do d) I make my teenager exercise or go out and play e) I try to be physically active when my teenager is around f) It's okay for me to make rules about how much time my teenager spends being physically active/playing
Parenting practices surrounding electronic device usage	The next questions ask about "SCREEN TIME" That is, the time your child spends using electronic devices to watch videos, surf the internet, play video games and do other activities that involve sitting and looking at a screen. Now think about your child's time with electronic devices. **[Strongly agree, Agree, Neutral, Disagree, Strongly disagree]** a) If my teenager has a bad day, I let him/her have screen time to feel better b) I take my teenager places where he/she can play video games, watch movies, etc. c) My teenager and I decide together how much screen time he/she can have d) I have to make sure my teenager does not have too much screen time e) I decide how much screen time my teenager can have f) I try to limit my own screen time when my teenager is around g) It's okay for me to make rules about how much screen time my teenager can have

Appendix B

Table B.1: Pearson and Spearman correlations between the dependent variables, independent variables, mediators, and covariates.

	Dependent Variables		**Independent Variables**			**Mediators**			**Covariates**	
	App Adoption	Mins of App Usage	Autonomy Practices	Structure Practices	Control Practices	Health Behaviours	Autonomous Motivation	Controlled Motivation	Adolescent Age	Adolescent Sex
Dependent Variables										
App Adoption	**1.00**	0.70	-0.02	-0.02	-0.02	0.13	0.02	0.08	-0.07	0.03
Mins of App Usage	0.82	**1.00**	0.12	0.06	0.08	0.13	-0.00	0.09	-0.09	0.06
Independent Variables										
Autonomy Practices	-0.02	0.11	**1.00**	0.48	0.58	0.10	0.18	0.24	-0.15	-0.07
Structure Practices	-0.04	0.03	0.48	**1.00**	0.37	0.16	0.12	0.27	-0.04	-0.08
Control Practices	-0.02	0.07	0.58	0.37	**1.00**	0.09	0.07	0.27	-0.29	-0.17
Mediators										
Health Behaviours	0.13	0.12	0.10	0.15	0.08	**1.00**	0.36	0.25	-0.12	-0.04
Autonomous Motivation	0.02	-0.00	0.18	0.11	0.08	0.36	**1.00**	0.40	0.00	0.09
Controlled Motivation	0.08	0.09	0.24	0.29	0.26	0.25	0.39	**1.00**	-0.01	-0.02
Covariates										
Adolescent Age	-0.07	-0.08	-0.14	-0.03	-0.29	-0.11	0.01	-0.01	**1.00**	0.13
Adolescent Sex	0.02	0.06	-0.07	-0.10	-0.17	-0.02	0.09	-0.01	0.13	**1.00**

Note: Pearson correlations are listed in white (bottom of the matrix) and Spearman correlations are listed in light grey (top of the matrix). The majority of the variables were not severely skewed (skewness<|1|), with the exception of the dependent variable "App Adoption", which was negatively skewed (skewness = -1.4).