TO WHAT EXTENT ARE MOVEMENT BEHAVIOURS ASSOCIATED WITH EMOTIONAL WELL-BEING IN GRADES FOUR AND FIVE CHILDREN? RESULTS FROM THE OPTIMIZING MOVEMENT IN CHILDREN STUDY

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Abstract

The potential mechanisms driving the optimal, healthy physical and psychological development of children have been studied extensively (Janssen et al., 2010; Milteer, Ginsburg, & Mulligan, 2012; Parfitt & Eston, 2005). Specific movement behaviours, including physical activity, sedentary time, and sleep have been studied independently to examine their influence on health outcomes. Emotional well-being, which encompasses a variety of psychological concepts including optimism, general self-concept, satisfaction with life, and sadness, is considered an important element in the healthy development of children (Guerra & Bradshaw, 2008). This study examined the extent to which four objectively-measured movement behaviours – light physical activity (LPA), moderate to vigorous physical activity (MVPA), sedentary time, and sleep – are associated with emotional well-being in a sample of grades four and five children (N = 21). This study had three objectives: 1) to examine independent associations between the four separate movement behaviours and emotional well-being, 2) to examine the relationship between one movement behaviour and emotional well-being relative to time spent in other movement behaviours using compositional analysis, and 3) to examine whether time spent in sedentary screen activities versus non-screen sedentary activities moderated the relationship between objectively-measured sedentary time and emotional well-being. For objective 1, among the independent Spearman correlations, only MVPA was significantly and positively correlated with emotional well-being ($\rho = 0.77$, $p < 0.001$). Using compositional analysis for objective 2, no significant relationships were found between any one of the four movement behaviours and emotional well-being relative to time spent in other movement behaviours. Finally, for objective 3, no significant moderating effects were found for time spent in sedentary screen time versus non-screen sedentary time on the relationship between objectively-measured sedentary time and emotional well-being. This study concluded that objectively-measured MVPA was significantly and positively associated with emotional well-being in the sample; however, future studies with a larger sample size are recommended, as these findings were limited by a small sample size.

Lay Summary

The physical health benefits of an optimal balance of movement behaviours in children are understood. However, the extent to which healthy movement behaviours are related to emotional health in children is less clear. The goal of this study was to examine whether the amount of time spent in different movement behaviours was associated with emotional well-being in grades four and five children, as well as to examine whether the quality of sedentary time (screen time versus non-screen time), influenced emotional well-being. It was found that moderate to vigorous physical activity was positively associated with emotional well-being, independent of other movement behaviours. No significant relationships were found when compositional analysis was used to examine how any particular movement behaviour was associated with emotional well-being relative to time spent in the other movement behaviours. The quality of sedentary time did not appear to moderate the relationship between sedentary time and emotional well-being.

Preface

The data for this investigation were obtained from the Optimizing Movement in Children Study (OMiCS).

The Optimizing Movement in Children Study is an ongoing research initiative by UBC's School of Kinesiology, Life Sciences Institute, the Faculty of Medicine, and the Office of the Provost and Vice-President Academic in collaboration with the not-for-profit B2Ten's Active for Life along with partners Molecular You and Mitacs. Principal Investigators include Drs. Eli Puterman and Guy Faulker, and Co-Investigators are Drs. Robert Boushel, Anne Lasinsky, Sarah Koch, and Kristin Houghton.

As a graduate student helping facilitate OMiCS, I designed my thesis project based on my interests in the field of physical activity and health in children, and the availability of accessible data through OMiCS. Along with other OMiCS team members, I assisted with multiple aspects of the project including participant recruitment, study coordination, communication with participants, data collection and organization, and volunteer coordination. For data analysis, I received consultation from Dr. Yan Liu, an Assistant Professor from the Faculty of Education. Additionally, I received guidance from my supervisor, Dr. Eli Puterman, and assistance from Ben Hives, a fellow graduate student, in running my statistical analysis using R Software. Upon consultation with Dr. Liu, Dr. Puterman, and Ben Hives, I was responsible for the cleaning and analysis of my data. Finally, for assistance with compositional analysis, I received guidance from Dorothea Dumuid at the University of South Australia. Dorothea was invaluable in assisting with setting up the proper R code to run the compositional analysis of the data.

As mentioned above, data for this project were obtained from OMiCS: a large, collaborative study with multiple contributors. The OMiCS project is anticipated to produce numerous peer-reviewed publications once all data collection has been completed, though no publications have currently been produced.

Ethics approval for the OMiCS study was provided by the UBC Clinical Research Ethics Board, Certificate number H17-00464.

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Finally, to my friends and family for your unconditional support, patience, and love.

Dedication

To my parents, Joanne and Gerry. You provided me with a childhood filled with movement, fresh air, and adventure. For that, I will always be grateful.

And to Gordie, for keeping me in the sunlight.

1 Introduction

The potential mechanisms driving the optimal, healthy physical and psychological development of children have been studied extensively (Janssen et al., 2010; Milteer et al., 2012; Parfitt & Eston, 2005). It is understood that healthy movement habits created throughout childhood and adolescence will carry through into adulthood (Malina, 2001; Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005), ultimately influencing health outcomes later in life. Specific habits, including physical activity, sedentary time, and sleep have been studied independently to examine their influence on health outcomes. Importantly, the examination of these movement behaviours together, including how they interact with, cluster with, and influence each other, has become a new topic of recent research (Laurson, Lee, Gentile, Walsh, & Eisenmann, 2014; Prochaska, 2008; Saunders et al., 2016). Examining multiple movement behaviours in relation to each other, instead of specific behaviours in isolation, provides a broader, more realistic, and more holistic understanding of how certain behavioural patterns influence health outcomes in children.

Social and emotional well-being encompasses how well a child experiences, expresses, and manages emotions, develops relationships, as well as their ability to actively explore their environment and learn (Cohen, Onunaku, Clothier, & Poppe, 2005). This research study will focus on emotional well-being, which is an important component within the construct of social and emotional well-being, and includes psychological concepts including optimism, general self-concept, satisfaction with life, and sadness. Emotional well-being is considered an important element in the healthy development of children (Guerra & Bradshaw, 2008). In addition, middle childhood, defined as the age range of 6-12, is considered a powerful predictor of success in adolescence (Schonert-Reichl & Rowcliffe, 2011) and is a time of significant growth and development: physically, socially, cognitively, and emotionally (Schonert-Reichl et al., 2013).

The goal of this study is to examine the relationships between movement behaviours and emotional well-being in grades 4 and 5 children.

1.1 Emotional Well-being and its Influence on Healthy Development from Childhood Onwards

Emotional well-being is influenced by factors such as biology and social environments, including peer and family relationships, and is linked to other developmental realms including physical growth, language development, and cognitive skills (Cohen et al., 2005). Cross-sectionally, teacher-reported emotional competence, in addition to social competence, significantly predicted higher scores in math and reading in adolescents one year later (Oberle, Schonert-Reichl, Hertzman, & Zumbo, 2014).

While cross-sectional studies can determine that an association exists between emotional well-being and specific outcomes, other factors, such as parenting styles, classroom, and school settings might account for these associations. To best determine causality, it is important to demonstrate that improving emotional well-being will improve academics, health, or other specific outcomes of interest. A recent meta-analysis of intervention studies – albeit non-randomized ones – using emotional and social learning programs and non-randomized control groups in children and youth found an 11-percentile-point gain in academic achievement that extended a minimum of six months after the intervention programs were completed (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011). With respect to the influence of interventions on depression, a randomized controlled trial using a mindfulness-based social and emotional intervention in 4^{th}- and 5^{th}-grade children demonstrated greater decreases in self-reported depression, as well as improvements in stress physiology, evidenced through changes in salivary cortisol slopes obtained at three time-points throughout one day pretest and post-test (Schonert-Reichl et al., 2015) . Additionally, in a 2-year randomized experimental intervention, elementary school children who received a social and emotional learning and literacy intervention showed significant improvement in self-reported depression (Jones, Brown, & Lawrence Aber, 2011).

From these studies, it is evident that emotional well-being is an important component to the healthy development of children, and additional research looking into the various means through which emotional well-being can be fostered is of paramount importance.

1.2 Role of Movement Behaviours on Child Health

The benefits of physical activity in children are numerous and well-understood; however, research has begun to examine the relationship between other movement behaviours such as sedentary screen time, non-screen sedentary time, and sleep, and health outcomes in children.

1.2.1 Physical Activity

When examining the specific health benefits of physical activity in childhood, Janssen and colleagues' systematic review in children found a dose-response relationship between increased levels of physical activity and a decrease in blood lipid profiles, blood pressure, metabolic syndrome, overweight and obesity, depression, and injury risk, and an increase in bone mineral density (Janssen et al., 2010). Sardinha and colleagues determined that time spent in physical activity was significantly and inversely associated with insulin resistance in 9- and 10-year-old children, indicating the protective role of physical activity on the development of metabolic syndrome (Sardinha et al., 2008). A review by Ortega and colleagues on physical fitness and health outcomes in children and adolescents found that cardiorespiratory fitness (as determined by various means included maximal ergometer tests, graded maximal treadmill tests, and multistage fitness tests) was negatively-associated with total and abdominal adiposity and cardiovascular disease risk factors (based on triglycerides, LDLc, HDLc and glucose values; Ortega, Ruiz, Castillo, & Sjöström, 2008). Early action in the prevention of metabolic syndrome and cardiovascular disease is imperative, as markers of metabolic syndrome in childhood predict metabolic syndrome and type 2 diabetes in adulthood (Morrison, Friedman, Wang, & Glueck, 2008).

With respect to the benefits of physical fitness on cognition, a cohort study of over one million Swedish adolescent boys found that cardiovascular fitness was positively associated with intelligence, even after adjusting for confounding variables. Prospectively, those who increased their cardiovascular fitness between the ages of 15 and 18 demonstrated higher global intelligence scores at age 18 compared to those whose fitness levels decreased over time. Finally, it was found that cardiovascular fitness at age 18 predicted educational achievement and socioeconomic status during an extended follow-up period of 10-36 years

(Aberg et al., 2009), even after controlling for relevant confounders including parental education. In addition to higher fitness predicting concurrent and future academic success, the positive relationship between physical activity and cognition has also been objectively observed through neuroimagery investigation, as children with higher aerobic fitness demonstrated greater bilateral hippocampal volumes in addition to greater relational memory performance compared with lower-fit children (Chaddock et al., 2010). Results from these studies build on previous findings examining the benefits of physical activity on the cognitive abilities of children (Hillman, Erickson, & Kramer, 2008).

All of these factors point to the abundance of physical and cognitive benefits, as well as protective influences, provided by physical activity throughout childhood and adolescence. In addition to the benefits of physical activity in childhood, it is important to note the negative consequences of inactivity. Despite the numerous known health benefits of physical activity (WHO, 2017), only 9% of 5- to 17-year-old Canadian children meet the recommended guidelines of 60-minutes of physical activity on a daily basis ("Children and physical activity," 2016). Inadequate physical activity levels are one of the leading mortality risks worldwide (Murray & Lopez, 1997), and children who do not achieve sufficient levels of physical activity are at an increased risk of developing noncommunicable diseases including cardiovascular disease, cancer, and type 2 diabetes mellitus during adulthood (WHO, 2017). In addition to these health risks, inactive children are more likely to suffer from mental health issues including depression, anxiety, low self-esteem, and sub-optimal cognitive functioning (Biddle & Asare, 2011). Furthermore, health habits during childhood may be associated with health outcomes later in life, as inactivity in childhood is predictive of a sedentary lifestyle in adulthood (Telama, 2009). Examining the myriad of benefits obtained from physical activity in conjunction with the host of detriments arising from inactivity solidifies the important role of physical activity in the healthy development of children.

1.2.2 Sedentary Screen Time

Although the health benefits obtained from physical activity during childhood have been identified, it is equally important to consider the sedentary behaviours of children. There is evidence that screen-based sedentary time is related to physical and mental health problems including overweight and obesity (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Anderson, Economos, & Must, 2008), and depression and anxiety (Brindova et al., 2015) in children. These findings are worrisome, as a study of Canadian children in grades 6-10 found that 82% of girls and 86% of boys exceeded the American Academy of Pediatrics screen time guidelines of no more than two hours of screen time per day (Mark, Boyce, & Janssen, 2006), while sedentary screen habits appear to be worsening with age (Anderson et al., 2008).

Anderson and colleagues demonstrated that children with obesity are more likely to have concurrently low levels of active play and high levels of screen time (Anderson et al., 2008). Furthermore, it was found that children and adolescents who spent four or more hours in front of the television each day had greater body fat and an increased BMI compared to those who watched less than two hours a day (Andersen et al., 1998). Additionally, objectively-measured sedentary activities were significantly and positively associated with insulin resistance in children, even after controlling for total or central fat mass (Sardinha et al., 2008).

A graded, negative relationship between sedentary behaviours and health outcomes has been evidenced in children. A recent systematic review in children aged 7-15 found that higher frequency and duration of screen time and TV viewing was associated with unfavourable body composition and higher clustered cardiometabolic risk scores (Carson, Hunter, et al., 2016). Furthermore, a similar systematic qualitative analysis of 232 studies found a dose-response relationship between increased sedentary behaviour and negative outcomes including unfavourable body composition, lower levels of fitness, and reduced academic achievement (Tremblay et al., 2011).

Intervention studies have also been performed to demonstrate the causal role of sedentary screen behaviours on physical and psychological health outcomes. A recent meta-analysis completed on all randomized-controlled studies aiming to reduce sedentary time in children aged 5-17 years revealed an overall significant effect of -0.81: the interventions were significantly associated with a decrease in mean BMI (Tremblay et al., 2011). Looking at psychological health, a study examining the influence of exercise or video-watching on mood in 9- and 10-year old children found that, when children watched a 15-minute video instead of completing the exercise treatment, positive mood decreased and negative mood increased (Williamson, Dewey, & Steinberg, 2001).

Taken together, these findings demonstrate the negative influences of sedentary screen behaviours on the physical and psychological health of children.

