Sleep Duration and Quality in Children: Interactions with Food Choices, Energy Balance, and Digital Screen-Time

by

© Roya Shamsi

A thesis submitted to the
School of Graduate Studies in
partial fulfilment of the
requirements for the degree of
Master of Science

Department of Biochemistry
Memorial University of Newfoundland

March 2023

St. John's Newfoundland

ABSTRACT

Introduction

Chronic obesity is a complex health problem that affects millions of people globally, including many children. Childhood obesity is a multifactorial condition affected by genetic and lifestyle factors that, if ignored, can cause serious health consequences such as insulin resistance, type 2 diabetes, and cardiovascular diseases. It is essential to identify modifiable lifestyle habits associated with childhood obesity, including sleep, dietary habits, physical activity (PA), and screen time (ST). The primary objective of this pilot and feasibility study was to evaluate the viability of implementing a larger-scale interventional trial in an identical cohort. This involved assessing recruitment rate, retention, attrition, data collection procedures, protocol adherence, data management, and potential obstacles or challenges to putting the intervention approach into practice. These preliminary findings establish the groundwork for future research while providing insights into the intervention's feasibility.

Methods

Participants (n=22) aged 9-12 years were recruited for this pilot and feasibility study. Anthropometric measurements were performed according to the WHO guidelines. Data on the demographic characteristics and ST were collected using different questionnaires. Sleep and PA data were obtained by using both actigraphy and questionnaires. The Automated Self-Administered 24-hour Dietary Assessment Tool (Canada-2018) was used to collect and analyze the dietary intake data from two dietary recalls. Linear regression analyses were adjusted for age, sex, parental education, and household income.

Results

In this pilot and feasibility study, the participant recruiting method demonstrated effective involvement, resulting in a 36.7% recruitment rate. With logistical obstacles, the study retained all 22 participants, obtaining a remarkable 100% retention rate. Participants followed study guidelines, thoroughly completing multiple parts such as questionnaires, dietary recalls, and actigraphy wear. The time required to collect data ranged from 5 to 35 minutes. Among the 22 participants (10.5 ±1.2 y, 59% girls, 68% Caucasian), 52% slept for less than eight hours based on the actigraphy report. Actigraphy measurements significantly differed from child- and parent-reported sleep durations ($p < 0.001$). Sleep duration had a positive correlation with sugar consumption ($r = 0.647$, $p = 0.001$), while other sleep parameters did not significantly correlate with intrinsic sugar, fruit, and vegetable intake. The relationship between sleep parameters, screen time, and physical activity level showed no significant associations.

Conclusion

In this pilot and feasibility study, participants engaged proactively, data was collected efficiently, and research procedures were implemented effectively, highlighting the study's practicality and success. Our data indicate that more than half of the participants slept less than the Canadian recommendation. It has been shown that sleep parameters may play a role in adolescents' choices of healthy and unhealthy foods. These data suggest that sleep patterns may be the target of intervention studies and obesity prevention programs.

Keywords

Pilot and feasibility, Sleep, Children, Food choice, Actigraphy, Screen time, Physical activity

ACKNOWLEDFEMENT

I want to express my deepest gratitude to the individuals who have been instrumental in completing this thesis.

First and foremost, I extend my sincere appreciation to my dedicated supervisor, Dr. Scott Harding. Your unwavering support, invaluable guidance, and profound expertise have been the driving forces behind this endeavor. I am grateful for the valuable research skills and knowledge you've imparted and, perhaps more importantly, for the life lessons I've learned under your mentorship. Your guidance has enriched my academic journey and taught me how to live a more fulfilling and meaningful life. Thank you for being not just a supervisor but also a source of inspiration for personal growth and well-being.

I also extend my heartfelt thanks to my thesis committee members, Dr. Janet Brunton and Dr. Sheila Garland, for their constructive feedback and insightful perspectives. Your contributions have greatly enhanced the quality and depth of this work.

To my loving husband, Arastoo, your unwavering confidence in my capabilities, boundless patience, and persistent support have been my pillars of strength. Your understanding has allowed me to dedicate time to this project. I am profoundly grateful for your steadfast love and encouragement.

To my parents, Jamil and Maryam, and my dear siblings, Nazila, Hamid, and Nima who are 4,872 miles away from me in St. John's, your continuous encouragement, sacrifices, and belief in my abilities have been a constant source of motivation.

I would also like to thank the participants and their parents, who graciously participated in this research. Your willingness to contribute to this study has been immensely appreciated, and your involvement has played a pivotal role in the success of this project.

This work would not have been possible without the collective support and encouragement of all those mentioned above. I sincerely thank each of you for participating in this transformative experience.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASA24 - Automated Self-Administered 24-H Dietary Assessment Tool

BIA – Bioelectrical Impedance Analysis

BMI – Body Mass Index

CBT – Cognitive Behavioral Therapy

CFG – Canada Food Guideline

CI– Confidence Interval

CRSP - Children’s Report of Sleep Patterns

CSHQ- Children's Sleep Habits Questionnaire

DRI – Dietary Reference Intake

EE – Energy Expenditure

ESS-CHAD - Epworth Sleepiness Scale for Children and Adolescents Questionnaire

FAST – Food, Activity, Screen Time

HDL – High Density Lipoprotein

HRQoL – Health-related quality of life

MVPA – Moderate to Vigorous Physical Activity

OR– Odds Ratio

PA – Physical Activity

PAEE – Physical Activity Energy Expenditure

PAQ-C – Physical Activity Questionnaire-Children

SD – Standard Deviation

SIB – Sustained Inactivity Bouts

SMR – Sexual Maturity Rating

SPT – Sleep Period Time

SSB – Sugar Sweetened Beverage

ST – Screen Time

TIB – Time in Bed

TST – Total Sleep Duration

WASO – Wake After Sleep Onset

WC – Waist Circumference

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Obesity in Children

Childhood obesity remains one of today's most significant public health challenges (Aris et al., 2022). It is estimated that the global prevalence of obesity among girls aged 5 to 19 has increased from 0.7% in 1975 to 5.6% in 2016 and that among boys, it has increased from 0.9% in 1975 to 7.8% in 2016 (Nicolucci et al., 2022). Obesity among children and adolescents in Canada has increased dramatically during the previous four decades (Roberts et al., 2012). Built upon recent data from Statistics Canada, the rate of overweight and obesity among children aged 5-17 is 30%. According to the most recent Canadian Community Health Survey, Newfoundland and Labrador (NL) has a significantly higher percentage of overweight and obese children compared to the national average (30%) and, notably, most other provincial health authorities in Canada. For instance, within NL, the Eastern Health Region reports rates ranging from 45% to 65%.(Rao et al., 2016).

Obesity is a physiological condition defined by an excessive accumulation of body fat. While obesity is characterized as surplus fat, direct body fat measurement is limited and expensive. Thus, the accepted clinical standard for diagnosing overweight and obesity is body mass index (BMI), which is determined by dividing body weight in kilograms by height in meters squared. However, because children's body composition varies as they get older and the dynamic nature of children's and adolescents' growth and development (Bradfield et al., 2019), BMI may not accurately indicate their weight status. BMI percentiles are preferable as they account for this change by comparing a child's BMI to that of other children of the same age and sex (Kuczmarski et al., 2002). These percentiles are based on standardized growth charts published by organizations such as the CDC and WHO (Kuczmarski et al., 2000, Ma et al., 2010, Onis et al., 2007), and they give a reference point for clinical interpretation for healthcare clinicians. This method allows for a better knowledge of a child's weight status and effective communication with parents. Furthermore, tracking BMI percentiles over the years provides insight into a child's growth trend and helps with the early detection of potential weight-related health issues. BMI percentiles, in essence, give a thorough and meaningful assessment of children's weight status throughout their developmental years (Wei et al., 2020). There is widespread agreement 'overweight' is defined as being at or above the 85th percentile on the sex-specific BMI-for-age growth charts. Obesity is defined as being at or above the 95th percentile (Flodmark et al., 2004, Koplan et al., 2005). When a child falls within or beyond 120% of the 95th percentile, it is deemed to have severe paediatric obesity (Gulati et al., 2012).It is estimated that a high percentage of obese children remain obese as adults (Kumar et al., 2017). The number of obese children who are obese in adolescence and the number of obese adolescents who are obese in adulthood are around 55% and 80%, respectively (Simmonds et al., 2016). Increased obesity among children has indeed contributed to the rise in chronic diseases such as obesity in adults, mental health issues, diabetes, cardiovascular disease, cancer in some cases (Sarni et al., 2022) and obstructive sleep apnea (Narang et al., 2012). Notably, type-2 diabetes is four times more likely to develop in obese children than in children with a normal BMI (Abbasi et al., 2017). During adolescence, children with overweight and obesity are more likely to struggle with low self-esteem and depression symptoms than normal weight children (Mühlig et al., 2016).

Childhood obesity is complicated and multifaceted, involving genetic (Kumar et al., 2017), endocrine cause (Reinehr et al., 2007), environmental, behavioral, and social factors (Gurnani et al., 2015). It is rare for a specific variant of a single gene to cause a clear pattern of inherited obesity within a family (Littleton et al., 2020). However, obesity tends to result from complex interactions among several environmental factors with a minor influence genetic variables (Thomas-Eapen, 2021). To become obese, there must be an imbalance between energy intake and expenditure. Energy imbalance may be caused by a diet high in fat, sugar, and sweetened beverages, a lack of physical activity (PA), increased sedentary behaviors (Hills et al., 2010; Neumark-Sztainer et al., 2003), longer screen time hours (Ng et al., 2010) and poor sleep patterns (Markwald et al., 2013)

Overweight and obesity are commonly thought to be the outcome of increased calorie intake (Dehghan et al., 2005). Drinking sugar-sweetened beverages (SSBs), excessive amounts of fruit juice, and sodas is connected to an increased risk of obesity (Lee et al., 2008, Pan et al., 2014). These sugary drinks loaded with excessive calories that can cause of imbalance between energy intake and expenditure. It is possible to gain weight over time by regularly consuming these beverages due to their excess calories. Diet patterns high in fast food and SSBs increase obesity risk by 30% compared to diet patterns high in fruits and vegetables (Kim et al., 2019). According to a European study, only 8.8% of children eat the recommended five servings of fruits and vegetables a day (Kovács et al., 2014).

1.2 Physical Activity as a Contributing Factor to Childhood Obesity

It has been predicted that a continuing decrease in physical activity (PA) among all age groups has substantially contributed to increasing rates of obesity worldwide (Guthold et al., 2020). PA is essential to childhood obesity prevention and treatment because of its major effect on body composition and metabolism (Atlantis et al., 2006). The ability to control appetite and energy balance throughout life may be improved by incorporating exercise into a regular lifestyle component (Fearnbach et al., 2016). Children need to engage in PA at an appropriate level during childhood to develop essential cognitive, motor, and social skills as well as health-related musculoskeletal, cardiovascular, and metabolic systems (Whiting et al., 2021). As PA levels continue to increase during childhood, establishing healthy PA behaviors in childhood can have positive long-term effects (Telama, 2009). Sedentary behavior decreases along with increasing PA in children (Pfefferbaum et al., 2022). A sedentary lifestyle or lack of PA can lead to unutilized energy accumulating, leading to fat storage. This can result in weight gain, which may occur without effective control or management (Qatrunnada, 2022). Compared to other levels of PA, moderate to vigorous physical activity (MVPA) is considered to have the greatest health benefits by the WHO (Janssen et al., 2010). For children and adolescents aged 5-17 years to maintain good physical and mental health, the WHO recommends at least 60 minutes per day of MVPA (Whiting et al., 2021). A person's daily step count also reflects how much they exercise regularly. Using Tudor-Locke et al.'s criteria (Tudor-Locke et al., 2011), for boys, the standard number of steps per day is 13,000-15,000 and for girls, 11,000-12,000. Children's healthy weight status is directly related to PA through higher energy expenditure levels (Hills et al., 2011). In addition, children's PA levels are associated with their health outcomes. Cardiometabolic and vascular diseases are more likely to develop in children who participate in less than 60 minutes of MVPA per day. (Strong et al., 2005). MVPA tends to have a more assertive effect on preventing overweight/obesity (Janssen et al., 2010). Studies shows that PA and mental health status can have significant association, having high level of PA is associated with better mental health and sedentary behavior (such as watching television) is related to worse mental health (Carson et al., 2016). Epidemiologic studies commonly use self-reported activity and accelerometers to measure activity amounts and intensities. Changing energy balance through PA or sedentary behavior mainly impacts energy expenditure and energy intake in both lean and obese youths (Thivel et al., 2013).

It is important to note that the absence of PA is just one aspect of sedentary behavior and does not entirely mirror it (Marshall et al., 2002). Another significant element of sedentary behavior involves engaging with digital screens including watching TV and playing video games which is associated with higher BMI in children and adolescents (Eisenmann et al., 2002, Dennison et al., 2002). The increasing prevalence of screens and technological advancements have raised concerns about how screen time affects overweight and obesity. Families and children are now surrounded by screens. There has been an increase in children's exposure to screen-based devices in the last 20 years, accompanied by a decline in the age at which they are first exposed. In parallel, the number of devices has expanded rapidly (Byrne et al., 2021). Although there is no agreement on screen time recommendations for children and adolescents, several experts have established guidelines that recommend up to 2 hours of recreational screen time per day for youth (Tremblay et al., 2016).

1.3 Screen Time and Digital Devices

Screen-based sedentary behavior and inadequate PA are linked to many physical and psychological disorders, which adversely impact health and wellbeing, including obesity, cardiovascular diseases, depression, anxiety, and poor cognitive function (Braig et al., 2018). As a first step, screen time may neglect other activities, for example, physical activity, that may be healthier and more beneficial to cognitive development (Mutz et al., 1993; Zhang et al., 2022; Alblas et al., 2021). Secondly, screen time could contribute to social isolation or poor relationships (Ahn et al., 2013). Recent research has shown that young people with healthy weight who spend more time using screens, such as computers, smartphones, and televisions, tend to have a higher energy intake and lower consumption of fruits and vegetables compared to those who spend less time on screens (Epstein et al., 2008; Utter et al., 2006). Consuming food while watching screen media is possibly an important contributor to increased energy intake in children. Research shows that children now spend more time eating while viewing screen media, with up to a third of their daily energy intake and half of their meals being consumed in front of a screen (Robinson et al., 2017).

An additional explanation for the link between excessive energy consumption and screen media exposure is food advertising (Kraak et al., 2006). The US Federal Trade Commission reports that US food and beverage companies spent $1.8 billion on advertising for children and adolescents in 2009. Between 2009 and 2014, children (ages 2 – 11 years old) and adolescents (12 - 17 years old) were exposed to 12.8 and 15.2, respectively, food, beverage, and restaurant advertisements daily on TV alone. It has been found that food advertisements influence children's choices and consumption habits (Robinson et al., 2017). There has been evidence that advertisements can affect eating behavior and brand preference. In particular, research shows that advertisements encourage automatic eating for foods both advertised and non-advertised (Harris et al., 2009). Ads for food can lead to individuals engaging in eating behaviors without consciously intending to do so (Smith et al., 2019). Additionally, it has been found that even a single 30-second commercial can influence individuals' preferences for specific brands, potentially influencing their purchase decisions (Harris et al., 2009; Robinson et al., 2017).

Various aspects of a child's lifestyle can be affected by screen time, making the mechanisms for any connections between sleep and screen time complex. One mechanism by which screen time can affect children's sleep is through the displacement of other activities. Screen time for children could be thought of as displacing other activities in a child's daily routine. Digital media devices and the content on these devices (i.e., videos, video games, messaging, social media, etc.) have been demonstrated to affect the sleep of children, by shortening the duration of sleep and negatively impacting the quality of the child’s sleep (Cheung et al., 2017). Other sociodemographic factors can further complicate this relationship as shown by a study in children from lower income homes (Magee et al., 2014). It was reported that children from lower income families had higher levels of screen time (i.e. reported as TV watching) and shorter sleep duration compared to children in higher income homes (Magee et al., 2014). These data were in spite of children in higher income homes having access to more digital devices (e.g., TV, table, computers, smart phones, etc.). Therefore, results like these and other researchers (Hale et al., 2015) would indicate the simply having access to devices is not a clear predictor of either screen time or sleep quality. Socioeconomic gaps, access to resources, community circumstances, and parental influences are only a few factors that may influence screen use and sleep habits in children from diverse socioeconomic backgrounds (Hoffmann et al., 2022).

The other mechanism is related to time of use. Blue light emitted by self-luminous devices, in addition to suppressing melatonin production, may also affect the timing of melatonin production, disrupting the circadian rhythm (Figueiro et al., 2016). In various age groups, media device use at bedtime is associated with compromised sleep components (Carter et al., 2016). There has been research showing that using bedtime devices can negatively impact sleep quality and quantity, as well as excessive daytime sleepiness. Therefore, access to digital devices alone does not fully explain the mechanisms by which screen time can negatively effect children’s sleep.

Similarly, the location of the digital devices may play an important role. The presence of media devices in children's bedrooms can increase overall screen exposure, particularly in the evenings. Researchers have found that electronic media devices being used in the bedroom reduce sleep duration for children (Brambilla et al., 2017). Furthermore, adolescents who own many media devices, primarily kept in their bedrooms , tend to experience later bed time, shorter sleep duration, and exhibit more sleep disturbances (Bruni et al., 2015; Hysing et al., 2015). A higher likelihood of detrimental sleep outcomes was also associated with media devices being in the bedroom (even if they were not used) (Carter et al., 2016).

1.4 Impact of Shortened or Interrupted Sleep on Physiology and Metabolism

To gain a clearer understanding of how screen time affects sleep patterns and its potential links to overweight and obesity, it is essential to delve into the nature of sleep itself. Sleep comprises interconnected components, such as sleep duration, efficiency, and wake-after-sleep onset (WASO). Sleep is a dynamic and cyclical physiological process with numerous functions that profoundly influence our health. Recent data suggests a significant decline in human sleep duration over the past century (Matricciani et al., 2012). However, it's worth noting that other studies indicate no substantial change in sleep duration (Al Khatib et al., 2017). In recent years, researchers have established a connection between sleep and cardiometabolic health, particularly its impact on obesity risk (Barragán et al., 2021; Zimberg et al., 2012). Sleep deprivation has far-reaching consequences for children and adolescents, affecting various aspects of their health, including overweight and obesity, cardiovascular health, academic performance, and behavior. This complex relationship between insufficient sleep and health issues involves multiple mechanisms that operate across various dimensions. Lack of sleep can disrupt hormone balance, leading to increased appetite and metabolic disorders, contributing to obesity and overweight. Additionally, it can negatively affect cardiovascular health, leading to alterations in inflammation, blood pressure regulation, and vascular function, all of which elevate the risk of cardiovascular disease (Shochat et al., 2014; Huang et al., 2022).

Moreover, inadequate sleep impairs cognitive abilities, memory consolidation, and sustained attention, thereby impacting academic performance. It can also lead to a range of behavioral problems, including mood disorders, impulse control issues, and emotional instability. Considering these interconnected and diverse mechanisms, it becomes clear that insufficient sleep has a broad and significant impact on health. This underscores the importance of comprehensive therapies that recognize the central role of sleep in overall well-being (Owens, 2014; Sadeh, 2007; Spruyt, 2019).

The relationship between sleep and body weight is influenced by several underlying mechanisms. Inadequate sleep can lead to an increase in energy consumption. Notably, studies have shown that adolescents with insufficient sleep tend to experience heightened cravings for snacks, particularly those with high glycemic and calorie content (Asarnow et al., 2017; Hart et al., 2013). In connection with energy balance, insufficient sleep might play a role in obesity by diminishing energy expenditure. It's important to note, however, that research in this specific domain is currently constrained and marked by conflicting findings (Chehal et al., 2022; Duraccio et al., 2019).