1.2.3 Non-screen Sedentary Time

When examining sedentary behaviours in children, the focus has almost entirely been on screen time: exposure to electronic media. However, this thesis also explored non-screen sedentary time, which includes sedentary activities such as listening to or playing music, reading books, or doing arts and crafts. A recent systematic review noted that different types of sedentary behaviour may have different impacts on health: TV and screen time were found to be detrimental to almost all outcomes including physical, social, emotional, mental, and intellectual health, while reading and homework appeared to offer benefits in academic achievement (Carson, Hunter, et al., 2016). Therefore, it is important when examining the influences of sedentary time on child health to differentiate between screen and non-screen time. Of the few studies that have examined non-screen sedentary time, a systematic review by Carson and colleagues investigating sedentary behaviour and cognitive development in early childhood found that reading was most consistently associated with positive cognitive development (Carson, Kuzik, et al., 2015). In addition, a recent study by Schonert-Reichl and colleagues found that children who spent more time in front of a television or computer screen reported being less happy and feeling less competent than children who spent less of their sedentary time in front of a screen (Schonert-Reichl & Rowcliffe, 2011). Though the research is scarce, promising findings such as these prompt the need to expand this investigation: although researchers focus on the *quantity* of sedentary time, it is equally important to examine the *quality* of sedentary time.

1.2.4 Sleep

In addition to movement behaviours such as physical activity and sedentary time, the sleep habits of children are related to their overall health. These findings are of significant interest, as researchers have found that sleep duration in children and adolescents had declined rapidly and consistently over the past 103 years (Matricciani, Olds, & Petkov, 2012). This decline in sleep duration, combined with the increase in sedentary screen time (Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006), may have negative health consequences on today's children and adolescents.

The majority of sleep research in children has focused on overweight and obesity, as they appear to be closely linked. A systematic review and meta-analysis found an inverse association between sleep duration and overweight/obesity in children aged ten years and younger (Chen, Beydoun, & Wang, 2008), while shorter sleep duration in adolescents doubled the risk of overweight/obesity compared to those who slept longer (Fatima, Doi, & Mamun, 2015). Negative sleep habits such as short sleep duration, poor sleep quality, and later bedtimes have been associated with obesity-related factors including increased food intake, lower diet quality, and increased body weight (Chaput, 2014). In addition, dose-response relationships between sleep and obesity risk have also been found: children with a shorter sleep duration had a 58% increased risk for overweight/obesity and, conversely, for each hour increase in sleep, the risk of overweight/obesity was reduced by an average of 9% (Chen et al., 2008). Findings such as these provide insight into how poor sleep habits contribute to the development of overweight and obesity throughout childhood and adolescence.

The relationship between sleep and other health indicators has also been studied. A recent systematic review by Chaput and colleagues found that a longer sleep duration was coupled with better mental health, improved academic achievement, and better quality of life in children and adolescents (Chaput et al., 2016), while Stroebele and colleagues found an association between sufficient sleep and improved academic performance in 5th grade children (Stroebele, McNally, Plog, Siegfried, & Hill, 2013). Furthermore, Sadeh and colleagues found that children who slept longer demonstrated improved memory performance, while those who had shorter sleep durations reported reduced alertness (Sadeh, Gruber, & Raviv, 2003).

In summary, evidence is pointing to the multitude of physical, emotional, and cognitive benefits provided by the attainment of sufficient levels of sleep in children.

1.3 Role of Movement Behaviours on Emotional Well-being

In addition to the substantial body of research examining the relationship between movement behaviours and physical health in children, additional research has explored the relationships between movement behaviours and emotional well-being in children.

1.3.1 Physical Activity

Active children and adolescents demonstrate increased self-esteem, decreased stress levels, and improved psychological health (Loprinzi, Cardinal, Loprinzi, & Lee, 2012). Based on these findings, research has begun to examine potential positive associations between physical activity and emotional well-being in children. As mentioned earlier, this thesis focused on four components of emotional well-being: sadness (depressive symptoms), general self-concept, satisfaction with life, and optimism.

1.3.1.1 Sadness and Depressive Symptoms

With respect to psychological variables including depression, research in children and adolescents has found significant negative associations between physical activity and depression (Brown, Pearson, Braithwaite, Brown, & Biddle, 2013), while a meta-analysis of both correlational and randomized controlled studies found that, on average, increased levels of physical activity were significantly associated with a reduction in depression and psychological distress (Ahn & Fedewa, 2011). In addition, a study of almost five thousand adolescents found that sport and vigorous recreational activity was positively associated with emotional well-being, and that this association was independent of sex, social class, health status, and use of hospital services (Steptoe & Butler, 1996). Furthermore, a study examining the effect of exercise on mood found that 9- and 10-year-old children demonstrated significant increases in positive mood and significant decreases in negative mood after an aerobic exercise treatment (Williamson et al., 2001). Finally, a recent physical activity intervention study in grades 5 and 6 children concluded that curriculum-based physical activity in schools may improve the psychological health of children, especially for girls (Bunketorp Käll, Malmgren, Olsson, Lindén, & Nilsson, 2015), while an additional intervention aimed at improving cardiorespiratory fitness demonstrated positive effects on depression, anxiety, and mood status (Ortega et al., 2008). Studies such as these demonstrate the positive role of physical activity in the context of depression, psychological distress, and mood disorders.

1.3.1.2 General Self-Concept

General self-concept, which is related to self-esteem and self-awareness, has also been associated with physical activity in many studies. Parfitt and Eston found a significant positive correlation between objectively-measured physical activity levels and global self-esteem in 10-year old children (Parfitt & Eston, 2005). A recent systematic review of cross-sectional and observational studies found that self-esteem was the most positively-associated outcome of sport participation in children and adolescents (Eime, Young, Harvey, Charity, & Payne, 2013). Importantly, exercise interventions have shown short-term positive effects on self-esteem (Ekeland, Heian, Hagen, & Coren, 2005), and increased self-concept and self-worth in children and adolescents (Liu, Wu, & Ming, 2015). One specific intervention study in boys aged 6-9 found that self-concept was significantly improved after participation in a sports camp experience (Anshel, Muller, & Owens, 1986), while another intervention found that participation in a dance team resulted in significant improvements in self-concept in female adolescents (Blackman, Hunter, Hilyer, & Harrison, 1988). Finally, another intervention aimed at improving cardiorespiratory fitness demonstrated positive effects on self-esteem in children (Ortega et al., 2008).

1.3.1.3 Satisfaction with Life

A survey of 14,880 children aged 6-18 years found that higher levels of physical activity were associated with higher levels of life satisfaction (Matin et al., 2017). In addition, Valois and colleagues demonstrated how a lack of physical activity in children and adolescents may be negatively-associated with satisfaction with life (Valois, Zullig, Huebner, & Drane, 2004). Finally, when Poulsen and colleagues examined how physical coordination in boys aged 10-13 influenced life satisfaction, they found that boys with moderate to severe physical coordination difficulties, who are therefore particularly vulnerable to physical activity participation limitations, had significantly lower life satisfaction than boys who had medium to high levels of physical coordination (Poulsen, Ziviani, & Cuskelly, 2006). However, it should be noted that this study did not control for the presence of bullying or other potential confounders in this population.

1.3.1.4 Optimism

Another concept of emotional well-being, which has been less-studied with respect to its relationship with physical activity, is optimism. However, one study found that three factors in sports participation (participation frequency, participation period, and participation intensity) were significantly and positively associated with optimism (Koo & Lee, 2014).

1.3.2 Sedentary Screen Time

Less explored is the relationship between sedentary screen time and emotional well-being. Of the existing research, a focus has been placed on psychological variables as well as general self-concept.

Looking at the relationship between sedentary screen time and mood, emotion, and other psychological variables, Brindova and colleagues found that 11-15-year-old children who watched more than three hours of television per day had an increased chance of feeling low, being irritable, or feeling nervous (Brindova et al., 2015). Yang and colleagues found a linear dose-response relationship between increased electronic screen use (watching TV, playing computer games on the internet, playing non-internet computer games, using internet chatting channels, and using the computer for other uses) and an increase in mental health symptoms in 10-year-old children including depression, loneliness, and sleep difficulties (Yang, Helgason, Sigfusdottir, & Kristjansson, 2013). In addition, in a two-year longitudinal study, Gentile and colleagues found that pathological video game use (commonly referred to as video game "addiction") in children in grades 3-8 was positively associated with depression, anxiety, and social phobias (Gentile et al., 2011).

With respect to general self-concept, Tin and colleagues found a negative association between increased television viewing and self-esteem in grade four children (Tin, Ho, Mak, Wan, & Lam, 2012). Furthermore, two recent systematic reviews found a dose-response relationship between time spent watching television or playing video games and lower self-esteem (Carson, Hunter, et al., 2016; Tremblay et al., 2011) in both children and adolescents.

Taken together, these findings demonstrate the negative association between excessive screen time and emotional well-being in children and adolescents. However, to date, it is unknown the extent to which sedentary screen time is related to satisfaction with life and optimism.

1.3.3 Non-screen Sedentary Time

Though the relationship between sedentary screen time and emotional well-being in children has been investigated to a certain extent, the relationship between non-screen sedentary time and emotional well-being is also worthy of more attention: when examining the specific use of sedentary time, a study in Canadian children found that those who spent more sedentary time in front of a screen (either computer, TV, or video games) were found to be less happy than children who spent their sedentary time pursuing other activities (Schonert-Reichl & Rowcliffe, 2011). Furthermore, a recent systematic review by Carson and colleagues of sedentary behaviour and cognitive development in early childhood examined the contribution of both sedentary screen behaviours (TV-watching) and non-screen sedentary behaviours (reading). This review found that reading was most consistently, and positively, associated with cognitive development (Carson, Kuzik, et al., 2015). Despite the fact that cognitive development is not specifically considered as a component of emotional well-being, it is understood that these two variables are interconnected and positively-associated (Jones et al., 2011; Oberle et al., 2014; Schonert-Reichl et al., 2015).

Based on the current limited evidence, it is reasonable to hypothesize that the relationship between non-screen sedentary behaviours and emotional well-being in children may differ from the (consistently negative) relationship between sedentary screen time and emotional well-being. However, the need to elaborate on this investigation is considerable: multiple recent publications have openly stated that future research needs to differentiate sedentary time into screen time and non-screen time to examine if relationships between health variables differ (Chaput, Saunders, & Carson, 2017; Tremblay et al., 2016). Research has demonstrated the beneficial relationships between non-screen sedentary activities and emotional health outcomes: playing music has been shown to foster the development of self-esteem children (Hietolahti-Ansten & Kalliopuska, 1990), while art has been shown to significantly decrease anxiety scores in adolescents (Sandmire, Roberts, Gorham, Rankin, & Grimm, 2012). These findings, though few, indicate the need to examine non-screen sedentary behaviours such as reading, writing, music, and art separately from sedentary screen time. Grouping all sedentary behaviours together in one category does not allow for an accurate depiction or interpretation of the data, and may result in erroneous conclusions. Therefore, it is in the best interest of researchers to begin to examine the separate contributions of sedentary screen time and non-screen sedentary time to the emotional well-being of children.

1.3.4 Sleep

Though there has been less research on the relationship between sleep and emotional well-being in children, a recent systematic review found associations between longer sleep duration and improved emotional regulation in children aged 5-7 years (Chaput et al., 2016). Lemola and colleagues objectively examined sleep quantity and quality in 8-year-old children, and found a non-linear, reverse J-shaped relationship with optimism: children who received an optimal amount of sleep (between 7.7-9.3 hours) each night demonstrated higher optimism than those who slept too little or too long (Lemola et al., 2011). In a longitudinal study of children from the age of four until adolescence, Gregory and colleagues found that sleep difficulties at age four predicted behavioural and emotional problems in mid-adolescence, and that the correlation between sleep problems and depression and anxiety increased significantly over time

(Gregory & O'Connor, 2002). The implications of this study are threefold: firstly, that sleep difficulties predict future behavioural problems. Secondly, that poor sleep habits are correlated with depression and anxiety and, thirdly, that this relationship becomes stronger with age. Examining these relationships in adult populations, Lemola and colleagues found that adults who did not receive adequate sleep demonstrated lower optimism and self-esteem, establishing that the relationship between sleep duration and emotional well-being is also important in adults (Lemola, Räikkönen, Gomez, & Allemand, 2013). Taken together, it is evident that sleep habits are associated with emotional well-being in children, adolescents, and adults, both acutely and over time. Therefore, it is important to continue to study these relationships, especially in the context of physical activity and sedentary behaviours.

1.4 The Combined Influence of Movement Behaviours

The associations between physical activity, sedentary behaviour, and sleep on child health have all been investigated; however, the majority of research has been examining these movement behaviours as independent factors. Considering that children have a finite amount of time each day to spend on different activities, it has been hypothesized that various movement behaviours, including physical activity, sedentary time, and sleep, may interact with, or influence, each other, ultimately affecting health outcomes in children (Carson, Tremblay, Chaput, & Chastin, 2016). The multicollinear nature of movement behaviour variables within a 24-hour day has now been acknowledged: time spent in one behaviour inevitably displaces time spent in another movement behaviour (Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015). Therefore, when examining multiple movement behaviours as a whole, results may differ in comparison to examining independent relationships between specific movement behaviours and health outcomes.

1.4.1 Influence on Physical Health

In certain cases, some movement behaviours may be independently associated with negative health outcomes, regardless of the health benefits of other movement behaviours performed. Rosen and colleagues found that, in preteens aged 9-12, daily sedentary screen time significantly predicted physical problems, even after covarying lack of physical activity (Rosen et al., 2014). Further, in a nationally representative survey of children aged 8-16, Andersen and colleagues found that TV-watching was more tightly related to skinfolds and BMI than was vigorous physical activity (Andersen et al., 1998).

Studying combinations of movement behaviours, Carson and colleagues examined movement behaviour patterns in adolescents and their relationship with overweight and obesity. They found three underlying subgroups of movement behaviours: the first group, the "healthiest movers" were those who demonstrated a combination of high levels of physical activity and sleep and low levels of sedentary behaviour. The second group, the "active screenies", demonstrated high levels of both physical activity and sedentary behaviour, while the final group, the "unhealthiest movers", demonstrated the lowest levels of physical activity in combination with the highest levels of sedentary time. Interestingly, it was found that both the "unhealthiest movers" *and* the "active screenies" were more likely to be categorized as overweight or obese compared to the "healthiest movers" (Carson, Faulkner, Sabiston, Tremblay, & Leatherdale, 2015). This indicates that getting enough physical activity is not sufficient to prevent overweight and obesity in these populations, or at least that the relationship between physical activity and overweight/obesity in children is moderated by screen time. In addition, a recent systematic review by Saunders and colleagues found that children and youth with a combination of high physical activity, high sleep, and low sedentary behaviour demonstrated more optimal measures of adiposity and cardiometabolic health as opposed to those with a combination of low physical activity, low sleep, and high sedentary behaviour (Saunders et al., 2016). Furthermore, health benefits were more positively associated with children with a combination of either high physical activity and high sleep or high physical activity and low sedentary behaviour, as opposed to children with combinations of either low physical activity and low sleep or low physical activity and high sedentary behaviour (Saunders et al., 2016). Once again, these findings confirm that specific combinations of multiple movement behaviours are associated, either positively or negatively, with health outcomes.

When examining how multiple movement behaviours influence health outcomes in a synergistic manner, Laurson and colleagues examined concurrent associations between physical activity, sedentary screen time, and sleep duration with obesity in children aged 7-12. They found that the odds of obesity were related, in a *graded* manner, with the addition of movement behaviour recommendations (Laurson et al., 2014). In other words, it was found that the risk of obesity decreased, in a dose-response manner, with every addition of a health movement behaviour recommendation. When they examined which children met the respective recommendations for sleep duration, physical activity, and sedentary screen time, they found that children who met all three recommendations simultaneously, which was only 9.2% of the total population, were the least likely to be obese. Furthermore, the children who met none of the recommendations (15% of the population) were eight times as likely to be obese than those meeting all of the recommendations (Laurson et al., 2014). This trend continued, as children who met one or two of the recommendations demonstrated incrementally decreased risks of obesity (Laurson et al., 2014). Results of this study indicate that movement behaviours exert a synergistic effect on obesity risk factors.

Following the research examining independent, combined, and synergistic influences of movement behaviours, Carson and colleagues analyzed the relationship between movement behaviours and health outcomes using compositional analysis, as it is understood that children only have a finite amount of time to dedicate to each movement behaviour. Their study examined the associations between self-reported sleep duration, accelerometer-derived physical activity and accelerometer-derived sedentary time with physical health outcomes in Canadian children and youth aged 6-17 years. Using compositional analysis to examine how the pattern of movement behaviours as a whole was associated with health outcomes, instead of examining each health behaviour independently, this study found that, relative to other movement behaviours, time spent in sedentary behaviours or light physical activity was positively associated with obesity risk markers, while time spent in moderate to vigorous physical activity or sleep was negatively associated with obesity risk markers (Carson, Tremblay, et al., 2016). When examining the relationship between movement behaviours and insulin, a marker of metabolic syndrome, it was found that those with the most unhealthy insulin profiles demonstrated a combination of lower levels of moderate to vigorous physical activity (MVPA), light physical activity, and sleep while those with the healthiest insulin profiles demonstrated a completely opposite combination of movement behaviours (Carson, Tremblay, et al., 2016).

Following this new compositional approach, a recent publication based on four systematic reviews was interpreted to determine 24-hour movement guidelines for children and youth (Tremblay et al., 2016). These systematic reviews examined the relationships between movement behaviours including objectively-measured physical activity, sedentary behaviour, sleep duration, and combinations of these behaviours and several health indicators. Based on extensive compositional analysis, 24-hour movement guidelines were published. These guidelines outlined recommendations for how to achieve optimal health through a combination of four movement behaviours: at least 60 minutes of MVPA, several hours of light physical activity, 9-11 hours of uninterrupted sleep, and no more than two hours of sedentary behaviour each day for children aged 5-17 years (Tremblay et al., 2016). This study illuminates the current shift in research approaches: from studying movement behaviours independently, to examining how different combinations of movement behaviours are associated with physical health.

1.4.2 Influence on Emotional Well-being

Although much is understood about the relationship between movement behaviour combinations and physical health in children, much less is known about the association between these behaviours and the emotional health of children. Is there a specific pattern of movement behaviours that facilitates optimal emotional well-being in children? Is this movement pattern similar to that which demonstrates benefits to physical health?

A recent study by Hamer and colleagues examined the relationship between emotional variables and movement behaviours in children aged 4-12. The outcome variables in this study, which used the Strengths and Difficulties Questionnaire, included emotional symptoms, conduct problems, hyperactivity, peer problems and prosocial behaviour, while sedentary screen time and physical activity levels were collected through self-report. The study demonstrated that sedentary screen time and physical activity levels were independently associated with emotional difficulties after adjusting for age, gender, area deprivation, single-parent status, medical conditions, and various dietary intake indicators (Hamer, Stamatakis, & Mishra, 2009). In addition to this finding, the researchers also found an interaction effect, demonstrating that a combination of both high sedentary screen time and low physical activity levels resulted in the highest total emotional difficulties scores (Hamer et al., 2009). The findings from this study are of interest for two reasons. Firstly, they demonstrate that both physical activity levels and sedentary screen time are independently and significantly associated with emotional difficulties. Secondly, they demonstrate an additive influence of these behaviours, in that those children with the highest total difficulties scores also demonstrated a combination of the highest levels of sedentary screen time and the lowest levels of physical activity.

Page and colleagues similarly examined the same outcome measure of emotional difficulties as well as self-report measures of daily television hours and computer use to determine sedentary screen time, but improved upon limitations of Hamer and colleagues by including accelerometers to objectively measure physical activity levels. This study found that, irrespective of objectively-measured physical activity levels, greater sedentary screen time was related to higher psychological difficulties in 10- and 11-year-old children (Page, Cooper, Griew, & Jago, 2010). Furthermore, an additive influence of these behaviours was found: children who reported spending more than two hours each day in sedentary screen time activities and simultaneously engaged in less than 60-minutes of physical activity each day were at an increased risk for psychological difficulties compared with children who exceeded screen guidelines while still maintaining physical activity recommendations (Page et al., 2010). Unexamined to date is the extent to which movement behaviours are associated with additional emotional variables including optimism, general self-concept, and satisfaction with life. This project addressed these gaps in the literature.

1.5 Objectives and Hypothesis

This study built on past research examining the relationship between multiple movement behaviours and the emotional well-being of children. A few studies have examined the combination of multiple movement behaviours including physical activity, sedentary time, and sleep on health outcomes in children (Carson, Tremblay, et al., 2016; Chaput et al., 2017; Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015; Saunders et al., 2016); however, none of these studies have examined the extent to which these behaviours are associated with emotional outcomes in children using compositional techniques. The importance of emotional well-being throughout childhood is now well-established (Caprara, Barbaranelli, Pastorelli, Bandura, & Zimbardo, 2000; Durlak et al., 2011; Oberle et al., 2014), and the importance of healthy levels of physical activity, sedentary time, and sleep have also been well-established (Tremblay et al., 2016). This research study combined these two concepts using objective measures of physical activity, sedentary time, and sleep and a comprehensive examination of emotional well-being, which measures optimism, general self-concept, sadness (depressive symptoms), and satisfaction with life.

As previously stated, it is now understood that examining movement behaviours independently of each other may not provide accurate results, as movement behaviours are inevitably codependent and multicollinear. Therefore, the analysis of movement behaviours and their relationship with health outcomes is now being approached through various new statistical methods, including compositional analysis. This technique was used in this project to examine the relationship between emotional well-being and one specific movement behaviour, while taking into account time spent in other movement behaviours.

This study followed the recommendations provided by the recent systematic review by Tremblay and colleagues (2016) outlining the 24-hour movement guidelines for children and youth. Among the many recommendations, it was suggested to examine how objectively-measured movement behaviours influence quality of life and well-being, psychological distress, and self-esteem, which are all elements of emotional well-being. In addition, it was recommended that further research seek to divide sedentary behaviour into screen time and non-screen time (Chaput et al., 2017; Tremblay et al., 2016) to examine whether these different sedentary pursuits, which this project has classified as sedentary screen time and non-screen sedentary time, have differential impacts on health outcomes.

This study addressed three primary objectives. The first was to examine the independent associations between physical activity, sedentary time, and sleep on emotional well-being. The second was to use compositional analysis to examine associations between one specific movement behaviour and emotional well-being while taking into account time spent in other movement behaviours. The third was to examine the moderating effect of different types of sedentary behaviour (sedentary screen time versus non-screen sedentary time) on the relationship between sedentary time and emotional well-being.

1.5.1 Hypothesis 1

It is hypothesized that increased levels of light physical activity (LPA), moderate to vigorous physical activity (MVPA), and sleep will be independently and positively associated with emotional well-being, while increased sedentary time will be negatively associated with emotional well-being.

1.5.2 Hypothesis 2

It is hypothesized that, when taking all other movement behaviours into account using compositional analysis: increased time spent in LPA, MVPA, and sleep will be positively associated with emotional well-being, while increased time in sedentary behaviour will be negatively associated with emotional well-being.

1.5.3 Hypothesis 3

It is hypothesized that an increased proportion of sedentary time spent on non-screen sedentary pursuits such as music, art, and reading, may moderate the negative relationship between sedentary time and emotional well-being. It is expected that children who spend a larger proportion of their total sedentary time in sedentary screen activities will demonstrate a stronger negative relationship between objectively-measured sedentary time emotional well-being. However, it is hypothesized that children who spend a larger proportion of their total sedentary time in non-screen sedentary activities may not demonstrate this negative relationship, or may even demonstrate a positive relationship between objectively-measured sedentary time and emotional well-being.

2 Methods

The data for this investigation were obtained from the Optimizing Movement in Children Study (OMiCS), run by Principal Investigators Drs. Eli Puterman and Guy Faulkner, and Co-Investigators Drs. Robert Boushel, Anne Lasinsky, Sarah Koch, and Kristin Houghton, The Optimizing Movement in Children Study is an ongoing research initiative by UBC's School of Kinesiology, Life Sciences Institute, the Faculty of Medicine, and the Office of the Provost and Vice-President Academic in collaboration with the not-for-profit B2Ten's Active for Life along with partners Molecular You and Mitacs.

The goal of OMiCS is to understand the social, emotional, and biological health of grades four and five children from the perspective of physical literacy and physical activity, as it examines multiple components of health including proteomic, metabolomic and microbiomic analyses. However, this thesis project focused on the accelerometer-based, objectively-measured movement behaviours of children and how they relate to emotional well-being.

2.1 Participants

The OMiCS study included a blood draw, a hair sample, and a fecal sample during two separate visits to the UBC campus, requiring a total commitment of around 15 hours for the participant and their parent. Therefore, participant recruitment was challenging due to parent and child concern over the blood draw, fecal sample collection, and/or lack of time in their schedule to participate. Recruitment efforts were wide-spread: research assistants set up recruitment booths at local community centres, UBC events, as well as at UBC summer camps. Posters were set up in various community centres and family medical clinics across the Lower Mainland, while OMiCS advertisements were sent out in newsletters including UBC Active Kids, BC Girl Guides, and Vancouver United Soccer Club. Additionally, an application to recruit through the Vancouver School Board was completed, though no recruitment occurred due to delays in application assessment. The majority of participant interest was obtained from Vancouver United Soccer Club, while additional participants were recruited through word of mouth. Recruitment efforts began during the summer of 2017, and the first data collection day did not occur until October 2017. The study is still ongoing.

The original sample contained 25 participants; however, three participants did not have valid accelerometer data, and one participant did not complete the outcome questionnaire. Therefore, the final sample included 21 participants.

2.2 Procedure

2.2.1 Study Visits

Upon expressing interest in the study, Visit 1 was scheduled with the participant and their parent. Visit 1 occurred either at the FAST Lab (located at 2176 Health Sciences Mall, UBC), or at a meeting place convenient to the participant and their parent. During Visit 1, the study was explained in detail, consent was obtained from the parent and assent was obtained from the participant. Questionnaires were distributed to be completed by the parent and participant at home, and both the parent and participant were administered an ActivPAL3™ accelerometer to be worn for seven consecutive days on the anterior thigh using a clear adhesive strip (Tegaderm). A demographics questionnaire (see Appendix A) was included among the questionnaires sent home with the participants. This questionnaire collected information regarding annual household income and parental highest level of education. Additionally, the participants also completed the Sedentary Time Questionnaire (STQ; see Appendix B) at home. The STQ has been adapted from the Sedentary Behaviour Questionnaire, a validated measure to assess the amount of time spent in different types of sedentary behaviours through self-report (Rosenberg et al., 2010a).

Approximately one week following Visit 1, the participant and their parent returned to the FAST lab for Science Camp Day. During this time, the accelerometers were returned, and the participants completed various data collection tasks for the OMiCS study, in addition to completing the Middle Years Development Instrument (MDI) questionnaire (see Appendix C) to obtain the emotional well-being data.

2.2.2 Data Collection

Data for this study were obtained from three sources: movement behaviour data were obtained from the accelerometers, emotional well-being data were obtained from the MDI questionnaire, while types of sedentary behaviours were obtained from the STQ.

2.2.2.1 Sedentary, LPA, and MVPA

To obtain movement behaviour data, ActivPAL3™ accelerometers were used, which are tri-axial accelerometers that measure acceleration at a sampling frequency of 20 Hz (Edwardson et al., 2017). Movement behaviour data were obtained from the accelerometers in excel format. Each row of data represented a specified amount of time during which the participant was engaged in one of three types of movement: sedentary, standing, or stepping. Therefore, according to the activPAL™ data, time spent sedentary included sleeping time and time spent in any sedentary positions such as sitting or lying down. Additionally, each row of data contained a value for energy expenditure (MET.h, which was expressed in METs per hour). Using the interval for that row (the number of seconds the behaviour was performed), MET.h was converted into METs for that specific interval, by taking the MET.h value, dividing it by the interval (in seconds), and multiplying it by 3600 seconds. Once this new data was created, each row (interval), had a subsequent MET value associated with it. One MET is defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O_2 per kg of body weight x minute in adults (Jetté, Sidney, & Blümchen, 1990). Based on research examining which MET thresholds capture sedentary behaviour (Saint-Maurice, Kim, Welk, & Gaesser, 2016) and physical activity (Chaput et al., 2017) in children, daily accelerometer data was classified into periods of sedentary behaviour (0-2 METs), LPA (2-4 METs), and MVPA (4+ METs).