A number of studies have explored the connection between sleep duration and hormones that regulate appetite. According to Spiegel and colleagues, sleep restriction can lead to an 18% reduction in leptin levels and a 24% increase in ghrelin levels (Spiegel et al., 2004). Additionally, shorter sleep durations, typically defined as 6 hours or less per night for adults, have been associated with irregular eating patterns, increased snacking between meals, higher salt consumption, and reduced vegetable intake (Imaki et al., 2002; Ohida et al., 2001). An intervention study further demonstrated that energy intake increased when sleep duration was restricted, such as in the case of one night with 7 hours, two nights with 6 hours, and one night with 4 hours of sleep per night, compared to nights with more than 8 hours of sleep (Bosy-Westphal et al., 2008).

Accordingly, it can be postulated that insufficient sleep amplifies hunger, creates more opportunities for eating, induces thermoregulatory changes, and heightens fatigue levels (Qatrunnada, 2022). In some instances, the fatigue and tiredness following sleep deprivation can lead to decreased spontaneous PA or even increased sedentary behavior (Klingenberg et al., 2012). Reports like these support the notion that individuals with short sleep durations may be at a greater risk of obesity due to increased food intake, which is not offset by the slight increase in energy expenditure (Shechter et al., 2013). The relationship between sleep and obesity is complex, **Figure 1** summarizes the current understanding of the association between sleep deprivation and obesity.

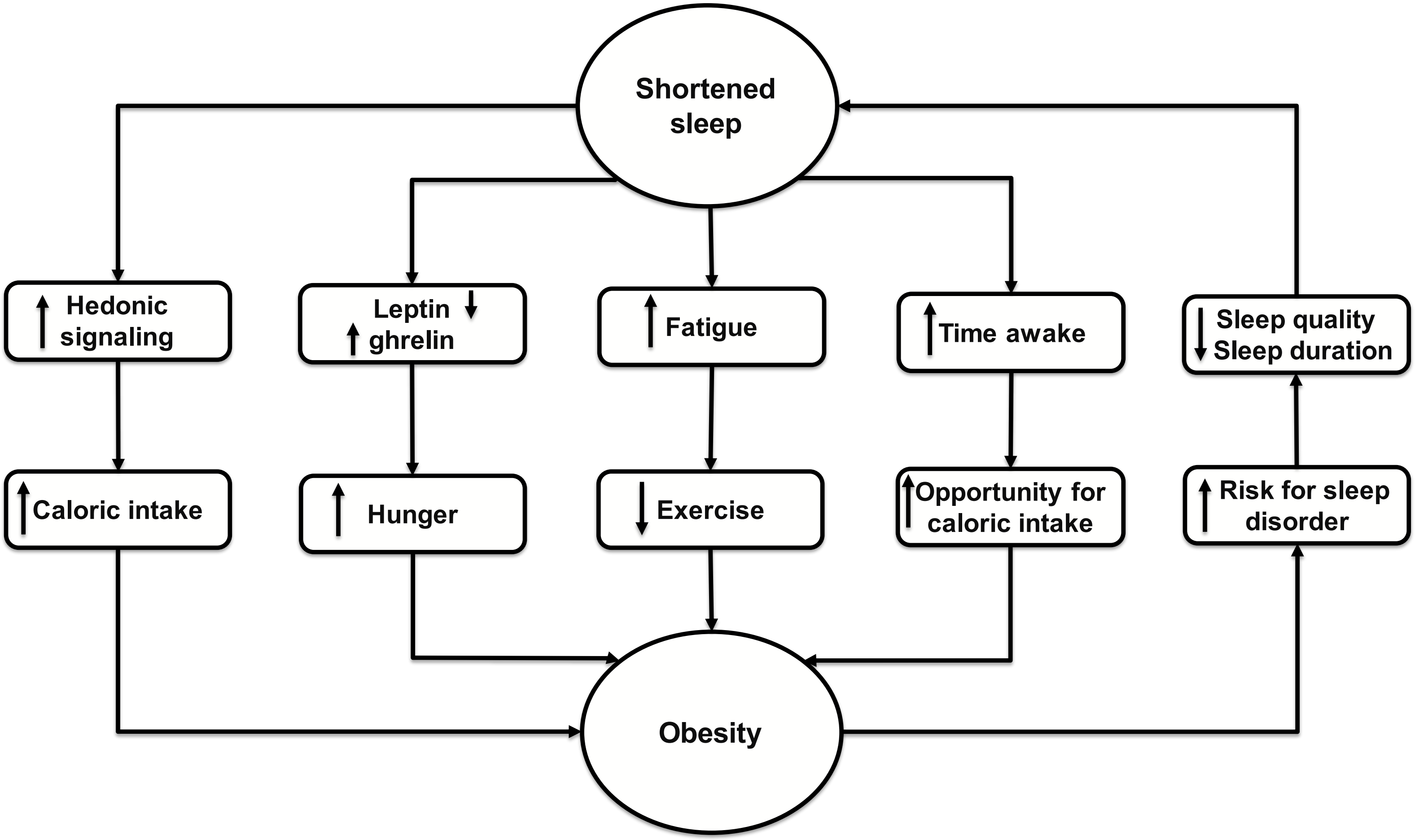


Figure 1. Sleep duration and obesity: potential mechanisms

1.5 Beyond Sleep Duration – Other Measurable Sleep Components

In addition to the association between sleep duration and obesity, another aspect of sleep - sleep quality - has also been linked to overweight and obesity (Morelhão et al., 2018). Sleep quality is a generic term that can be described by many different types of data, both subjective and objective. Sleep quality is critical to health, and the long-term effects of poor sleep quality are linked to a variety of serious health outcomes, including diabetes and cardiovascular disease (Baron et al., 2014; De Nys et al., 2022).

Subjective sleep quality is determined by how individuals feel upon waking, how they feel throughout the day, and how often they wake up at night. Objective measures, such as polysomnography and actigraphy, are used to assess sleep quality, quantifying parameters such as total sleep time (TST), sleep onset latency, sleep efficiency (SE), and wake after sleep onset (WASO). These objective measures help provide an accurate evaluation of sleep quality.

1.5.1 Sleep Duration

Sleep duration refers to the total time spent sleeping during the night or over a period of 24 hours (Chaput et al., 2018). Objective measurement is more accurate than subjective measurement, although both can be performed. The recommended sleep duration for children aged 6-12 years is 9-12 hours, whereas for adolescents aged 13-18 years it is 8-10 hours (Watson et al., 2015). The relationship between short sleep duration and body weight is stronger in children and decreases with age. Based on these findings, children may be more at risk of being overweight as a result of short sleep duration (Gangwisch, 2009). Results from a study in children aged 5-10 years showed that short sleep duration was the most critical risk factor for obesity and overweight. When compared to parental obesity, more than 3 hours of television viewing, and physical inactivity for obesity and overweight the odds ratios were 2.39, 2.08, and 1.45, respectively, vs. 3.45 for short sleep duration in boys and girls combined (Chaput et al., 2006). However, a bias may exist in the association between sleep duration and body weight in children because natural growth and development cause children to gain weight over time (Magee et al., 2012).

1.5.2 Sleep Efficiency

A measure of sleep efficiency is the ratio between total sleep time and total time in bed (TST), which decreases with age. The ideal sleep efficiency measurement is 85% or higher (Ohayon et al., 2017) among all age group. A sleep efficiency score of less than 74% is considered poor among all age groups except young adults.

1.5.3 Wake After Sleep Onset

An individual's WASO is the number of minutes they are awake between sleep onset and sleep offset (Shrivastava et al., 2014). When someone sleeps 420 minutes (seven hours) at night, WASO time is normally less than 10%, or 42 minutes. An average WASO time for a child is less than 20 minutes (Berger et al., 2005).

1.6 Linking Diet and Lifestyle to Sleep

The rise in obesity in the past 20 years can be attributed largely to lifestyle changes and social changes. Public health initiatives concentrating on prevention have proven to be the most effective in combating obesity (Brown et al., 2015). Multi-component procedures such as dietary adjustment, increasing physical activity level, and behavioral interventions that limit screen time and improve sleep patterns are beneficial in preventing obesity (Dabas et al., 2018). A summary of the interrelation between lifestyle factors, their connections with obesity, and the mutual influences they exert on one another is presented in **Figure 2**.

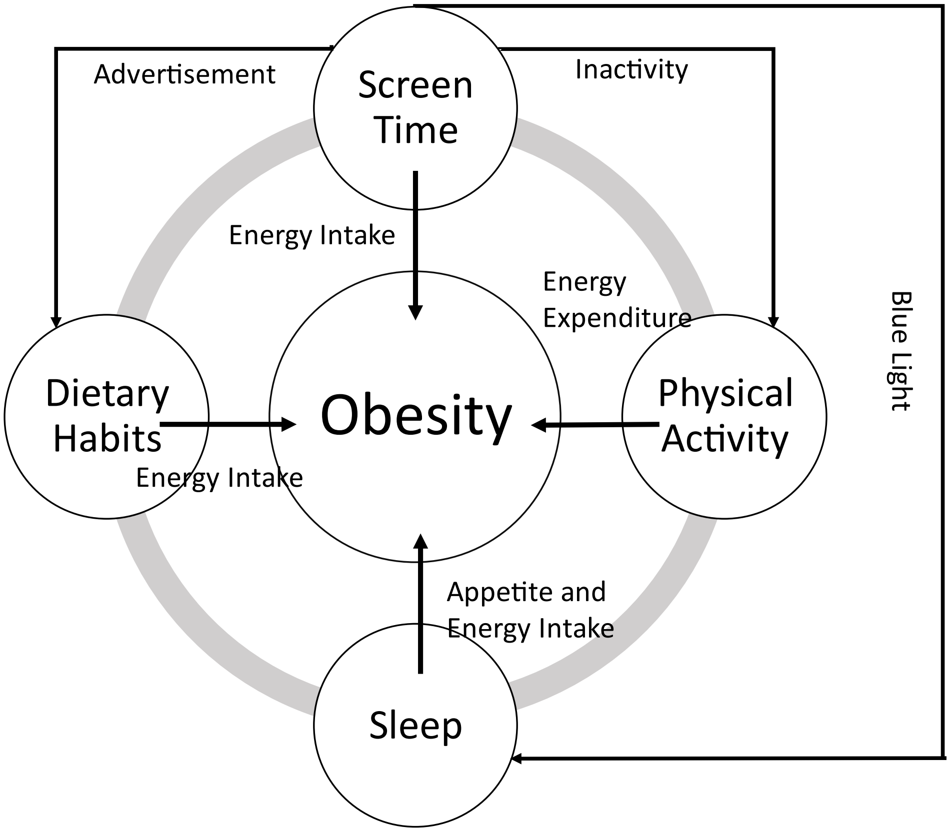


Figure 2. Lifestyle factors involved in the development of obesity.