Data transformation and classification was completed using R software (R Core Team, 2017). Using an excel spreadsheet created by the R software, the number of minutes per day spent in each of the three movement behaviours was obtained. Using this spreadsheet, it was possible to calculate how many minutes the accelerometer tracked movement behaviour during that 24-hour period. Valid days were considered those during which the accelerometers were tracking for approximately a full 24-hour hours (or 1440 minutes +/- 45 minutes). Invalid days were any day during which the accelerometer was not recording for that entire period. Therefore, invalid days included the first day of collection (when the accelerometer was applied at some point in the afternoon), and the last day of collection (when the accelerometer was removed), as both of these did not contain a full 24-hours of movement behaviour data. Furthermore, one participant's accelerometer stopped working mid-way through the collection period (most likely due to a battery malfunction), and a new accelerometer was supplied at that time. Therefore, due to the mid-week interruption and switching over of accelerometers, this participant only ended up with three valid days (or three valid 24-hour periods) of accelerometer data.

Following this, an average amount of time (in minutes) spent in each movement behaviour was calculated based on the number of valid days (*M* = 6.45, *SD* = 1.12, range = 3-8) obtained from the accelerometer data.

2.2.2.2 Sleep Duration

As stated earlier, the amount of objectively-measured sedentary time calculated in the above section included both sleeping time and sedentary time, as the accelerometers are unable to distinguish between sitting and lying. Therefore, it was necessary to obtain the amount of time spent asleep during each 24-hour period, and to subtract this from the total objectively-measured sedentary time.

To estimate sleep and wake times, the raw accelerometer data were visually scanned to determine the last recorded movement of the evening (sleep time), and the first recorded movement of the morning (wake time). These times were used to calculate the number of minutes slept per night, and an average number of minutes slept per night was created based on the number of valid nights (*M* = 7.18, *SD* = 1.27, range = 3-9). The average number of minutes slept per night was then subtracted from the average number of minutes in sedentary behaviour within the 24-hour period, to establish the average number of minutes spent in each of these two movement behaviours during a 24-hour period for each participant.

2.2.2.3 Obtaining Emotional Well-being Data

The participants completed the short version of the MDI questionnaire, which includes a total of 34 questions asking about demographics, language(s) spoken, emotional well-being, relationships with parents, teachers, other adults in the community and friends, eating habits, sleep habits, and extracurricular activities. The MDI, developed by team lead by Dr. Kim Schonert-Reichl at the University of British Columbia, is a self-report questionnaire completed by children in grades 4 and 7 and has been previously validated for use in school-aged children with strong psychometric reliability and validity (Schonert-Reichl et al., 2013). As stated earlier, this study focused on the questions related to emotional well-being: optimism, general self-concept, sadness (depressive symptoms), and satisfaction with life.

From these 34 questions, data were obtained from the 14 questions relating to emotional well-being: three questions each relating to optimism, general self-concept, and sadness, and five questions relating to satisfaction with life. This composite has been used in previous research by Guhn and colleagues (Guhn et al., 2012); however, the question asking about overall health was omitted from the current study in order to specifically focus on emotional well-being. Each question was a statement, and asked participants to provide an answer on a scale of 1 (disagree a lot) to 5 (agree a lot). Answers to the questions about sadness were reverse-coded, so a high score indicated low sadness. From these scores, a mean score representing total emotional well-being was calculated for each participant (M = 4.33, SD = 0.32, range = 3.36-4.71) and this score was used as the outcome variable in the analyses. Cronbach's alpha was used to assess the internal consistency between all fourteen items. The standardized Cronbach's alpha for these four constructs was 0.57.

2.2.2.4 Obtaining Non-screen Sedentary Behaviour

To obtain a measure of the amount of time the participants spent in screen-based versus non-screen based sedentary activities, the participants completed the STQ questionnaire. The questionnaire asked participants to indicate the amount of time (in minutes) they spent in different activities, including 1) watching/streaming TV, 2) playing computer/video games, 3) sitting listening to music, 4) sitting and talking or texting on the phone, 5) sitting at the computer to do homework, 6) sitting at the computer to send emails or surf the internet, 7) sitting and reading, 8) playing a musical instrument, 9) doing artwork or crafts, and 10) sitting and riding in a car, bus, or train. Participants were asked these questions for three different time-points: in the morning before school, in the afternoon/evening after school, and on the weekends. From these values, minutes spent in each behaviour during weekdays were multiplied by five, and minutes spent in each behaviour on weekends were multiplied by 2, in order to obtain the estimated minutes per week spent in each activity. This technique was used by Rosenberg and colleagues in their validation of the Sedentary Behaviour Questionnaire in adults (Rosenberg et al., 2010a).

Two questions from the STQ were omitted from analysis: question 5 (sitting at the computer to do homework) and question 10 (sitting and riding in a car, bus, or train). The homework question was omitted because sedentary behaviour related to school-work has been shown to be positively associated with physical activity (Feldman, Barnett, Shrier, Rossignol, & Abenhaim, 2003), indicating potential confounding influences. Self-reported time spent riding in a car, bus, or train was removed because self-reported transit-related sedentary behaviour has demonstrated low test-retest reliability in previous research (Hardy, Booth, & Okely, 2007). From these data, two values were calculated: 1) the total self-reported minutes of sedentary time per week, and 2) the total self-reported screen activities per week (from questions 1 and 2 exclusively). These two values were used to create a ratio of time spent in sedentary screen activities to time spent in all sedentary activities (SST ratio), which was used in the analysis of hypothesis 3. Although questions 4 (sitting and talking or texting on the phone) and 6 (sitting at the computer to send emails or surf the internet) may be considered as sedentary screen behaviours, they were not included in the calculation of sedentary screen time for a couple of reasons. Firstly, there was minimal response to these questions, with a maximum of three participants self-reporting any time in these two behaviours, likely a function of the age of the participants. Secondly, both of these sedentary activities include elements of social connection and communication, which may be positively associated with emotional well-being (Best, Manktelow, & Taylor, 2014). A study by Valkenburg and Peter found that online communication was positively associated with closeness of friendships in both adolescents and preadolescents (Valkenburg & Peter, 2007), indicating potential positive social and emotional influences of online communication.

2.3 Data Analysis

All data analysis was completed using R software (R Core Team, 2017), the details of each analysis are included below.

2.3.1 Hypothesis 1

The outcome variable was not normally distributed, and correction for negative skew did not normalize the data. As a result, four Spearman rank correlation tests were performed to examine the independent associations between the four movement behaviours (MVPA, LPA, sedentary time, and sleep) and emotional well-being. Significance was assessed using the false discovery rate (Benjamini, Hochberg, & Benjaminit, 1995).

2.3.2 Hypothesis 2

To examine the relationship between one movement behaviour and emotional well-being relative to the contribution of the other movement behaviours, compositional analysis was performed. Compositional analysis is a relatively new approach that has been used in nutritional epidemiology (Leite, 2016), epidemiology of disease (Mert, Filzmoser, Endel, & Wilbacher, 2016), as well as analysis of the microbiome (Tsilimigras & Fodor, 2016). In addition, this analytical method has recently been used to examine movement behaviours (Dumuid et al., 2017). Essentially, compositional data analysis is a tool that enables researchers to examine variables as components or ratios of a whole, which provides a better understanding of how combinations of multiple variables interact with each other within a finite framework such as a 24-hour period. When examining contributions of individual variables within traditional methods such as multivariate analysis, it is only possible to determine how one variable, in isolation, influences the outcome variable. This becomes an issue when dealing with multicollinear variables, those which contribute to a finite number, such as compositions of a 24-hour day. Movement behaviour patterns are included among these multicollinear variables, as the total time available for these behaviours each day is restricted to a 24-hour period, and therefore time spent in each behaviour inevitably influences time spent in another behaviour. Because of the finite nature of these movement behaviour variables, it is important, and necessary, to examine these behaviours together, as components of a whole. A recent study compared the use of traditional multivariate analysis to the new method of compositional analysis in the examination of the influence of physical activity, sedentary time, and sleep behaviours on adiposity in children. When analyzing the data using the standard regression method, Dumuid and colleagues' study found that the regression estimates were inconsistent across all of the tested models (Dumuid et al., 2017). This is due to the fact that, with the traditional analytical method, four models had to be used, each one excluding a different behaviour (sleep, sedentary time, LPA, or MVPA). These results demonstrated that having to perform analyses on separate models while omitting behaviours may have a significant influence on the interpretation of the relationships between the remaining variables and the outcome variable. When the same variables were analyzed using compositional data analysis, which employed a log-ratio approach to enable all variables to be examined in relation to each other at once, it was found that sleep and MVPA were negatively correlated with BMI, while light physical activity and sedentary behaviour were positively correlated with BMI (Dumuid et al., 2017). These results were not consistently seen across the multiple models used in the traditional multivariate regression method, due to the inability to account for all movement behaviours at one time. For example, the regression coefficients for the influence of sleep and sedentary time on adiposity varied from positive to negative, depending on which model was being used (Dumuid et al., 2017). From this study, it is evident that compositional data analysis is a way to avoid any inconsistency and unreliability in the interpretation of multicollinear data, which may arise from the use of traditional regression methods.

Therefore, for this hypothesis, compositional analysis was used to examine how emotional well-being is associated with a specific movement behaviour, relative to the time spent in all other movement behaviours. Data analysis is approached differently using this technique, as data are transformed from the standard real space to the constrained simplex space (Chastin & Palarea-Albaladejo, 2015). This transformation to a constrained simplex space is to account for the fact that movement behaviour data are inherently collinear: one value will only increase at the expense of another value decreasing, and all data values will add to a whole value (1440 minutes when considering a 24-hour day). Therefore, it is not appropriate to consider each movement behaviour as an independent variable, it is important to view each movement behaviour variable as relative to the others (Chastin & Palarea-Albaladejo, 2015). In order to run a linear regression while accounting for co-dependence and collinearity between the variables, data were transformed using an isometric log-ratio (ilr) transformation. This transformation enables the relative positions of the data points to be conserved from standard real space to the constrained simplex space (Chastin & Palarea-Albaladejo, 2015). These ilr values were then entered into four separate regression models, with age as a covariate. The beta value from the output corresponds to the change in the outcome variable (emotional well-being) when one movement behaviour is increased while the remaining three movement behaviours are decreased in equal proportions in order to maintain the total constant (1440 minutes).

This analysis was performed using R software (R Core Team, 2017), and the code was provided by Dorothea Dumuid at the University of Southern Australia, who has performed this analysis using movement behaviour data (Dumuid et al., 2017).

2.3.3 Hypothesis 3

To examine the moderating influence of sedentary screen time versus non-screen sedentary activities on emotional well-being, the SST ratio, a ratio of self-reported sedentary screen time to total self-reported sedentary time, was created using results from the STQ. A median split method was used to divide participants into two groups: those with a high SST ratio, and those with a low SST ratio. This binary variable was entered into a multiple linear regression model along with the amount of objectively-measured sedentary time as two independent variables and an interaction term, with the emotional well-being score as the dependent variable.

3 Results

3.1 Demographics

Demographic information was collected including age and gender of the child, as well as parental level of education and household income. Descriptive data for movement behaviours was also determined. Descriptive data can be visualized in Table 1. The original sample contained 25 participants; however, three participants did not have valid accelerometer data, and one participant did not complete the MDI. Therefore, the final sample included 21 participants, 6 male (28.6%) and 15 female (71.4%). Mean age of the sample was 9.49 years, with a standard deviation of 0.48 years. The demographics of the sample were highly skewed towards higher household income, with 18 participants (85.7%) being in the highest income category of $130,000 or more in yearly household income. Additionally, the majority of the parents (51.1%) had achieved the highest level of education (University certificate above a Bachelors degree). The average time spent in each movement behaviour within a 24-hour period is listed below in Table 1.

Table 1: Sample Demographics

Demographic		Statistic
Sex (N, %)		
	Male	6, 28.6%
	Female	15, 71.4%
Age (Mean, SD)		9.49, 0.48
Parent Demographics		
Household Income (N, %)		
	\$50,000-\$69,999	1, 4.8%
	\$70,000-\$89,999	0, 0%
	\$90,000-\$109,999	1, 4.8%
	\$110,000,\$129,999	1, 4.8%
	\$130,000 or more	18, 85.7%
Parent Demographics		
Parental Education (N, %)		
	University cert. below Bachelor	1, 4.8%
	Bachelor's degree	8, 38.1%
	University cert. above Bachelor	12, 51.1%
Movement Behaviours in Minutes/Day (Mean, SD)		
	Sleep	609.24, 38.55
	Sedentary Time	693.83, 58.81
	LPA	113.58, 31.01
	MVPA	22.93, 9.35

To determine if significant differences exist between the male and female participants in the sample, an independent samples *t*-test was used. No significant differences between the sexes were found for average time spent in sleep ($p = 0.54$), MVPA ($p = 0.07$), LPA ($p = 0.10$) or Sedentary Time ($p = 0.38$).

3.2 Hypothesis 1

To examine the independent associations between the four movement behaviours (MVPA, LPA, sedentary time, and sleep) and emotional well-being, four Spearman rank correlation tests were performed, and significance was assessed using the false discovery rate (Benjamini et al., 1995). Of the four correlations, only the relationship between MVPA and emotional well-being was significant ($\rho = 0.77$, $p < 0.001$), demonstrating a strong positive correlation between MVPA and emotional well-being.

To address the issue of reliability as determined by the low Cronbach's alpha value, these correlations were performed independently with the four individual constructs of optimism, general self-concept, satisfaction with life, and sadness. A total of 16 spearman rank correlation tests were performed between the four emotional well-being constructs and the four movement behaviours. However, none of these correlations were statistically significant after correction using the false discovery rate (Benjamini et al., 1995).

3.3 Hypothesis 2

To examine the relationship between one movement behaviour and emotional well-being relative to the time spent in the other three movement behaviours, compositional analysis was performed. This analysis transforms the movement behaviour data using an isometric log-ratio transformation, which preserves the relative position of the data points but enables data to be visualized in a constrained simplex space (Chastin & Palarea-Albaladejo, 2015). Through this technique, it is possible to run a linear regression model examining the relationship between one movement behaviour and emotional well-being, relative to the three other movement behaviours. This is because the regression is being performed on the log ratio of one movement behaviour relative to the other three movement behaviours, and the corresponding beta coefficient corresponds to relationship between the outcome (emotional well-being) and one movement behaviour relative to the remaining behaviours.

From the four regression models using the transformed data, none of the beta coefficients were statistically significant, meaning that no one movement behaviour was significantly associated with emotional well-being relative to the other three movement behaviours. Although not statistically significant ($p = 0.15$), the relationship between MVPA and emotional well-being was positive ($\beta = 0.27$), indicating a similar trend as that found using the independent correlations from hypothesis 1.

As with hypothesis 1, compositional analysis was also performed on each of the four emotional well-being constructs independently in order to address the issue of low reliability. Therefore, 16 regression models were run between the four emotional well-being constructs (optimism, general self-concept, satisfaction with life, and sadness), and the four movement behaviours. However, none of the beta coefficients were statistically significant.

3.4 Hypothesis 3

The total self-reported minutes of sedentary time per week and the total self-reported screen activities per week were used to create a ratio of time spent in sedentary screen activities to time spent in all sedentary activities (SST ratio; *M* = 0.33, *SD* = 0.23, range = 0.00 – 0.90).

The multiple linear regression model of the two independent variables (SST ratio and objectively-measured sedentary time) and emotional well-being was not statistically significant ($F(3,17) = 0.77$, $p = 0.53$, $R^2 = 0.12$). From Figure 1, it can be seen that there is a trend towards a negative relationship between objectively-measured sedentary time and emotional well-being, and that this relationship is not moderated by the SST ratio.

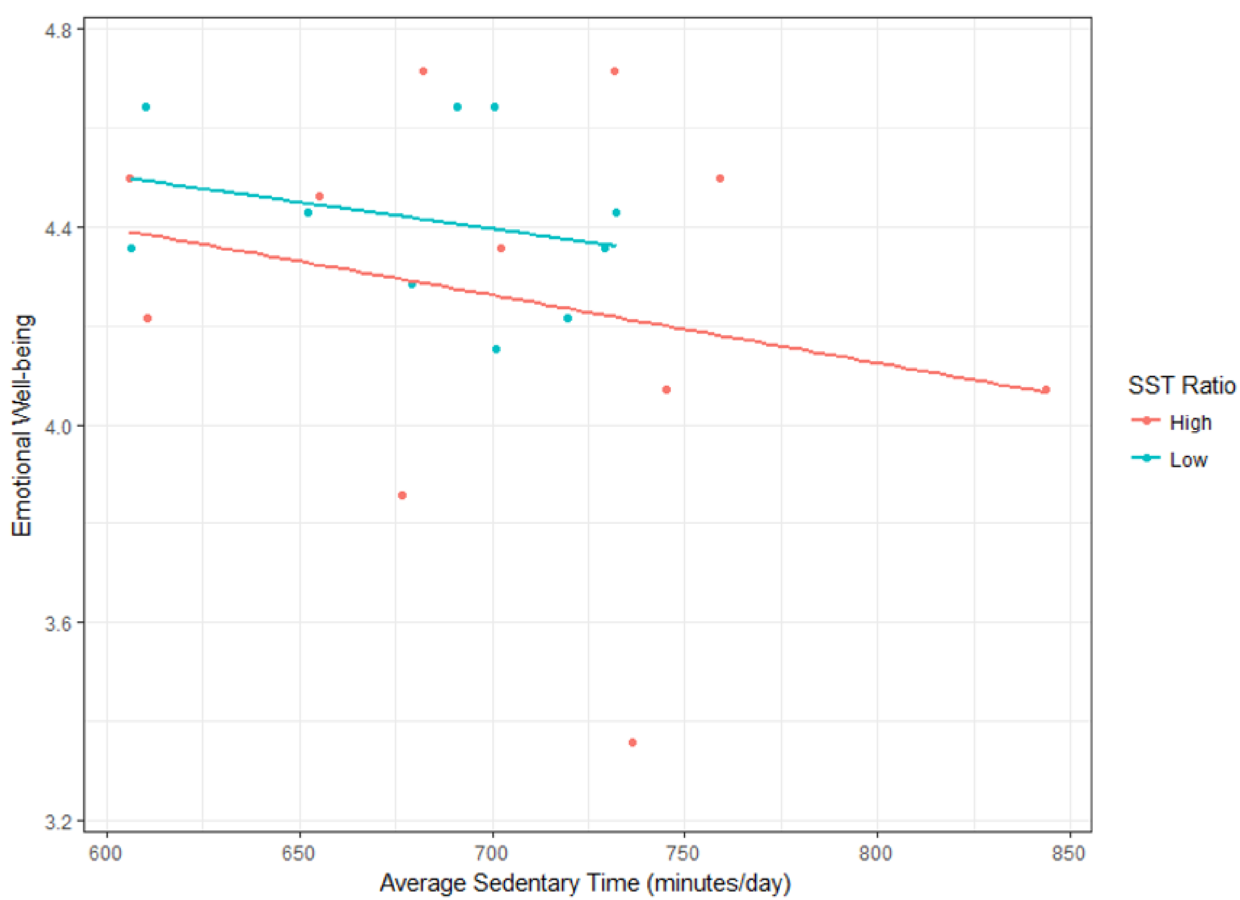

Figure 1. Emotional well-being as a function of average sedentary time and SST ratio.

4 Discussion

To the author's knowledge, this was the first study to use both objective measures of movement behaviours and compositional analysis to examine the relationship between movement behaviours and emotional well-being in children. Although many of the analyses did not produce significant results, there were notable trends in the data, which warrant further discussion.

4.1 Independent Relationships between Movement Behaviours and Emotional Well-being

Based on results from hypothesis 1, only MVPA was found to be significantly and positively associated with emotional well-being. These results support previous research including a meta-analysis of the relationship between physical activity and mental health in children (Ahn & Fedewa, 2011), though these previous findings were not based on objectively-measured physical activity data. Interestingly, very few studies have examined independent associations between objectively-measured MVPA and emotional well-being in children. Much research, especially in younger children, has focused on the relationship between sedentary time and emotional well-being (Hinkley et al., 2014), while the existing studies examining physical activity and emotional well-being have mostly used self-reported measures of physical activity.

A study by Dunton and colleagues used Ecological Momentary Assessment (EMA) to examine the relationship between physical activity and positive and negative affect in children aged 9-13. The EMA technique provided the opportunity to examine immediate relationships between bouts of objectively-measured physical activity, and self-reported positive and negative affect, as the EMA responses were time-matched to accelerometer-derived MVPA. It was found that engaging in more MVPA than usual led to greater positive affect at the subsequent EMA prompt, while children with higher levels of MVPA before the prompt reported lower negative affect compared with children with lower levels of MVPA (Dunton et al., 2014). This finding illustrates how relationships between MVPA and emotional well-being can be visualized acutely. These findings suggest the need for future research to examine independent relationships between objectively-measured movement behaviours, especially MVPA, and emotional well-being in children. These future studies should combine objective measures of movement behaviours with emotional well-being outcomes obtained acutely through EMA and with trait-level questionnaires. Findings from these future studies would help tease apart how momentary shifts in affect occurring after engaging in behaviours such as MVPA, sedentary time, or sleep, are associated with a more global measure of emotional well-being.

Furthermore, although the independent relationships between the other three movement behaviours (LPA, sedentary time, and sleep), were not significant, many previous studies have obtained significant and meaningful results. When examining the relationship between sleep and emotional well-being, a systematic review by Chaput and colleagues found that longer sleep was associated with improved emotional regulation, including stress, anxiety, depression, and mental health (Chaput et al., 2016). Furthermore, a systematic review by Carson and colleagues found that higher levels of sedentary screen behaviour were significantly associated with lower levels of self-esteem in children, an important component of emotional well-being (Carson, Hunter, et al., 2016). However, data for these findings did not use objective measures of sedentary time, and focused instead on self-report screen time. Taking these findings into account, it is reasonable to hypothesize that relationships between the other movement behaviours and emotional well-being may have produced significant results, had the sample size been larger.

4.2 Combinations of Movement Behaviours and their Relationship with Emotional Well-being

The results from the compositional analysis examining the relationship between each movement behaviour, relative to the remaining behaviours, and emotional well-being were not statistically significant. These results can potentially be attributed to a small sample size, as a larger sample would have provided more power for the analysis. Though not statistically significant, the compositional analysis revealed a positive trend between increased time spent in MVPA and emotional well-being. The analysis provides a regression coefficient related to the isometric log ratio of one behaviour (MVPA) relative to the remaining behaviours (LPA, sedentary time, and sleep). This regression coefficient can be interpreted as the change in emotional well-being when MVPA is increased while the three remaining behaviours are decreased in equal proportions. In this manner, the influence of one movement behaviour on the outcome variable is assessed relative to the other movement behaviours. It is through this technique that issues of collinearity between movement behaviour variables are resolved.

As previously mentioned, the compositional analysis approach to examining movement behaviours and various health outcomes in children is relatively new. Only a few studies have used this technique (Carson, Tremblay, et al., 2016; Chastin et al., 2015; Tremblay et al., 2016), and these studies have focused on physical health variables such as obesity risk markers, triglycerides, plasma glucose, and blood pressure, while placing less emphasis on emotional well-being variables. Additionally, both the Chastin (2015) and Carson (2016) papers did not utilize objective measures of sleep, and relied on self-report measures. The current study was able to utilize the accelerometer data to obtain more precise measures of sleep, which was one notable improvement on previous research. However, as stated earlier, a larger sample size is required to obtain more definitive conclusions.

To determine the optimal sample size to obtain significant results using compositional analysis, a post-hoc power analysis using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) was performed using a medium effect size F^2 of 0.15, $\alpha = 0.05$, predictive power $(1 - \beta) = 0.8$ and five predictors (four movement behaviours plus age as a covariate) using a multiple linear regression. The power analysis revealed that a sample size of 92 would be necessary to detect a medium effect size.

4.3 The Moderating Influence of Sedentary Screen Behaviours versus Non-screen Sedentary Behaviours on Emotional Well-being

Based on the findings from hypothesis 3, the ratio of sedentary time spent in screen behaviours versus all sedentary behaviours did not appear to moderate the relationship between sedentary time and emotional well-being.

This was an interesting result, as previous research has found that sedentary screen behaviours are associated with lower emotional well-being (Brindova et al., 2015; Yang et al., 2013), while sedentary pursuits such as art (Sandmire et al., 2012), music (Hietolahti-Ansten & Kalliopuska, 1990), and reading (Carson, Kuzik, et al., 2015), demonstrate positive relationships with certain components of emotional well-being. However, no previous research has specifically examined how the ratio of sedentary screen time to total sedentary time is associated with emotional well-being.

There are many possible explanations as to why the results were inconclusive. Firstly, these results could simply be attributed to an insufficient sample size. Secondly, one interesting finding was that participants in the low SST ratio group (those who spent less of their total sedentary time in front of a screen, i.e. lower half of median split SST variable), also demonstrated shorter objectively-measured sedentary time in comparison to those in the high SST ratio group (i.e. top half of median split SST variable); however, the difference between these two groups was not statistically significant. Nevertheless, this may be another contributing factor as to why the SST ratio did not appear to moderate the relationship between sedentary time and emotional well-being. Therefore, it is unclear whether or not the SST ratio has a moderating influence on the relationship between sedentary time and emotional well-being, or whether these results can be attributed to the imbalance in objectively-measured sedentary time between these two groups. From this, it can be cautiously interpreted that, although spending more time in sedentary behaviours may be associated with lower emotional well-being, the specific type of sedentary behaviour (sedentary screen time versus non-screen sedentary time), may not be an important moderator of this relationship. However, a larger sample size would be needed to fully elucidate this statement.

Finally, it is possible that better, more sensitive methods of obtaining these data exist. The STQ questionnaire was originally developed to obtain information about sedentary behaviours through self-report (Rosenberg et al., 2010b); however, it was not validated for the specific purposes of this research question. Therefore, it may be beneficial to develop a new measurement tool to serve this purpose. This tool could include a more exhaustive self-report questionnaire, or a sedentary behaviour diary to be completed on a daily basis by participants.

As previously stated, though much research has examined the relationships between sedentary time and emotional well-being, the majority of this research has focused on sedentary screen time, or failed to distinguish between different types of sedentary behaviours. Though no studies to date have examined how different types of sedentary activities are associated with emotional well-being, a doctoral dissertation by Sweiss examined how combinations of structured programs and free-time activities in grade four children were related to positive youth development (Sweiss, 2014). Although this study looked at both sedentary and physical activity behaviours, it focused on how different types of activities may have different relationships with emotional well-being in children, as it categorized activities as either structured programs or free-time activities. Cluster analysis revealed two distinct profile groups based on whether the children participated in structured programs such as educational lessons, art/music lessons, and sports, or free-time activities such as exercising for fun, watching TV, playing on the computer, reading for fun, and arts and crafts. It was found that children clustered into a group who spent most of their time in free-time activities like watching TV, playing video/computer games, and reading for fun demonstrated significantly lower general self-concept and prosocial behaviour (Sweiss, 2014) compared to those clustered into a group who spent most of their time in structured activities. These findings, although examining slightly different concepts than this current project, are noteworthy, as they demonstrate that the way in which children spend their time, both sedentary and while physically-active, is associated with their emotional well-being.

Furthermore, the way in which different sedentary behaviours are categorized, and whether those behaviours are classified as beneficial or detrimental to health outcomes in children, should be considered. As the majority of research examining sedentary behaviour in children has focused on self-reported sedentary screen time, the scope of past research has been effectively narrowed to one specific type of sedentary behaviour. It is important to acknowledge that time spent sedentary does not necessarily mean time spent in front of a screen. Additionally, it is equally important to consider whether all sedentary screen activities should be considered as negative or detrimental to health outcomes. A recent policy report on families and screen time acknowledged that, in the past, families were told to pay most attention to the amount of time children spent in front of a screen in order to prevent the detrimental effects of excessive sedentary screen time. However, the report discussed how the focus on simply the *quantity* of screen time may not be sufficient, and that it may be more important to focus on *quality* of screen time (Blum-Ross & Livingstone, 2016). The report emphasized the importance of context, content, and connections when considering sedentary screen time. This is noteworthy, as the influence of screen media on the consumer varies widely, depending on the content of the media, the context in which the media is being consumed (in the company of others versus in isolation, for example), and the potential connections and relationships being created through the use of this media (Blum-Ross & Livingstone, 2016). Therefore, it is important to recognize that the dichotomization of sedentary behaviours as inherently beneficial (non-screen activities) or detrimental (screen-based activities) may not be as straightforward as previously believed. Further investigation into the specific influences of different types of sedentary behaviour are necessary, perhaps through qualitative analysis, to obtain a more thorough understanding of the full spectrum of sedentary activities and their relationship with emotional outcomes in children.