Researchers conducted a cross-sectional analysis as part of an extensive investigation that delved into the intricate connections between lifestyle factors and childhood obesity (Wilkie et al., 2016). Focusing on children aged 9 to 11 years, the study effectively employed objective measures and questionnaires to explore key factors such as physical activity, sleep duration, screen time, and dietary habits. This research was part of the International Study of Childhood Obesity, Lifestyle, and the Environment, designed to illuminate the intricate interplay between lifestyle factors and their influence on childhood overweight and obesity. The study aimed to identify determinants of childhood obesity. Their findings revealed a significant relationship between higher levels of moderate-to-vigorous physical activity (MVPA) and longer sleep duration with a reduced risk of overweight and obesity. Conversely, increased screen time and unhealthy dietary patterns were associated with a heightened risk of being overweight or obese. Notably, the study also identified significant two-way interactions involving physical activity and sleep, screen time and sleep, as well as physical activity and dietary habits.

While this investigation provides valuable insights, it is essential to acknowledge certain limitations. One limitation lies in the use of food frequency questionnaires (FFQ) to collect dietary data, as FFQs rely on participants' recollection over a specific period, introducing potential recall bias. The limitation of manual data entry was further highlighted when applied to foods data and analysis. In addition to being susceptible to human error, this method is inefficient when it comes to managing large datasets, and difficulties are encountered when maintaining accuracy, consistency, and scalability. It is unsuitable for real-time updates and offers security problems, highlighting the usefulness of automated data entry and management solutions across various datasets. The cross-sectional nature of the research restricts the ability to draw causal conclusions, highlighting the need for longitudinal studies to better comprehend the dynamic connections between lifestyle behaviors and childhood obesity. Given the observed substantial two-way interactions, future research should explore potential three-way or more complex interactions to gain a comprehensive understanding of their combined impact on childhood obesity.

In a similar study, Ding and colleagues (2022) explored the interactions among various lifestyle factors, including sedentary behavior, physical activity, sleep, and dietary habits, in relation to childhood obesity. This cross-sectional study involved face-to-face interviews to collect data on sedentary behavior, physical activity, and sleep, while dietary data was obtained using a 100-item food frequency questionnaire. Their results indicated that sedentary behavior, sleep duration, and diet score were independently linked to BMI z-scores. However, the relationship between physical activity and BMI z-scores was more intricate, particularly when combined with dietary choices. Nevertheless, it's important to note that the cross-sectional methodology employed in this study, collecting data at a single time point, poses limitations in establishing direct causal links between lifestyle behaviors and obesity. Longitudinal studies are necessary to determine causal and temporal relationships accurately. Additionally, relying on self-reported measurements for lifestyle behaviors introduces the possibility of recall biases, potentially affecting data accuracy. Furthermore, certain relevant factors, such as biological age, family size, parents' socioeconomic status, parental role modeling, and variations in lifestyle behaviors on different days (e.g., school days vs. weekends), were not adequately accounted for. Finally, considering the rapid technological advancements and societal changes affecting screen time and dietary habits, the data collection period from 2010 to 2012 may limit the study's relevance to the current context.

In a related context, Bawaked and colleagues (Bawaked et al., 2020) investigated the impact of lifestyle factors during early childhood on obesity. This study focused on children from the INMA (Infancia y Medio Ambiente) birth cohort in three Spanish regions recruited between

2003 and 2008. At age 4, 1480 children were included in the cross-sectional study, and the longitudinal analysis involved 1256 children at age 7. Lifestyle behaviors, including physical activity, television viewing, sedentary activities, sleep duration, and eating patterns (including ultra-processed and plant-based foods), were assessed using parent-administered questionnaires. A child healthy lifestyle score (CHLS) was developed based on these five behaviors, and blood pressure, cholesterol levels, and anthropometric data were collected.

Regarding the relationship between lifestyle factors and anthropometric measurements, at age 4, increased television viewing time was positively associated with higher BMI z-scores. By the time the children reached age 7, their BMI z-scores and waist circumference (WC) measurements remained linked to their lifestyle choices. Notably, longer sleep duration was associated with lower BMI and WC values. While television time initially correlated with higher BMI z-scores, this association became non-significant after controlling for maternal BMI and education. Furthermore, lower consumption of ultra-processed foods was linked to lower BMI z-scores.

A distinguishing feature of this study is its prospective design, which sets it apart from previous research on the cumulative impact of lifestyle behaviors on childhood obesity. Additionally, the study's strength lies in its inclusion of a large, population-based birth cohort from diverse regions in Spain. However, the study is not without limitations. Subjective collection of lifestyle variables such as physical activity, television viewing time, sleep duration, and dietary habits may introduce recollection and response bias. Furthermore, the study employed categorical variables to calculate a preset score instead of using continuous variables, potentially compromising precision due to the use of lifestyle parameters in tertiles.

Supporting these cohort studies, Saunders and colleagues (Saunders et al., 2016) conducted a systematic review to examine the association between a combination of physical activity, sedentary behavior, sleep, and various health indicators, including adiposity measurements, in a sample of ten cross-sectional studies involving 30,746 participants aged 9.3 to 11.6 years. While their review offered insights into the association of increasing physical activity, reducing sedentary behavior, and ensuring sufficient sleep with lower adiposity and a reduced likelihood of being overweight, it is essential to highlight that the study did not consider the impact of dietary habits and their potential interactions with these lifestyle factors (Chaput et al., 2014; Hjorth et al., 2014; Laurson et al., 2014). This omission underscores the need for comprehensive research that investigates the complex interplay between multiple lifestyle components and their collective influence on obesity and overall health outcomes.

1.7 Limitations in Methodologies

The comprehensive review of existing literature indicates that there is a noteworthy gap in assessing lifestyle behaviors among children and adolescents in real-time, using methodology that is robust, valid, and has minimal bias potential. This gap is most apparent in the area of dietary assessment, where the standard methodology frequently fails to capture food patterns over extended periods of time accurately. A change in approach that involves evaluating dietary habits over several days, including weekdays and weekends, rather than relying exclusively on a single FFQ, represents an important step forward. This process consequently minimizes the likelihood of recall bias and improves the accuracy of the data collected. This study effectively addresses this gap by using a validated and reliable tool to evaluate dietary practices thoroughly over two days (Hughes et al., 2017; Foster et al., 2019).

Further, a general pattern in the literature structure is the predominance of methods based on questionnaires for gathering data on sleep. By adopting actigraphy (Antczak et al., 2021), a method acknowledged for its accuracy in collecting sleep data, this study differs from other studies. It places the investigation at a high level of methodological accuracy. Aside from assessing dietary habits and sleep with validated tools, this study also evaluates screen time and physical activity. This comprehensive approach is justified by the knowledge that, as previously discussed, screen time and physical activity levels can have a significant impact on eating and sleeping patterns (Kredlow et al., 2015). To better understand how these elements interact and influence one another, researchers evaluate these aspects comprehensively. Moreover, the study addresses an important research gap in the Canadian context, especially in Newfoundland and Labrador, which has alarming rates of childhood obesity. The critical need to understand the complex web of factors contributing to childhood obesity drives the study's pioneering role within this framework. The research uses pilot and feasibility methods to do this, allowing a multifaceted exploration of the preliminary stages.

1.8 Pilot and Feasibility Studies

Pilot and feasibility studies assess viability, practicality, and potential outcomes of a proposed research study play a crucial role in the early stages of research. It is important to conduct preliminary research in order to gain essential insights and inform decisions before embarking on larger-scale research. A pilot study is an initial investigation conducted on a small scale to determine the viability of a larger research project or to collect preliminary data for the purpose of informing the design of the larger study (Arain et al., 2010). The objective of a pilot study is to detect and solve potential issues with the study's design, such as issues with the sampling, data gathering techniques, or recruitment methods. Additionally, the pilot study aims to determine the sample size required for the larger study.

A feasibility study is a variety of pilot study that concentrates on examining whether or not a larger research project is practicable. Such studies typically entail a comprehensive evaluation of the logistical, ethical, and financial factors that are essential for the successful execution of the larger study.

Following the above principles of pilot studies and feasibility studies, the present study is designed as both a pilot study and a feasibility study. The purpose of this research is to evaluate the feasibility and practicality of a comprehensive sleep analysis methodology involving actigraphy for identifying sleep patterns and correlation between questionnaire approaches and actigraphy data. Moreover, the evaluation of whether accurate dietary information can be collected via two 24-hour recalls is planned. This pilot and feasibility study is intended to provide useful insights into the technique, logistical issues, and potential problems involved with our major study.