Although no studies to date have addressed how different types of sedentary activities are associated with emotional outcomes in children, a few have examined how various sedentary behaviours are associated with physical activity in adolescents. In a study of Canadian adolescents, it was found that, although television viewing was significantly associated with a lack of physical activity for both males and females, sex-based differences were found in other types of sedentary behaviours: males who spent time on the computer were still more likely to be active than those who did not use the computer, while among the females, reading was associated with physical activity (Koezuka et al., 2006). Furthermore, another study examined whether a relationship existed between time spent in physical activity and other sedentary pursuits. Interestingly, this study dichotomized sedentary behaviours into “productive” behaviours, which included working on a computer, reading, or doing homework, and “leisure” behaviours, which included watching television or playing video games. It was found that increased time spent in "productive" sedentary behaviours was associated with increased physical activity, while time spent in "leisure" sedentary behaviours was not associated with physical activity (Feldman et al., 2003). Studies such as these demonstrate how, once different types of sedentary behaviours are taken into account, relationships between these behaviours and physical activity differ. These findings further emphasize the need for future research aiming to elucidate the relationship between different types of sedentary behaviours and emotional well-being in children.

4.4. Potential Mechanisms

Though this study examined the relationship between movement behaviours and emotional well-being in children, it did not address the multitude of potential mechanisms that may drive the relationship between movement behaviours, especially physical activity, and emotional well-being in children. These potential mechanisms will be addressed in the following section.

4.4.1 Neurotransmitters and Neurotrophic Factors

When considering the potential mechanisms through which movement behaviours, more specifically physical activity, are associated with emotional well-being, neurotransmitters such as serotonin, and neurotrophic factors such as brain-derived neurotrophic factor, must be considered.

4.4.1.1 Serotonin

Serotonin is a neurotransmitter that has been implicated in many mental health conditions including major depressive disorder, mood disorders, anxiety disorders, and schizophrenia (Lin, Lee, & Yang, 2014). It is important to note that it is not only the amount of serotonin present that influences mental well-being, but also the quantity and function of serotonin receptors and transporters. The issue of serotonin imbalance in the brain has become the basis for the pharmacological family of selective-serotonin reuptake inhibitors (SSRIs), which is a family of medications that serve to prevent the re-uptake of serotonin in the synaptic cleft, ultimately resulting in an increased level of serotonin in the brain. As the therapeutic benefits of

SSRIs on depression and anxiety are now documented (Blier & de Montigny, 1994; Popovic, Vieta, Fornaro, & Perugi, 2015), conclusions can be drawn as to the serotonin-related pathology of mood disorders.

Examining the potential mechanistic role of serotonin in the relationship between physical activity and mental well-being, a study by Wipfli and colleagues carried out a prospective, randomized, 7-week exercise intervention in which participants were randomized to an aerobic exercise group or a stretching-control group. Measures of depression and anxiety were obtained, and blood was collected pre- and post-test to assess serum serotonin levels. It was found that, post intervention, the exercise group demonstrated lower levels of depression in addition to a larger percentage decrease in serum serotonin in comparison with the control group (Wipfli, Landers, Nagoshi, & Ringenbach, 2011). Additionally, it was found that the percent change in serum serotonin partially mediated the relationship between physical activity and depression (Wipfli et al., 2011), further emphasizing the role of serotonin in the relationship between physical activity and emotional well-being.

Additionally, it is now understood that genetic variation in the serotonin transporter gene exists, resulting in certain individuals having a greater predisposition for specific mood disorders. This variation exists within the 5-HTTLPR polymorphic region of the serotonin transporter gene, and individuals have either the short variant or the long variant. The short variant of this polymorphism reduces the efficiency of the gene promoter, resulting in decreased transporter expression and ultimately leading to a reduced uptake of serotonin. This short variant is also associated with anxiety and depression (Lesch et al., 1996), increased waking cortisol levels (O'Hara et al., 2007), as well as an increased reactivity to stress in females (Gotlib, Joormann, Minor, & Hallmayer, 2008). Therefore, the short variant of the 5-HTTLPR region has become an important component in the study of the relationship between specific genetic polymorphisms and emotional well-being. However, mixed and inconsistent findings exist within these relationships, leading to the hypothesis that 5-HTTLPR genotype may be an important predisposing factor to environmental sensitivity (Obradović & Boyce, 2009), along with other potential moderating factors. This theory has led to the hypothesis that physical activity may be one of the factors moderating the relationship between 5-HTTLPR genotype and psychological outcomes. To examine this hypothesis, Rethorst and colleagues performed a study in a sample of 170 participants aged 18-23. They obtained 5-HTTLPR genotype information through a saliva sample, measured physical activity levels through a self-report questionnaire, and assessed depression symptoms using the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Interestingly, their analysis revealed a significant interaction between 5-HTTLPR genotype and physical activity: individuals with at least one short allele (therefore at an increased risk for anxiety and depression) who also demonstrated low levels of physical activity had significantly higher levels of depressive symptoms compared to individuals without the short allele (Rethorst, Landers, Nagoshi, & Ross, 2011). This finding supported the potential moderating influence of physical activity on the relationship between 5-HTTLPR genotype and psychological distress. Therefore, the 5-HTTLPR polymorphism is another important component in serotonin's potential mechanistic role in the relationship between physical activity and emotional well-being.

4.4.1.2 Brain-derived Neurotrophic Factor

Brain-derived neurotrophic factor (BDNF) is a protein encoded by the BDNF gene, and exerts its effects on both the central and peripheral nervous system (Binder & Scharfman, 2004). This protein has been found to enhance neurogenesis, and plays an important role in synaptic plasticity, learning, and memory (Binder & Scharfman, 2004). Furthermore, BDNF signaling has been associated with the regulation of neurogenesis in adults (Lu & Chang, 2004). An association between BDNF and mental well-being has also been substantiated: decreased levels of hippocampal BDNF were found in rats experiencing various stressors including immobilization stress (Smith, Makino, Kvetnansky, & Post, 1995) and maternal deprivation (Roceri, Hendriks, Racagni, Ellenbroek, & Riva, 2002), while individuals receiving antidepressant medication at the time of death demonstrated higher levels of hippocampal BDNF expression compared with untreated subjects with MDD (Chen, Dowlatshahi, MacQueen, Wang, & Young, 2001). These findings implicate the role of BDNF levels in psychological well-being, as psychological stressors appear to lower BDNF levels, while SSRI treatments appear to increase BDNF levels. The relationship between serum BDNF levels and depression was further demonstrated by Shimizu and colleagues, who found that serum BDNF was significantly lower in individuals with major depressive disorder (MDD) who were not on medication in comparison to antidepressant-treated individuals with MDD and in comparison to control participants (Shimizu et al., 2003). Additionally, there was a significant negative correlation between serum BDNF levels and depressive scores in all individuals (Shimizu et al., 2003), further substantiating the association between serum BDNF levels and mood. With the relationship between serum BDNF and mood well-established, this protein has been implicated as a potential mechanism in the relationship between physical activity and mental health, as exercise serves to increase serum BDNF levels in adults (Szuhany, Bugatti, & Otto, 2015; Zoladz et al., 2008). Therefore, it is reasonable to hypothesize that exercise-induced increases in BDNF may be a reasonable mechanistic explanation for increased emotional well-being in active individuals.

There are also certain genetic predispositions within the BDNF protein complex that have provided further elucidation on the role of BDNF in the relationship between physical activity and emotional well-being. As stated earlier, it is now understood that physical activity serves to increase the expression of BDNF (Cotman & Engesser-Cesar, 2002), which provides many neurological benefits including increased synaptic activity. In a study examining whether the BDNF gene interacts with physical activity to predict depressive symptoms in adolescent girls, participants were genotyped to distinguish between those who had the BDNF val66met polymorphism and those who did not. Individuals with this polymorphism demonstrate a lower expression of BDNF, and are therefore at a greater risk for Major Depressive Disorder (Karege et al., 2002). Using questionnaires to determine their depressive symptoms and physical activity levels, it was found that the BDNF polymorphism moderated the relationship between physical activity and depressive symptoms (Mata, Thompson, & Gotlib, 2010). Of the adolescent girls who had the polymorphism predisposing them to depressive symptoms, those who reported higher levels of physical activity had lower levels of depressive symptoms that those with the polymorphism with low levels of activity. This moderating influence was not found in the participants who did not have the BDNF polymorphism, indicating that genotype plays a role in determining how, and if, BDNF serves to moderate the relationship between physical activity and depressive symptoms in adolescent girls. This study chose to focus their examination on adolescent girls because it's been established that females experience depression at a higher rate compared with males (Albert, 2015), while many mental disorders present themselves during the critical period of adolescence (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003), making adolescent females an especially vulnerable population. However, it would be interesting to examine whether this relationship also exists in adolescent males.

4.4.2 Brain Structure

Looking at the relationship between physical activity and brain structure, a review by Chaddock and colleagues found that childhood aerobic fitness is associated with differences in brain structure and function. Specifically, fitness-related differences in basal ganglia volumes exist in preadolescent children, while lower-fit children also demonstrated decreased bilateral hippocampal volume (Chaddock, Pontifex, Hillman, & Kramer, 2011). Although the basal ganglia region has not been associated with emotional health in children, alterations in hippocampal volume have been associated with a higher risk of depression (Carballedo et al., 2012). Furthermore, research in mice has demonstrated differences in hippocampal activation in runner mice versus sedentary mice after a cold water stressor: the runner mice did not demonstrate the same stress-induced increase in protein expression and granule cells in comparison to the sedentary mice (Schoenfeld, Rada, Pieruzzini, Hsueh, & Gould, 2013). Additionally, it was found that the runner mice demonstrated decreases in anxiety-like behaviour (Schoenfeld et al., 2013), further emphasizing the role of aerobic exercise in both hippocampal structure and emotional well-being. Therefore, it can be hypothesized that exercise-induced alterations in brain structure and function may serve as another mechanism within the relationship between physical activity and emotional well-being.

4.4.3 Peripheral Influences

In addition to changes in brain chemistry and function, it is important to acknowledge how peripheral changes induced by physical activity, such as the release of endorphins and anti-inflammatory compounds, may also serve as mechanisms in the relationship between physical activity and emotional well-being.

Elevated inflammation has been implicated in mood disorders such as anxiety (Kiecolt-Glaser, Belury, Andridge, Malarkey, & Glaser, 2011), major depression and bipolar disorder (Rosenblat, Cha, Mansur, & McIntyre, 2014), demonstrating a potential relationship between systemic inflammation and emotional well-being. Interestingly, one of the many benefits of physical activity includes the release of many anti-inflammatory compounds including interleukin-6 from muscles (Papanicolaou et al., 1996; Pedersen, Steensberg, & Schjerling, 2001). Additionally, indirect anti-inflammatory effects of habitual physical activity include a reduction in visceral fat mass, resulting in a subsequent decrease in the release of inflammatory adipokines (Gleeson et al., 2011). Consequently, it has been hypothesized that these physiological changes may also serve to influence mood. Therefore, with the understanding that mood disorders have been associated with elevated levels of inflammation, that physical activity lowers inflammation, and that physical activity is associated with elevated mood (Kanning & Schlicht, 2010; Penedo & Dahn, 2005), it is reasonable to hypothesize that the anti-inflammatory effect of exercise may serve as a mechanism through which physical activity influences emotional well-being.

Additionally, plasma endorphins, specifically β-endorphins, have been implicated as a potential mechanism within the relationship between physical activity and emotional well-being. In a study examining the plasma β-endorphin response to exercise in pre-pubertal and pubertal children, it was found that exercise resulted in a significant increase in β-endorphin (Bouix et al., 1994). From this, it is reasonable to hypothesize that β-endorphin levels may also serve as a potential mechanism between physical activity and emotional well-being, as increased levels of β-endorphins have been associated with mood-related benefits (Dinas, Koutedakis, & Flouris, 2011).

4.4.4 Bolstering Resiliency

4.4.4.1 The Hypothalamic Pituitary Adrenal Axis

In addition to examining specific molecular mechanisms including neurotransmitters, neurotrophic factors, and endorphins, it is important to consider how the relationship between physical activity and emotional well-being may be explained by a larger, system-wide adaptation. One such system within the body that has been shown to both influence emotional well-being and be influenced by physical activity is the hypothalamic pituitary adrenal (HPA) axis.

The HPA axis, a major neuroendocrine system involved in the physiological stress response, is responsible for the release of many hormones including cortisol, a glucocorticoid hormone (Stephens & Wand, 2012). Cortisol has many roles in the body upon its release, including increasing blood glucose levels, modifying fat and protein metabolism, decreasing immune responses such as inflammation, and increasing blood pressure (Stephens & Wand, 2012). All of these responses are associated with sympathetic nervous system activation, which functions to prepare the body to deal with a physiological stressor or threat. Although the release of glucocorticoid hormones such as cortisol can be helpful in dealing with acute incidents of physiological stress, chronic glucocorticoid exposure through prolonged HPA axis activation can lead to negative health consequences including obesity and dendritic atrophy in hippocampal neurons (Raber, 1998). This is especially important when considering that the body has similar reactions to physiological stressors and psychosocial stressors, leaving individuals at risk for chronic HPA axis activation when exposed to long-term or repeated psychosocial stressors. An ideal response of the HPA axis is acute, with feedback mechanisms that terminate the response after the stressor has subsided; however, in cases of chronic stress, these feedback mechanisms may start to lose their sensitivity, and dysregulation may occur (Herman et al., 2016). The association between elevated cortisol and chronic stress is well-established in adults (Miller, Chen, & Zhou, 2007; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000). This is even true of children: higher parenting stress and greater socio-emotional difficulties has been associated with increased hair cortisol in a sample of 1-year old children (Palmer et al., 2013).