CHAPTER 2: RATIONALE, OBJECTIVES AND HYPOTHESIS

2.1 Rationale

It is imperative to reveal the contributing lifestyle factors to the alarming prevalence of overweight and obesity among children in Newfoundland and Labrador, which is highest in Canada. Considering the intricate relationship between these factors and their bidirectional influences, a comprehensive study is essential. As part of a pilot and feasibility study approach, this study marks the first research project to examine lifestyle factors among children aged 9-12 years in Newfoundland and Labrador. This study investigates the complex interplay of physical activity, screen time, sleep parameters, and dietary patterns. Our dual-method approach incorporates subjective and objective measures to capture the full range of these complex factors. The use of multiple methods within a pilot and feasibility study framework aims to find the most appropriate measures for informing future studies. By conducting an in-depth analysis of these factors within the focus of Newfoundland and Labrador, our research holds promise for improving childhood obesity interventions. Through the integration of objective as well as subjective tools, comprehensive insights can be gained and targeted strategies can be designed to address childhood overweight and obesity. This pilot and feasibility study provides the potential to present insight into the requirement to include expensive interventions like actigraphy in bigger intervention studies, offering important information on the feasibility of these efforts. Following a review of the current literature, it becomes apparent that sleep duration has a substantial impact on energy balance, as evidenced by prior work in our lab on the increased calorie intake and added sugar consumption reported in persons with shorter sleep duration among adults (Al Khatib et al., 2017).

2.2 Objectives

This study aimed to generate pilot, cross-sectional data to assess the feasibility of conducting a larger-scale interventional trial in a similar cohort. The primary outcome of this pilot and feasibility study was to determine the recruitment rate, retention and attrition of participants, data collection procedures and measurements, adherence to protocol, data management, and any potential barriers or challenges to implementing the intervention approach. Although these preliminary findings provide insights into the feasibility of the intervention, they lay the foundation for future research.

The secondary outcomes of this study were: a) evaluate sleep duration and sleep quality in children aged 9-12, objectively and subjectively; b) determine correlations between sleep duration and quality with energy, sugar, fruit, and vegetables consumption; c) determine correlations between sleep duration and quality with various lifestyle factors, including digital screen time, physical activity levels, and anthropometric measurements in children aged 9-12.

2.3 Hypothesis

The preliminary nature of this study does not lend itself to a testable primary hypothesis. While the secondary outcomes assess testable research questions, the study sample size (a priori) was not powered to determine the difference between means but rather to determine the appropriate sample size required for testing these secondary outcomes in another trial. This pilot and feasibility study yielded comprehensive insights into the feasibility of conducting a larger-scale interventional trial targeting childhood overweight and obesity. The study effectively measured sleep duration and quality in children aged 9-12, utilizing both objective (actigraphy) and subjective (child-report, parents-report) tools while also demonstrating recruitment feasibility, participant retention, adherence to protocol, and potential barriers or challenges to implementing a larger study.

Furthermore, the measurements of sleep duration and quality allowed for the determination of potential associations with energy, sugar, fruit, and vegetable consumption, providing a deeper understanding of how sleep can influence dietary habits in children aged 9-12. Additionally, the study explored the connections between sleep and other lifestyle factors (e.g., digital screen time, physical activity levels, and anthropometric measurements), which can help to account for potentially confounding behaviors in a larger study.

CHAPTER 3: METHODS AND MATERIALS

3.1 Ethical Aspects

This clinical study was conducted in accordance the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS 2) and approved by the Health Research Ethics Board (HREB; Approval Number: 20222194).

Participant Informed Consent: The study provided detailed information about its objectives, procedures, potential risks, benefits, and confidentiality measures to all participants prior to participation. Written informed consent was obtained from each parent, and assent was obtained from each child. During their participation, they were informed that withdrawal from the study was voluntary and would not result in any consequences. As part of the consent process, participants had the opportunity to ask questions.

Confidentiality and Data Security: Participant confidentiality was maintained throughout the study. Identifiable personal information was separated from research data, and all collected data were assigned unique identifiers. Data were securely stored on password-protected servers accessible only to authorized research personnel. In order to prevent the identification of individual participants, results were presented aggregately.

Disclosure of Potential Conflicts of Interest: It has been declared that none of the researchers involved in this study have any conflicts of interest that could compromise the objectivity or integrity of the study.

3.2 Recruitment and Enrollment

The recruitment approach used several passive and directed approaches to recruit children and their parents/guardians. Standard passive procedures were used, including flyers/posters on community bulletin boards, flyer handouts via afterschool programs, promotion by community radio stations and Memorial University Newsline, advertisements on research group websites and social media channels and snowball sampling in which initial participants were encouraged to invite others. Directed approaches were also used, including posting/messaging on age group-related parent Facebook groups (e.g., buy/sell/trade kids clothing groups, elementary school parent Facebook groups, etc.) with permission from group administrators. An interview was conducted with a journalist from a local newspaper (The Telegram) to explain the study, how we intend to conduct it, and why people should take part. This recruitment approach allowed the study team to recruit a convenience sample from Newfoundland and surrounding area.

The decision of how large a sample size to use is a crucial one, which requires balancing a number of factors in order to ensure that the study's objectives are met. After evaluating both practical and scientific issues, we sought a sample size of 30 participants in our pilot and feasibility studies.

3.2.1 Rationale for the Chosen Sample Size

Rule of thumb: A simple strategy for determining the appropriate sample size for a pilot study uses sample size rules of thumb. Browne (1995) generally suggests having at least 30 subjects to estimate a parameter, whereas Julious (2005) suggests 12 subjects per treatment arm. Teare and colleagues (2014) advocate a larger pilot trial sample size of 70 for greater precision in estimating the standard deviation.

Balance of Feasibility and Representativeness: As a master's student in a two-year programme, the COVID-19 epidemic provided significant obstacles, including programme shutdowns, which resulted in time limits for my studies. This background supports the rationale for picking a sample size of 30. This decision allowed for the construction of a pragmatic balance between securing a large dataset for research and successfully managing existing resources and time constraints. This balance is critical in assuring the feasibility of data gathering and analysis, and hence the study's potential to extract meaningful insights.

3.2.2 Rationale for Choosing the Target Age Group of 9-12 Years

In this age range, 9-12 years of age, significant cognitive and developmental changes are typical of the preadolescent stage. Self-reporting skills, language proficiency, and interest in research engagement are improved in children in this range. This stage is crucial for creating habits and behaviours that will last a lifetime. It is possible to identify prospective treatments for promoting health-conscious behaviour by looking into health-related behaviours throughout this time. Preadolescents have enough cognitive maturity to give informed assent for study, ensuring ethical research practices through their voluntary participation.

3.3 Retention and Attrition

A key component of pilot and feasibility studies is ensuring participant retention and minimizing attrition. Participants' retention, measured as their regular participation from the beginning to the end of the study, provides an indication of participants' commitment to the study. On the other hand, attrition refers to the loss of participants during the study, as measured by calculating the number of participants who leave before the study concludes. In order to assess participant retention and attrition, a variety of approaches were used incorporating diverse strategies for sustaining engagement. They include email correspondence, in-person meetings, and other interactive channels. As a result of these measures, participants were able to sustain ongoing participation and address any potential challenges or questions that arose during the research.

3.4 Data Collection Procedures and Measurements

Data collection procedures were attentively designed and implemented to gather the necessary data for our study. A systematic approach has been used to acquire accurate and reliable information pertinent to our research objectives.

Study team members recruited a convenience sample for this pilot and feasibility study. The study's goal was to include children aged 9 to 12 years old and their parents in at least one 7-day phase throughout the regular school year. Prospective participants interested in participating in the study contacted the Nutrition and Lifestyle Lab by emailing or calling to seek more information or to confirm their eligibility. Those who were deemed to be eligible and willing to participate were then asked to visit the lab at Memorial University.

During the baseline visit, both parents and children provided written informed consent and assent. Anthropometric measurements such as weight, height, and waist circumference were taken during the visit. Following the anthropometric measurements, the children filled out demographic questionnaires with the help of their parents. The demographic questionnaire also collected parent-specific information about several lifestyle factors. Following that, the children completed the screen-time questionnaire, while the parents completed the Children’s Sleep Habit Questionnaire (CSHQ).

Participants were given wrist-worn actigraphy devices and told to wear them for the duration of the seven-day trial. The study team gave parents detailed instructions on how to complete two 24-hour dietary recalls, one during the week and one on the weekend, using the ASA24 cloud-based software. Additionally, sleep diary questionnaires were given to parent-child dyads, with different forms for children and parents to report daily sleep-related information during a seven-day period.

On the last day of the study, children completed numerous questionnaires with the help of their parents, including the Physical Activity Questionnaire, Children's Report of Sleep Patterns Questionnaire, and Epworth Sleepiness Scale for Children and Adolescents Questionnaire. The study team scheduled a time for collecting the actigraphy devices and the completed questionnaires from the participants at the end of the seven-day period (see **Figure 3**).

There was no obligation to participate in this study. Therefore, participants were aware that they could withdraw from the study at any time for any reason, including a self-reported inability to follow the specified protocols. Participation in the study was discontinued according to the following criteria: (A) the participant voluntarily dropped out of the study, (B) procedures/visits were not completed according to the protocol by the participant, including removal of their actigraphy during the study time and unwillingness to complete questionnaires, or (C) the week the child was supposed to participate in the study was not a typical week of the child's life due to different situations, such as traveling or being sick. The study team employed the following strategies to increase adherence to the study protocols, (A) as part of the consenting process, addressed all concerns and questions, (B) scheduling study participants was done in a flexible manner, (C) provided an information sheet about the timeline for completing the questionnaires, (D) supplied instructions on how to complete dietary recall on ASA24, and (E) responded to the parents' emails during the seven days of study as soon as possible if they had any questions regarding any issues.

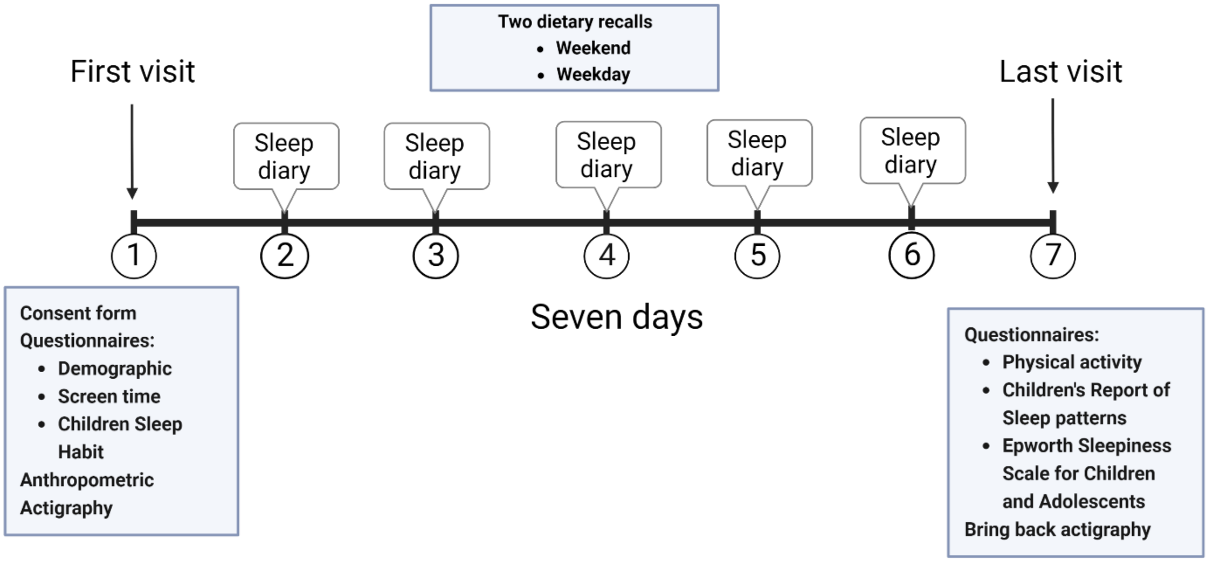


Figure 3. Timeline of study protocol

3.4.1 Anthropometric Measurement

Anthropometric measurements included weight, height, and waist circumference. To measure height, the study team asked the participants to remove their footwear and headgear. The exception was for those sensitive to removing their scarf or veil, so the measurements were taken over light fabrics. Participants stood (feet together, heels against the backboard, knees straight) in front of a standard board measurement, facing the person who performed the measurements. Participants breathed deeply and stood tall while the study team gently moved the measuring arm down onto their heads and then read the height in centimeters. After height measurements, participants stepped onto a scale with one foot on each side. Participants stood still, faced forward, placed their arms to the side, and waited for instructions to step off. The weight was recorded in kilograms. The subsequent measurement was waist circumference. The study team stood at the participant's side and marked the inferior margin (lowest point) of the last rib and crest of the ilium (top of the hip bone). The midpoint was found with a tape measure, and the point was marked. The tension tape was applied over the marked midpoint and was checked if it was horizontal across the back and front of the participant. Participants stood with their feet together, placed their arms at their sides with the palms of their hands facing inward, and breathed out gently. Waist circumference was measured at the level of the tape to the nearest 0.1 cm (WHO organization, 2011).

3.4.2 Sleep Measurement

Measuring sleep is a multifaceted process encompassing a diverse range of methodologies that provide insights into various sleep patterns and quality aspects. Objective and subjective methods are used to assess sleep in this study.

3.4.2.1 Objective Method

Actigraphy: The gold standard for sleep assessment is polysomnography (PSG). Polysomnography is a diagnostic technique that monitors multiple physiological parameters simultaneously while sleeping, including brain waves, eye movements, muscle activity, heartbeat, and breathing patterns. An understanding of sleep patterns and the diagnosis of sleep disorders can be gained from this comprehensive assessment. Despite this, the procedure is costly, invasive, and disruptive to participants' usual sleep routines, making it unsuitable for population-based epidemiologic studies (Fekedulegn et al., 2020). It is noteworthy that actigraphy has been validated (against PSG) in variety of populations including children (Meltzer, Montgomery-Downs, et al., 2012; Meltzer, Walsh, et al., 2012). The actigraphy is able to distinguish between periods of reduced movement and periods of wakefulness while sleeping. Using algorithms and complex signal processing techniques, it can track wakefulness, light sleep, deep sleep, and rapid eye movement (REM) sleep (Fekedulegn et al., 2020). Based on the movements and body postures associated with each sleep phase, these stages can be identified. The GENEActiv (GA) triaxial accelerometer (Activinsights Ltd, Cambs, UK) used in this study is a modern implementation of actigraphy, that children and adults have been studied with this device previously (Koopman-Verhoeff et al., 2019; van Hees et al., 2015).

3.4.2.2 Subjective Methods

Children's Sleep Habits Questionnaire (CSHQ): This questionnaire has high sensitivity (r = 0.80), specificity (r = 0.72), and test-retest reliability (r = 0.79) for identifying sleep problem in elementary-age children (Markovich et al., 2014). Essentially, this questionnaire asks parents to report daily bedtimes, morning wake times, and sleep duration as well as sleep patterns within several domains throughout a typical week. Using the questionnaire items, a composite sleep quality score was calculated, where a higher score (Markovich et al., 2015) would indicate more frequent reported sleep problems and worsened sleep quality (Owens et al., 2000).

Children's Report of Sleep Patterns (CRSP): CRSP provides clinicians and researchers with a multidimensional measure of child self-report. A validated self-report sleep measure for children aged 8-12 years was required, which is precisely why CRSP was developed (Meltzer et al., 2013). (CRSP) comprises three modules (Sleep Patterns, Sleep Hygiene Index, Sleep Disturbances Scale), which can be used independently or in combination. There are separate questions for determining last night (for example, immediately prior to completing the questionnaire), typical weekdays when the child is in school, typical weekends/holidays when the child is out of school, and overall sleep "most days" in the Sleep Patterns questionnaire. This questionnaire covers bedtimes, wake times, sleep onset latency, night waking frequency and duration, naps, sleep schedule variability, and subjective sleep quality. Among the questions included in the Sleep Hygiene Index are questions regarding caffeine consumption, activities before bed, sleep location (where children fall asleep and wake up), and use of electronics before sleep. Among the questions on the Sleep Disturbance Scale were those about fear of going to bed, restless legs syndrome symptoms, insomnia, and parasomnias. A snoring indicator, an enuresis indicator, and a nightmare indicator were also included. Sleep hygiene and pattern are poorer with higher scores, and sleep disturbances are greater with higher scores.

Epworth Sleepiness Scale for Children and Adolescents Questionnaire (ESS-CHAD): The Epworth Sleepiness Scale was developed in 1990 to measure daytime sleepiness in adults (Johns, 1991). An official, modified version of (ESS-CHAD) was proposed for children and adolescents. This unidimensional scale can be used to measure daytime sleepiness in children and adolescents and is reliable and internally valid (Wang et al., 2022).

Sleep Diary: Two sleep diaries were used to collect data on children's sleep patterns. It was intended that the children themselves fill out the first type of sleep diary. It included questions regarding children's bedtimes, wake-up times, and any nocturnal awakenings they encountered, enabling subjective sleep information to be collected directly from the subjects. A second type of sleep diary was completed by parents and included questions about their child's sleep habits, such as bedtime routine, time taken to fall asleep, and sleep disturbances during the night. Parent's observations of their children's sleep quality and duration are often more accurate than those of their children, so this diary provided an external perspective. Data on the child's perception of their sleep, as well as the parent's observations of it, were collected to provide a complete picture of the child's sleep patterns. A comparison of two types of sleep diaries allowed us to learn more about the sleeping habits and quality of the child by comparing the subjective reports of the child with the subjective observations of his or her parents. This comparison also helped assess the possible costs and expenses of using comparable methods in future research.

3.4.3 Physical Activity Measurement

Physical activity assessment encompasses a variety of approaches, with objective and subjective methods for evaluation available. Tools such as motion sensors (accelerometers), physiological indicators (biomarkers), and direct or indirect calorimetry (Prince et al., 2008) are used in objective approaches. Subjective approaches, on the other hand, rely on self-reporting through diaries, questionnaires, and interviews. These approaches, taken together, provide a comprehensive framework for evaluating an individual's physical activity behaviour.

3.4.3.1 Objective Method

The accelerometer is a valuable tool for analyzing free-living behaviors such as sleep, physical activity, and sedentary time. It is possible to collect detailed information about 24-hour behavior over several days using these devices, which can be useful for large-scale studies, and are less likely to introduce biases or errors (Antczak et al., 2021). Actigraphy, which contain accelerometers for motion detection, produce continuous electrical signals (voltages) as the participants move. Using this constant signal, 100 samples were collected per second after converting the motion into an analog electrical form. In our project, we intend to utilize the Zero Crossing Mode (ZCM), the Time Above Threshold (TAT), and the Proportional Integration Mode (PIM) processing techniques. With these techniques, we can gain valuable insight into movement patterns and characteristics of our sampled voltage signals. In ZCM, we can identify pivotal points of signal change, enabling us to recognize distinct movements. In contrast, TAT measures sustained movement intensity by gauging how long signals remain above a threshold. In addition, PIM enables us to determine overall movement intensity by integrating signals over time. These techniques collectively provide us with the tools to analyze movement frequency, duration, and intensity comprehensively. This contributes significantly to our project's objectives of understanding and interpreting sleep patterns and different levels of physical activity. In the following step, data points are digitized (stored) at 1-min intervals; the user can specify the interval anywhere between 1 second and 10 minute (Jean-Louis et al., 2001; Rupp et al., 2011); however, most applications use a 1-minute interval. The GA triaxial accelerometer which used in our study is capturing and quantifying movement patterns and activity levels with advanced sensor technology. The GA is a small (43 mm ×40 mm ×13 mm), lightweight (16 g), waterproof device that collects raw acceleration data in ±8 g, where g is gravity's acceleration. Therefore, it is capable of detecting a broad spectrum of motion, from subtle movements to the intense accelerations caused by vigorous exercise or sudden changes in motion. Through its 8 g range, the device can provide comprehensive insight into an individual's movement behaviors and physical activity across various intensity levels. It was chosen because it outputs raw acceleration data and has been validated with children (Phillips et al., 2013; Schaefer et al., 2014). The device was set to record at 100 Hz. Using a 100 Hz frequency facilitated data collection, analysis, and storage throughout a 7-day protocol that operates 24-h a day.