Furthermore, dysregulation of HPA axis reactivity has been implicated in MDD (Jarcho, Slavich, Tylova-Stein, Wolkowitz, & Burke, 2013; Stetler & Miller, 2011; Vreeburg et al., 2009). A meta-analysis by Burke and colleagues found that depressed individuals demonstrated a blunted cortisol reactivity profile to acute stressors and an impaired cortisol recovery after a stress response (Burke, Davis, Otte, & Mohr, 2005).

Though more prospective studies are necessary to determine causality between altered HPA axis function and the onset of depressive symptoms, the fluctuating relationship between the HPA axis and depressive symptoms is evident: it has been found that MDD patients demonstrate erratic patterns of cortisol secretion throughout the day, evidenced by significantly lower sample-to-sample autocorrelation compared to controls. Additionally, these unstable patterns in cortisol output over successive measures become even more pronounced with illness severity or recurrence (Peeters, Nicolson, & Berkhof, 2004). Furthermore, a meta-analysis by Nelson and Davis found that patients with psychotic depression frequently demonstrate unsuppressed cortisol responses to a dexamethasone suppression test in comparison to patients with nonpsychotic depression (Nelson & Davis, 1997), indicating that the negative feedback loop within the HPA axis may be dysregulated in these individuals. Finally, a study by Essex and colleagues followed children from infancy into adolescence to examine the relationship between early life stressors (i.e. maternal and paternal depressive symptoms and family expressed anger), HPA axis activity, and alterations in their mental health symptoms. It was found that specific early life stressors influenced the covariation between epoch-specific cortisol output and children's concurrent mental health symptoms (Essex et al., 2011). For example, children exposed to maternal depression demonstrated increases in morning cortisol levels and steeper cortisol slopes while they were experiencing increased mental health symptom severity; however, when their mental health symptoms were less severe, they demonstrated decreased morning cortisol levels and flatter cortisol slopes (Essex et al., 2011). Therefore, it has been hypothesized that HPA axis dysregulation as a consequence of early life trauma may be the early manifestation that predisposes an individual to depression (Pariante & Lightman, 2008), pointing to a potential directional relationship between HPA axis dysregulation and emotional health outcomes.

The role of physical activity in mitigating the negative effects of HPA axis dysregulation has been studied as well (Duclos & Tabarin, 2016; Wittert, Livesey, Espiner, & Donald, 1996). The relationship between physical activity and HPA axis activity in response to psychosocial stressors was recently demonstrated in a cross-sectional study in a sample of 258 children aged eight years. Physical activity levels were assessed using wrist-worn accelerometers, and overall time spent in physical activity and percentage of time spent in vigorous physical activity was categorized by sex into thirds. The participants were then exposed to a psychosocial stressor in the form of the Trier Social Stress Test for Children, and saliva samples were collected at baseline and various time-points after the stressor to obtain cortisol output. It was found that the children with the highest levels of overall physical activity or vigorous physical activity showed no, or very small, increases in salivary cortisol after the stressor, whereas the children with the lowest and intermediate physical activity levels demonstrated significant increases in salivary cortisol over time after the stressor (Martikainen et al., 2013). Furthermore, this relationship was not moderated by sex. Cortisol spiking after a psychosocial stressor is referred to as high HPA axis reactivity, in which the system responds with a large surge of stress hormones upon the presentation of a stressor. Therefore, having a lower cortisol output after a stressor is an indication of lower HPA axis reactivity.

It has been hypothesized that individuals who undergo regular exercise training also demonstrate lower reactivity to psychosocial stressors, indicating an adaptation of the neuroendocrine system to both physical stress (in the form of physical activity), and psychosocial stress (Hackney, 2006). This was the first study to demonstrate the association between objectively-measured physical activity levels and HPA axis reactivity in children. The implications of this study include the consideration of physical activity as a moderator or protective factor of the HPA axis response to psychosocial stress, which may serve as one explanatory mechanism for the relationship between higher levels of physical activity and improved emotional well-being in children.

4.4.4.2 Physical Activity and Affective Responses to Stressors

In addition to focusing on the relationship between physical activity and HPA axis reactivity, research has broadened its scope to examine the relationship between physical activity and negative affect, which is defined as a general measurement of subjective distress that includes a variety of mood states such as anger, contempt, disgust, guilt, fear, and nervousness (Watson, Clark, & Tellegen, 1988). As longitudinal studies have demonstrated that exercising on a regular basis may protect against the onset of depression or the recurrence of depressive symptoms (Teychenne, Ball, & Salmon, 2008), research has begun to explore the direct effects of physical activity on negative affect. In a study by Bernstein and McNally, participants completed one of three lab-based activities: cycling (aerobic exercise condition), stretching (active control condition), or resting (inactive control condition). These activities were followed by an experimental stressor, and the researchers obtained self-reported rumination after the stressor in addition to recording positive and negative emotions throughout the study. It was found that, although participants who ruminated more following the stressor reported more negative emotions than those who ruminated less, this effect was moderated by exercise: those who completed the aerobic exercise prior to the stressor did not show this rumination-associated negative affect increase (Bernstein & McNally, 2017). This study demonstrated the potential buffering role of physical activity, in that it may serve to mitigate the negative emotions following a stressor, therefore increasing emotional resiliency in active individuals. Findings from this study are consistent with findings from a naturalistic study by Puterman and colleagues (2017). Puterman and colleagues examined whether daily physical activity served to mitigate the negative affect that occurs on days where adults reported experiencing daily stressors such as arguments with others, stressors at work/school, discrimination, or stressors at home. This study focused on negative affective reactivity, which corresponds to changes in negative affect on stressor days compared to days free of stressors. The results of this study were twofold: firstly, it was found that individuals who attained recommended physical activity levels demonstrated significantly attenuated affective reactivity. Secondly, regardless of habitual physical activity levels, individuals who were physically active on a stressor day demonstrated significantly lower affective reactivity in comparison to those who were inactive (Puterman, Weiss, Beauchamp, Mogle, & Almeida, 2017). Together, these studies demonstrate the capacity for physical activity to mitigate negative affective reactivity to stressors, an important finding since negative affective reactivity has been associated with psychological problems measured ten years later (Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013). Therefore, when considering the relationship between physical activity and emotional well-being, the role of physical activity in mitigating negative affective responses to stressors may serve as one potential mechanism.

4.5 Limitations

Despite the strengths of this study including objectively-measured movement data and a validated measure of emotional well-being, there are several limitations to be noted.

The first and most important limitation is the small sample size. Due to the small sample size, many of the analyses were not sufficiently powered. This is especially true of the compositional analysis, which would have most likely produced more meaningful results given a larger sample size.

The cross-sectional nature of this study is a second limitation, which means that results can only be interpreted as correlations, and no causation or directionality may be implied. This study is unable to determine whether movement behaviours, namely MVPA in this study, affect emotional well-being, or if emotional well-being is what dictates MVPA in children.

An additional limitation of the study is the scope of the outcome variable: emotional well-being. Due to concern over participant burden, the participants completed the short version of the MDI, which contained questions related only to emotional well-being, and omitted questions related to social well-being. The majority of research within this domain has focused on the construct of social and emotional well-being in its entirety, as these two components are considered interrelated. Using the full version of the MDI, which contains three additional constructs (empathy, prosocial behaviours, and worries), would have provided a more holistic outcome of social and emotional well-being.

Furthermore, the emotional well-being data within the sample were negatively skewed, with the majority of the participants reporting high levels of emotional well-being. These findings are in line with previous research using the Middle Years Development Instrument in the Vancouver School District: the majority of children were considered as “thriving” in multiple measures from the social and emotional well-being assessment including optimism, self-esteem, happiness, and absence of sadness (MDI, 2014). Furthermore, children assessed in grade four reported higher levels of emotional well-being in comparison to children assessed in grade seven (Schonert-Reichl, 2011). Additionally, previous studies have found that boys tend to report lower optimism, general self-concept, and satisfaction with life than girls (Schonert-Reichl, 2011). Therefore, the combination of the participants in the current study being 1) primarily within the Vancouver School District, 2) younger in age (grades four and five), and 3) mostly female (71%), may have contributed to higher emotional well-being scores. These high emotional well-being scores resulted in a restricted range of the outcome variable, meaning that the observed data from the sample were not spread out across the entire range of interest. The most important consequence of restricted range within data is that correlations may be reduced (Bland & Altman, 2011), resulting in an increased risk of non-significant findings. Therefore, the restricted range of the outcome variable is another limitation within this study, as it may have contributed towards non-significant findings.

Cronbach’s alpha was used to assess the internal consistency between the four emotional well-being constructs, as the combination of these four constructs into a measure of emotional well-being was a relatively novel approach. The standardized Cronbach’s alpha for these four constructs (a total of 14 questions) was 0.57, which is considered poor. Therefore, it is possible that the results of the analyses were not significant due to the lack of reliability between the four constructs within the composite of emotional well-being. To address this issue, independent correlations and compositional analyses were run between all four movement behaviours and all four constructs (optimism, satisfaction with life, general self-concept, and sadness). However, none of the correlations or compositional analyses were statistically significant. As previously stated, this composite was used by Guhn and colleagues (Guhn et al., 2012) in a study examining well-being in middle childhood, with the addition of a question asking participants to rate their overall health. However, in Guhn and colleagues' study, which had a sample size of over 3,000 participants, scores in each of the five constructs (satisfaction with life, optimism, general self-concept, sadness, and overall health) were used to assign a child to one of three categories: low, medium, or high well-being. This categorization was not possible with the current data set, due to the small sample size as well as the skewness of the data, which prevented an evenly-distributed number of participants into each category.

A final limitation of the study can be attributed to the method through which the SST ratio was calculated. Although there has been plenty of research examining the relationship between sedentary behaviour and multiple well-being outcomes in children, very little research has ventured to examine how different types of sedentary pursuits influence variables such as emotional well-being. Furthermore, although attention has been placed on the specific influence of sedentary screen behaviours, research examining the potential moderating influence of other non-screen sedentary behaviours is currently lacking. Therefore, the use of the SST ratio as a moderating variable in the relationship between sedentary time and emotional well-being was a novel approach. However, it is possible that improvements can be made on the calculation of this ratio. Interestingly, a recent systematic review examining the measurement properties of self-report sedentary behaviour questionnaires in children and adolescents found that none of the questionnaires included were considered as both valid and reliable (Hidding, Altenburg, Mokkink, Terwee, & Chinapaw, 2017). It was recommended that future studies should focus on construct validity, reliability, measurement error, and responsiveness of the questionnaires in order to determine the best methods for obtaining sedentary behaviour data (Hidding et al., 2017). Studies such as these demonstrate that many methodological limitations currently exist with respect to the measurement of sedentary behaviour in children. This is especially true when separating sedentary screen time from non-screen sedentary time, as no tool currently exists.

4.5.1 Future Directions

To address these limitations, future studies should be performed using a larger sample size, as a post-hoc power analysis for the compositional analytical technique indicated that a sample size of 92 would be necessary to obtain meaningful results.

Furthermore, while this project examined components of emotional well-being including optimism, empathy, satisfaction with life, and sadness, other components such as prosocial behaviour, empathy, and worries were not examined due to concern of participant burden. Including these three components would complete the construct of social and emotional well-being, which is a holistic measure of a child's ability to manage a full range of positive and negative emotions and develop healthy relationships with others (Cohen et al., 2005). When looking at psychosocial health outcomes in children, most research has focused on both social and emotional well-being as a holistic construct (Green, Howes, Waters, Maher, & Oberklaid, 2005; Oberle et al., 2014; Schonert-Reichl et al., 2015; Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2012). Therefore, in order to add to previous literature on social and emotional well-being in children, future studies should utilize the full version of the MDI, which contains questions relating to both social and emotional well-being variables.

To address the homogeneity in emotional well-being, as the data were negatively-skewed, it would be of benefit to recruit a more diverse sample of participants. Ideally, this would be a large enough sample to include children across the spectrum of emotional well-being, in addition to children with diverse socio-economic, geographic, and cultural backgrounds. Previous research using the Middle Years Development Instrument in grade four children has found that emotional well-being differs across neighborhoods (MDI, 2014), therefore it would be valuable to expand participation across the Lower Mainland. Obtaining this diversity would result in a more heterogeneous sample, and ensure that the emotional well-being data are normally-distributed. This would allow for more confident interpretations of the data, in addition to greater external validity. Furthermore, it would also provide the opportunity to place participants into categories of low, medium, or high emotional well-being, as performed by Guhn and colleagues in a previous study exploring the relationships between a composite of child well-being and social and contextual assets (Guhn et al., 2012).

Additionally, it would be of value to develop a new measurement tool to better assess the ratio of time spent in sedentary screen versus non-screen behaviours. As previously discussed, the STQ was developed for the purposes of assessing self-reported sedentary time; however, it was not developed to distinguish between different types of screen-based and non-screen based activities. Although there has been much research examining the relationship between screen time and emotional well-being in children, this study was the first to examine whether different types of sedentary pursuits may moderate the relationship between sedentary time and emotional well-being. A more detailed questionnaire, or perhaps a sedentary behaviour diary to be completed on a daily basis by participants, may be a helpful tool in fully addressing this research question.

Conclusion

This study built on previous research examining the relationship between movement behaviours and emotional well-being. New contributions from this project included the addition of objectively-measured sleep, while also utilizing compositional analysis to examine how one movement behaviour, relative to others, is associated with emotional well-being. Though compositional analysis has been used in the investigation of the relationships between movement behaviours and physical health outcomes, very little research has used this technique in the context of emotional well-being. Despite a small sample size, this study found a significant correlation between MVPA and emotional well-being, demonstrating a robust relationship worthy of further investigation; however, no significant associations were found using compositional analysis, which was most likely due to the aforementioned small sample size. Should these effects prove robust with a larger sample, these findings add to the growing call to develop community and school wide activity-based interventions in children and adolescents to support emotional well-being and health (Beauchamp, Puterman, & Lubans, 2018; Strong et al., 2005).