PA levels can be objectively measured with accelerometers by capturing movement accelerations. An accelerometer can be used to measure the frequency, duration, and intensity of PA. Data on PA were averaged over 5-second epochs. Epochs refer to time intervals or segments used for aggregating and summing data. During this analysis, each epoch represents a continuous 5-second interval, and physical activity levels were averaged within each epoch to provide an overall assessment. Additionally, the acceleration associated with recorded movement was measured using the Euclidean Norm Minus One approach and represented in milligravity units (mg) (Bakrania et al., 2016). As accelerometer-based activity trackers become more widely available, researchers can collect objective, continuous, and highly precise data over extended periods of time with minimal interference (Wang et al., 2023).

3.4.3.2 Subjective Method

One of the self-report tools that is acceptable to researchers, affordable, simple to use, and can be used to collect data on the PA of a sizable population is the physical activity questionnaire (PAQ) (Chinapaw et al., 2010). It is essential to consider factors such as validity and reliability when evaluating the psychometric characteristics of various physical activity questionnaires designed for children. Despite the availability of numerous questionnaires, each with its strengths, none stands out as the ultimate choice regarding comprehensive validation and consistently high reliability. It is important to note that these questionnaires have a wide range of validity studies and reliability assessments, and none of them have universally earned a higher status for accurately measuring children's physical activity behaviors. Nevertheless, the Physical Activity Questionnaire for Older Children (PAQ-C) has received favorable reviews in the scientific community because of its widespread use to measure PA levels in children aged 8 to 14 over the previous seven days (Crocker et al., 1997). Its all-inclusive approach to covering numerous physical activities across various structured and unstructured domains provides an integrated understanding of children's activity patterns. It supports accurate self-reporting by using a simple questionnaire format focused on children's cognitive capacities. The PAQ-C has an easy-to-use interface and a well-established scoring system that improves data collection and processing, making it ideal for large-scale investigations. Its ability to assess habitual physical activity over a specified time period provides benefits by capturing children's long-term activity According to the PAQ-C manual, the scoring process entails giving a numerical value to each response on the questionnaire items and generating the final PAQ-C activity summary score. Individual item scores are calculated using a scale ranging from 1 to 5, with 'no activity' equivalent to 1 and 'maximum activity response' matching to 5 for most items. For item 1, the method begins by calculating the mean of all actions on the checklist, whereas for items 2 through 8, the reported value corresponding to the selected response is used. The composite score for item 9 is calculated by averaging the replies from all days. Item 10 is significant in that it serves to identify anomalous behaviour but is not included in the final summary score. The final step in this process is to compute the mean of the nine-item scores, which yields the final PAQ-C activity summary score. This score, which ranges from 1 to 5, has important implications for categorising physical activity levels: scores around 1 suggest 'low' physical activity, scores between 2 and 4 indicate ‘moderate' physical activity, and scores around 5 indicate 'high' physical activity. These categories provide insights into individuals' physical activity behaviours, assisting in the assessment of their overall activity patterns and compliance with set activity guidelines. The PAQ-C demonstrated acceptable psychometric properties, along with acceptable-to-good internal consistency, test-retest reliability, and gender sensitivity (Crocker et al., 1997). For investigating PA, PAQ-C and accelerometers are both useful tools. Instead of investigating absolute PA, the PAQ-C may examine children's PA behaviors (e.g., type and schedule). A simultaneous use of the two tools might result in a quantitative evaluation of PA that clarifies the connection between children's self-perception and actual PA.

3.4.4 Dietary Intake Measurement

Parents completed two 24 h recalls for their children, one on weekday and the other one on a weekend day, using the Automated Self-Administered 24-H Dietary Assessment Tool (ASA24). US National Cancer Institute developed the ASA24 to assess dietary intake in 24 hours (Subar et al., 2007; Krehbiel et al., 2017). In ASA24, respondents are guided through the assessment via an interactive online platform, which includes multiple passes and customized portion size images. The average completion time for ASA24 is 25 to 45 minutes (median 35 minutes). Aside from recording types and amounts of food consumed, ASA24 also takes into account portion sizes and preparation methods. Dietary information collected with this level of detail is accurate and complete. Participants can also accurately identify and quantify their consumption of foods and beverages using ASA24's comprehensive database. Data collected regarding dietary intake were rigorously analyzed to reveal meaningful insights. Nutrient analysis was performed using established databases and algorithms integrated into ASA24, including macronutrients, micronutrients, and energy intake. The two dietary recalls were analyzed separately to estimate daily dietary intake and thoroughly assess participants' dietary habits. These daily estimates were added together and averaged to produce an overall picture of dietary intake during the evaluation period.

As part of the ASA24-2018 methodology, food recommendations were generated using the previous version of Canada's Food Guide (Health Canada, 2019), which included explicit recommendations regarding servings of food groups such as fruits and vegetables.

3.4.5 Screen Time Measurement

The measurement of screen time requires a reliable assessment. It is challenging to measure screen time objectively, and few studies have captured the real-time use of screen devices using objective measures in the young adult population(Perez et al., 2023). Screen media environments now include multiple devices such as televisions, gaming consoles, smartphones, tablets, personal computers, and passive and interactive applications (Yland et al., 2015). A screen time questionnaire was used to collect screen time data (Araujo et al., 2017). The self-designed questionnaire consisted of 12 items consisting of questions like "What type of digital device do you use? (you can choose more than one)" with the following options: "Smart Phone, Tablet, TV, Video Console, Computer (Desktop and Laptop)". In addition, data on time engaged with the screen on weekdays and weekends were collected separately with asking these questions: "On weekdays, how many total hours per day (on average) do you spend on digital devices?" and "On weekend, how many total hours per day (on average) do you spend on digital devices?" with these options: "<1 hour, 1-2 hours, 2-3 hours, 3-4 hours, >4 hours". Additionally, questions were asked regarding the amount of time spent on screen media related to schoolwork or leisure activities with asking "On weekday, how many hours were for schoolwork / study?", "On weekday, how many hours for leisure time?" and "On weekend, how many hours were for schoolwork / study?", "On weekend, how many hours for leisure time?". Furthermore, this questionnaire gathered data on having a TV in a child's bedroom, children's beliefs, and parents' beliefs about how much screen time children had.

3.5 Adherence to Protocol

The study's commitment to the defined procedure was critical to guaranteeing data collection accuracy, reliability, and consistency. Several strategies were utilized to ensure participants were completely engaged and compliant with the study protocols. For better adherence to the dietary assessment component, participants were reminded via email to complete the 24-hour dietary recalls during the seven days of the study. These reminders were precisely timed to fit the participants' schedules, ensuring convenience, and lowering the risk of missed assessments. In addition, on the final day of the trial, participants received email notifications suggesting that they complete the surveys as soon as possible. The goal of this proactive approach was to capture participants' views and experiences while the facts were still fresh in their memories. In addition, an instructional sheet was provided at the beginning of the study to offer participants with clear instructions and recommendations. This chart defined the timeline for the study. It provided step-by-step instructions for accessing the ASA24 cloud-based software, allowing for accurate and consistent completion of the dietary recalls. The research team kept an open line of communication with participants, responding quickly to any questions, concerns, or technical challenges. This method created a setting of trust and collaboration, enhancing participants' understanding of the protocol and their role in the study.

3.6 Data Management

Data Collection and Entry: Raw data was carefully obtained from a variety of sources, including questionnaires, dietary recalls, and actigraphy assessments. A standardised strategy which includes double-input procedures and regular quality checks was used to reduce errors during data entry.

Database Creation and Organization: Management and oversight of data collected were easily accomplished using Microsoft Excel as the primary tool for data management. Excel's data handling capabilities made it an excellent choice for organizing and maintaining our collection. A secure electronic database within Excel was created to ensure the security and confidentiality of participant information. Each participant was given a unique identifier, which protected their privacy while allowing for smooth data tracking and linking.

3.7 Logistical Challenges

A variety of logistical obstacles developed throughout the course of the study, spanning different dimensions of research implementation. These difficulties included participant recruiting, engagement, and time, resource, and personnel constraints. Continuous monitoring was conducted to identify any unforeseen circumstances that might delay registration. Contact information changes and technical difficulties faced by participants were cited as challenges to maintaining constant communication. The study team evaluated the feasibility of adhering to the set data collection and analysis timeframe, considering possible consequences for participant involvement and research activities. The study approach was modified to fit realistic constraints by regularly assessing the availability of personnel, equipment, and financial resources.

CHAPTER 4: ANALYSIS PLAN

4.1 Pilot and Feasibility Analysis

4.1.1 Participant Recruitment and Retention Analysis

An assessment of participant recruitment and retention was conducted by calculating the recruitment rate as the percentage of eligible participants who consented to participate. Further, the retention rate was calculated by analyzing the percentage of enrolled participants that completed the study and provided usable data.

4.1.2 Adherence Analysis

Participants' experiences, obstacles, and reasons for adherence or non-adherence to study protocols, including completing questionnaires and wearing the actigraphy devices, were qualitatively analyzed. This approach allowed for gaining insights into the factors influencing participants' decisions to follow or deviate from the protocols.

4.1.3 Data Collection Practicality Analysis

The feasibility of data-collecting processes, including dietary recalls and questionnaire completion, was evaluated by analyzing the average time required for participants to complete these tasks. Descriptive statistics such as mean and standard deviation were used to summarise the time needed for each data-gathering activity.