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Appendices

Appendix A – Demographics Questionnaire

OMiCS Demographic Questionnaire

We ask that the parent or guardian who is primarily responsible for the child participating in the OMiCS study to complete the following questionnaire. For your reference, in questions that refer to "you" or "your", the question is asking for an answer from you, the parent or guardian.

1. Please enter your study number: ______________________

2. Please enter your age in years: _____

3. How do you identify (check all that apply):
   - ☐ Male
   - ☐ Female
   - ☐ Trans
   - ☐ Other __________

4. Please select your relationship to your child:
   - ☐ Parent
   - ☐ Step-parent
   - ☐ Foster Parent
   - ☐ Legal Guardian
   - ☐ Grandparent
   - ☐ Other

5. Please enter your child's month and year of birth (MM/YY): __/__

6. How does your child identify? (Check all that apply):
   - ☐ Male
   - ☐ Female
   - ☐ Trans
   - ☐ Other __________

7. Please enter only the first three letters/number of your postal code (or the postal code at which your child lives the majority of his or her time): __ __ __

8. How would you describe your ethnicity (check all that apply)?*

☐ Caucasian	☐ South American	☐ Asian
☐ First Nations	☐ Arab	☐ Métis
☐ African American	☐ Inuk (Inuit)	☐ Other ____________________

9. How would you describe your child's ethnicity (check all that apply)?*

☐ Caucasian	☐ South American	☐ Asian
☐ First Nations	☐ Arab	☐ Métis
☐ African American	☐ Inuk (Inuit)	☐ Other ____________________

10. Were you born in Canada?
    Yes No

10.a. (If No to Q10) In what year did you move to Canada?
____

11. Including you, how many people are currently living in your household, including yourself?

☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7+

12. How would you describe your level of education?

☐ Less than high school diploma or its equivalent
☐ High school diploma or a high school equivalency certificate
☐ Trade certificate or diploma
☐ College, CEGEP or other non-university certificate or diploma (other than trade certificate/diploma)
☐ University certificate or diploma below the bachelor's level
☐ Bachelor's degree (e.g. B.A., B.Sc., LL.B.)
☐ University certificate, diploma or degree above the bachelor's level

13. What is your approximate yearly **household** income?

☐ Less than $29,999
☐ $30,000-$49,999
☐ $50,000-$69,999
☐ $70,000-$89,999
☐ $90,000-$109,999
☐ $110,000-$129,999
☐ $130,000 or more
☐ Prefer not to answer

Providing information on your race, ethnic origin, or salary is voluntary.

Appendix B – MDI Questionnaire

[LABEL]

UNDERSTANDING OUR LIVES

MIDDLE YEARS DEVELOPMENT INSTRUMENT
Survey of Grade 4 students
2014-2015

We would like to learn more about the lives of elementary school children in Canada, and the best way to do that is to ask YOU about your life in school and outside of school. It has been a long time since we were your age, so we need you to be our "teachers", so that we can learn more about the lives of children today. To learn about children your age, we would like to ask you some questions about how you think and feel about things in your life and about what you like to do.

Here are some things to know before getting started:

1. This is **not a test!** There are **no right or wrong answers**. Some people think or feel one thing and other people think or feel something else. We want to know what *you* think and how *you* feel. Your answers are VERY IMPORTANT and will help improve activities and programs for children your age.

2. It is **your choice** to fill out the survey. You can choose not to fill out the survey at any time before, during, or after your survey is finished, and you will not get in trouble or lose marks. If you are not going to fill out the survey, you can leave the survey blank or write "Do not include" on the top of this page and place your survey inside your blank envelope.

3. It is important for you to know that ALL OF YOUR ANSWERS that you put in this survey will be **confidential (private)** and will **not** be shared with your teacher, principal, parents, or your friends.

Please answer each question the best you can. **Thank you for your help!**

UBC United Way HUMAN EARLY LEARNING PARTNERSHIP

Please tell us a little bit about yourself

1. Are you a boy or a girl? *(Circle One)* Boy Girl

2. What is your birth date? ____________ ________ __________

Month Day Year

3. Which of these adults do you live with <u>most of the time</u>? *(Check all adults you live with.)*

☐ Mother ☐ Grandmother ☐ Part time with each parent

☐ Father ☐ Grandfather ☐ Foster parent(s) or caregiver(s)

☐ Stepfather ☐ Second mother (two mothers)

☐ Stepmother ☐ Second father (two fathers)

☐ Other adults (write in the space below, for example, aunt, uncle, mom's boyfriend or girlfriend, dad's boyfriend or girlfriend):

____

4. How many brothers and sisters do you have?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 or more

Aboriginal people in Canada are sometimes called First Nations, Native Indian, Inuit, or Métis. All of your family members might not be Aboriginal but maybe some of them are. Sometimes Aboriginal people only have one parent or grandparent who is Aboriginal. We want to know about YOU. Do you think of yourself as Aboriginal? If so, please answer YES.

5. Do you have Aboriginal ancestry? ☐ **No** ☐ **Yes** ☐ **Partly**

If you answered **Yes** or **Partly**, you can share the name of your Nation here: ______________

6. What is the first language you learned at home? *(You can check more than one if you need to.)*

☐ Aboriginal language If yes, which one? ______________

☐ English ☐ Hindi ☐ Punjabi

☐ Cantonese ☐ Japanese ☐ Spanish

☐ Filipino/Tagalog ☐ Korean ☐ Vietnamese

☐ French ☐ Mandarin ☐ Other __________________

7. Which language(s) do you <u>speak</u> at home? *(You can check more than one if you need to.)*

☐ Aboriginal language If yes, which one? ______________

☐ English ☐ Hindi ☐ Punjabi

☐ Cantonese ☐ Japanese ☐ Spanish

☐ Filipino/Tagalog ☐ Korean ☐ Vietnamese

☐ French ☐ Mandarin ☐ Other __________________

8. How difficult is it for you to read in English?

☐ Very hard ☐ Hard ☐ Easy ☐ Very easy

INSTRUCTIONS

- If you do not understand a question, please raise your hand and **ask for help**.
- Make sure you **understand** the question and how to mark your answer **before** you answer.
- Only check **one answer** for each question.

Here are sample questions for practice.
These questions ask you how much you agree or disagree with the statement.

	Disagree a lot	Disagree a little	Don't agree or disagree	Agree a little	Agree a lot
I like to eat pizza.	☐	☐	☐	☐	☐
I like to eat carrots.	☐	☐	☐	☐	☐

Let's start now! Remember, there are no right or wrong answers!

	Disagree a lot	Disagree a little	Don't agree or disagree	Agree a little	Agree a lot
1. I have more good times than bad times.	☐	☐	☐	☐	☐
2. I believe more good things than bad things will happen to me.	☐	☐	☐	☐	☐
3. I start most days thinking I will have a good day.	☐	☐	☐	☐	☐
4. In general, I like being the way I am.	☐	☐	☐	☐	☐
5. Overall, I have a lot to be proud of.	☐	☐	☐	☐	☐
6. A lot of things about me are good.	☐	☐	☐	☐	☐

	Disagree a lot	Disagree a little	Don't agree or disagree	Agree a little	Agree a lot
7. I feel unhappy a lot of the time.	☐	☐	☐	☐	☐
8. I feel upset about things.	☐	☐	☐	☐	☐
9. I feel that I do things wrong a lot.	☐	☐	☐	☐	☐
10. In most ways my life is close to the way I would want it to be.	☐	☐	☐	☐	☐
11. The things in my life are excellent.	☐	☐	☐	☐	☐
12. I am happy with my life.	☐	☐	☐	☐	☐
13. So far I have gotten the important things I want in life.	☐	☐	☐	☐	☐
14. If I could live my life over, I would have it the same way.	☐	☐	☐	☐	☐

The next question asks about your physical health. Sometimes children your age may feel that these kinds of questions are uncomfortable to answer. Remember you are helping us to learn more about the health of children your age in Canada.

	Poor	Fair	Good	Excellent
15. In general, how would you describe your health?	☐	☐	☐	☐

How true is each statement for you?

At my school, there is a teacher or another adult ...	Not at all true	A little true	Pretty much true	Very much true
16. ... who really cares about me.	☐	☐	☐	☐
17. ... who believes that I will be a success.	☐	☐	☐	☐
18. ... who listens to me when I have something to say.	☐	☐	☐	☐

The next three questions are about your parents (or guardians) or other adults who live in your home. Parents can be biological parents, adoptive parents, step-parents, same-sex parents, or foster parents.

In my home, there is a parent or another adult ...	Not at all true	A little true	Pretty much true	Very much true
19. ... who believes that I will be a success.	☐	☐	☐	☐
20. ... who listens to me when I have something to say.	☐	☐	☐	☐
21. ... who I can talk to about my problems.	☐	☐	☐	☐

In my neighbourhood/community (not from your school or family), there is an adult ...	Not at all true	A little true	Pretty much true	Very much true
22. ... who really cares about me.	☐	☐	☐	☐
23. ... who believes that I will be a success.	☐	☐	☐	☐
24. ... who listens to me when I have something to say.	☐	☐	☐	☐

Please answer the following questions about you and <u>your friend(s)</u>.

		Disagree a lot	Disagree a little	Don't agree or disagree	Agree a little	Agree a lot
25.	I feel part of a group of friends that do things together.	☐	☐	☐	☐	☐
26.	I feel that I usually fit in with other kids around me.	☐	☐	☐	☐	☐
27.	When I am with other kids my age, I feel I belong.	☐	☐	☐	☐	☐
28.	I have at least one really good friend I can talk to when something is bothering me.	☐	☐	☐	☐	☐
29.	I have a friend I can tell everything to.	☐	☐	☐	☐	☐
30.	There is somebody my age who really understands me.	☐	☐	☐	☐	☐

		Never	Once a week	2 times a week	3 times a week	4 times a week	5 times a week	6 times a week	Every day
31.	How often do you eat breakfast?	☐	☐	☐	☐	☐	☐	☐	☐
32.	How often do your parents or other adult family members eat meals with you?	☐	☐	☐	☐	☐	☐	☐	☐
33.	How often do you get a good night's sleep?	☐	☐	☐	☐	☐	☐	☐	☐

ABOUT MY AFTER SCHOOL TIME

The next questions are about activities that are **organized**. That is, the questions are about activities that are planned and supervised by a teacher, instructor, adult, coach, or volunteer.

We would like to know what you did after school **last week**.

34. During last week from **after school to dinner time (about 3:00 pm to 6:00 pm)**, how many days did you participate in:	Never	Once a week	Twice a week	3 times a week	4 times a week	5 times a week (every day)
a) Educational lessons or activities (for example, tutoring, math, language school, or something else)?	☐	☐	☐	☐	☐	☐
b) Art or music lessons (for example, drawing, painting, playing a musical instrument, or something else)?	☐	☐	☐	☐	☐	☐
c) Youth organizations (for example, Scouts, Girl Guides, Boys and Girls Clubs, or something else)?	☐	☐	☐	☐	☐	☐
d) Individual sports with a coach or instructor (for example, swimming, dance, gymnastics, tennis, skating, or something else)?	☐	☐	☐	☐	☐	☐
e) Team sports with a coach or instructor (for example, basketball, hockey, soccer, football, or something else)?	☐	☐	☐	☐	☐	☐

Appendix C – STQ Questionnaire

OMiCS Sedentary Time Questionnaire

Adapted from the Sedentary Behaviour Questionnaire

I. In a typical weekday, which of the following activities do you do before you go to school? How long do you do those activities before you go to school? (Please use 15 minute increments – i.e. 15 min, 45 min, 1 hr 15 min…)

1. **Watching/streaming TV (regular TV, Netflix, DVDs, YouTube, etc.)**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

2. **Playing computer/video games (console games, PlayStation, Xbox, etc.)**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

3. **Sitting listening to music (streaming music, CDs, etc.)**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

4. **Sitting and talking or texting on the phone**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

5. **Sitting at the computer to do homework**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

6. **Sitting at the computer to send emails or surf the Internet**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

7. **Sitting and reading (paper books, ebooks, online articles, etc.)**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

8. **Playing a musical instrument**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

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9. **Doing artwork or crafts**
   - I don't do this before school
   - I do this before school, for around _______ minutes each day

10. **Sitting and riding in a car, bus, or train**
    - I don't do this before school
    - I do this before school, for around _______ minutes each day

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II. In a typical weekday, which of the following activities do you do after you come home from school? How long do you do those activities when you come home from school? (Please use 15 minute increments – i.e. 15 min, 45 min, 1 hr 15 min...)

1. **Watching/streaming TV (regular TV, Netflix, DVDs, YouTube, etc.)**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

2. **Playing computer/video games (console games, PlayStation, Xbox, etc.)**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

3. **Sitting listening to music (streaming music, CDs, etc.)**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

4. **Sitting and talking or texting on the phone**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

5. **Sitting at the computer to do homework**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

6. **Sitting at the computer to send emails or surf the Internet**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

7. **Sitting and reading (paper books, ebooks, online articles, magazines, etc.)**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

8. **Playing a musical instrument**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

9. **Doing artwork or crafts**
   - I don't do this after school
   - I do this after school, for around _______ minutes each day

10. **Sitting and riding in a car, bus, or train**
    - I don't do this after school
    - I do this after school, for around _______ minutes each day

---

III. On a typical weekend day (Saturday or Sunday), which of the following activities do you do? How long do you do those activities? (Please use 15 minute increments – i.e. 15 min, 45 min, 1 hr 15 min...)

1. **Watching/streaming TV (regular TV, Netflix, DVDs, YouTube, etc.)**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

2. **Playing computer/video games (console games, PlayStation, Xbox, etc.)**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

OMiCS Sedentary Time Questionnaire

Adapted from the Sedentary Behaviour Questionnaire

3. **Sitting listening to music (streaming music, CDs, etc.)**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

4. **Sitting and talking or texting on the phone**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

5. **Sitting at the computer to do homework**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

6. **Sitting at the computer to send emails or surf the Internet**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

7. **Sitting and reading (paper books, ebooks, online articles, magazines, etc.)**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

8. **Playing a musical instrument**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

9. **Doing artwork or crafts**
   - I don't do this on the weekends
   - I do this on the weekends, for around _______ minutes each day

10. **Sitting and riding in a car, bus, or train**
    - I don't do this on the weekends
    - I do this on the weekends, for around _______ minutes each day