4.2 Statistical Analysis

4.2.1 GENEActiv

A useful R package called GGIR (Generalized Graded Intensity Representation) processes and analyzes accelerometer data collected from wearable devices. Part of its functionality includes tools and functions for processing accelerometer signals and calculating indicators of physical activity and sleep, such as activity counts, step counts, sleep duration, and sleep quality. GGIR is study population agnostic, which makes it useful for a wide range of research domains, ranging from data quality management to 24 hours/7 days time consumption characterisation of physical activity and sleep based on literature-supported approaches (Migueles et al., 2019). GGIR was used to analyze the GENEActiv sleep, and physical activity data derived from a convenience sample. GENEActiv accelerometer data were processed in R programming language using the GGIR package (vanHees et al., 2015; VanHees et al., n.d.). To eliminate non-wear periods or periods when the device malfunctioned, quality checks were performed. To classify accelerometer data into sleep and wake periods, the GGIR sleep detection algorithm was used. The threshold for sleep detection was set at 40 counts per minute, and periods less than 10 minutes were excluded. A variety of sleep measures were obtained for each participant using the GGIR package, including total sleep time, sleep efficiency, and wake after sleep onset. A variety of physical activity measures can be calculated using GGIR, including sedentary time, light activity, moderate-to-vigorous activity, and steps taken. To determine intensity of physical activity, GGIR uses raw acceleration ENMONZ values (i.e., Euclidian norm less one and negative values set to zero) with validated cut-points (Antczak et al., 2021).

Two types of sleep analysis are conducted in GGIR package: identifying the main Sleep Period Time (SPT) window or the time in bed window (TIB) and discriminating between sleeping and waking. In accelerometry, the term "sleep" can be debated because accelerometers only measure lack of motion. As a result, the GGIR calls the sleep periods classified as "sustained inactivity bouts" (SIB). As of now, GGIR gives the user the option to identify SIB period based on any of the following algorithms: vanHees 2015, Sadeh 1994, Galland 2012, and Cole-Kripke 1992. The van Hee’s (2015) algorithm was chosen for this investigation because of its thorough approach and applicability to our study objectives. The algorithm has demonstrated accurate sleep and wake detection using accelerometer data. Since our research focuses on sleep patterns and their links with eating habits, the van Hees algorithm's ability to identify periods of time when the z-angle remains static by more than 5 degrees for at least 5 minutes is especially useful. With this feature, we are able to capture sleep and waking episodes in a precise and accurate manner. It differs from traditional sleep detection algorithms like Sadeh, Galland, and Cole-Kripke, which use acceleration to estimate sleep. To estimate sleep and waking durations, the van Hee's (2015) algorithm employs extensive mathematical modelling approaches. To increase sleep-wake categorization accuracy, it takes into account not only movement but also other parameters such as body position and light exposure. It also includes periodograms, sleep fragmentation indexes, and regression models to capture sleep and wake behaviours. Furthermore, it offers detailed sleep metrics like sleep onset delay, sleep efficiency, and wake following sleep onset (van Hees et al., 2015, Sabia et al., 2014).

4.2.2 Statistical

The statistical methods employed in this study followed a systematic approach. Firstly, the data were tested for normality using the Kolmogorov-Smirnov test and homogeneity using Levene's test. Descriptive statistics were reported as mean and standard deviation (mean ± SD) for continuous variables, while frequencies and percentages were presented for categorical variables. Relationships between categorical variables were evaluated using chi-square tests, and differences between mean values of normally distributed variables were assessed using t-tests. To compare the agreement among three methods of measuring sleep duration (actigraphy, parental report, and self-report), Bland-Altman plots were utilized. These plots visualize the average difference and range of differences between pairs of measurements. Furthermore, ANOVA was performed to investigate if there were statistically significant mean differences among ethnic groups, different income brackets, and participants with different parents' relationship statuses, considering group variability. Correlation analysis was utilized to investigate potential correlations between pairs of continuous variables including sleep, dietary intakes, screen time, physical activity, and anthropometric indicators. An extensive visual inspection of scatter plots and box plots was conducted to identify outliers in the dataset. Various sensitivity analyses were performed to assess the impact of outliers on correlations, and results were compared based on analyses including all participants and analyses excluding outliers. To explore the potential influence of inadequate sleep duration on dietary habits, multiple regression analysis was conducted. Odds ratios (OR) with 95% confidence intervals (CI) were estimated, while accounting for confounding factors, including sex, age, weight, ethnicity, household income, parents’ relationship status. The statistical tests and methods used were chosen to ensure that the research questions were addressed effectively and that the analyses were linked with the study's specific aims. The dataset used for analysis did not contain any missing data.

All statistical analyses were performed using SPSS Statistics version 28.0 software for Windows (SPSS Inc., Chicago, Illinois, United States). The level of statistical significance was set at 0.05.

CHAPTER 5: RESULTS

5.1 Feasibility Outcomes

5.1.1 Participant Recruitment Process

Over the two-month recruitment period, 60 parents contacted the study team to participate. Throughout the process, their participation was influenced by other factors. There were 22 people who indicated disinterest due to a lack of incentives and a sense of time commitment due to the two-visit requirement of the study. Following that, 38 (63.3%) exhibited continuing engagement by actively keeping communication via email interaction. This starting point was critical for establishing confidence and laying the basis for their constant involvement. Of these 38 interested participants, 6 participants resided in Corner Brook, an 8-hour drive from the researchers. It was difficult to conduct in-person visits because of this geographical limitation. Two individuals refused to wear the actigraph for seven days. Five participants were affected by Covid-19, and changes in circumstances, such as relocating out of the city, prevented three participants from participating in the study. After combining these considerations, 22 subjects provided informed consent to participate in the study, completing the recruitment procedure. This resulted in a recruitment rate of 36.7% reflecting the proportion of eligible persons who were selected to participate in the study after being contacted to receive information about its goals. Because of the delays in starting this graduate program of study due to the Covid-19 pandemic, the thesis supervisory committee agreed that 22 participants were sufficient to conduct the overall pilot analysis. A summary of recruitment process can be found in **Figure 4**.

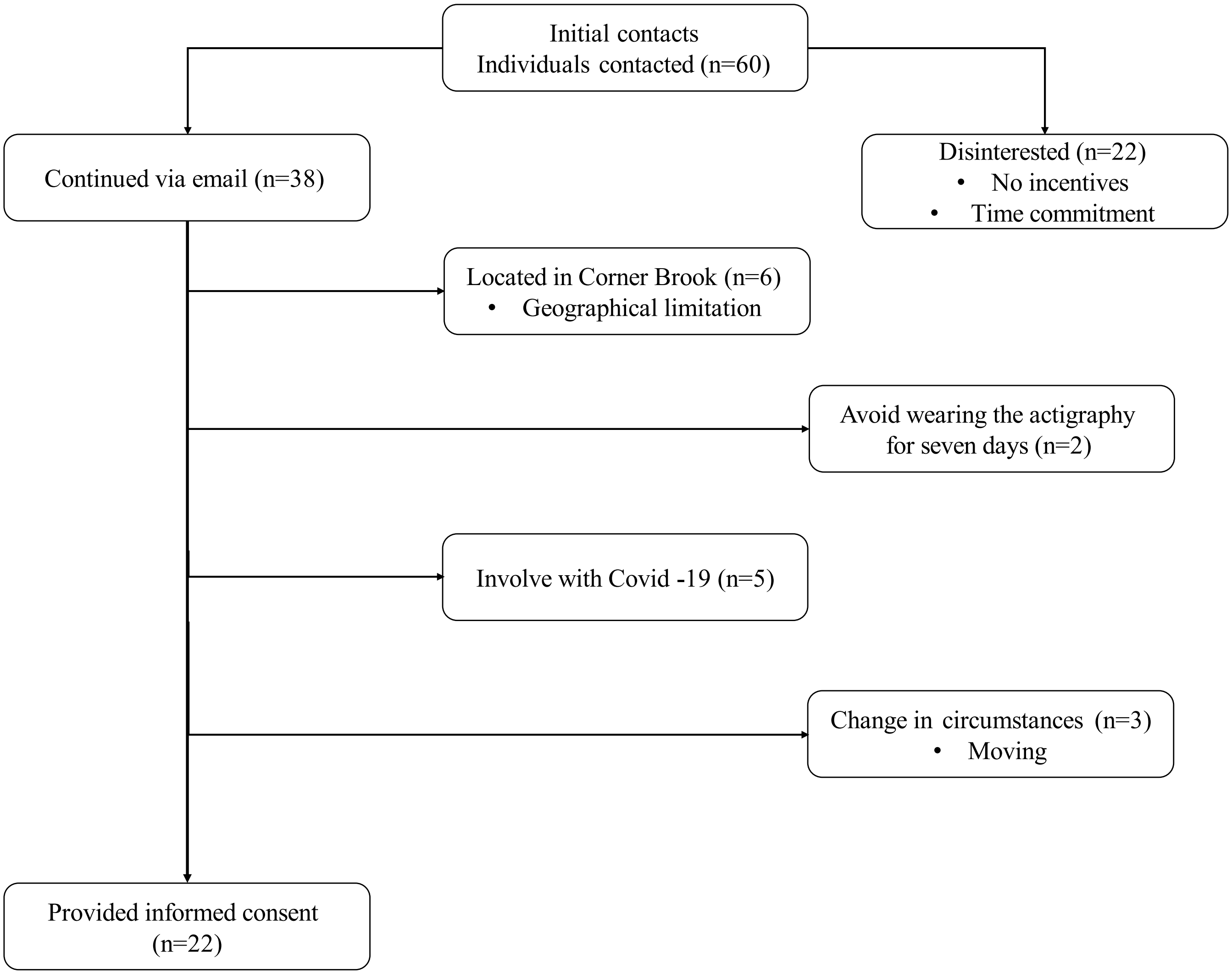


Figure 4. CONSORT flow diagram of the recruitment process for the Sleep-FAST Study.

5.1.2 Retention and Attrition

In particular, the most impressive accomplishment was the full retention of all 22 participants who agreed to participate throughout the period of the study. The research's remarkable retention rate of 100% demonstrates its capacity to keep participants' interest and dedication throughout the study duration. The study's 22 participants who initially consented remained steadfastly engaged and actively participated, demonstrating their commitment to its broad objectives. Besides agreeing to participate, all participants actively took part in the study. They diligently completed questionnaires and consistently wore actigraphy devices as prescribed, contributing to the comprehensive nature of our dataset. Our participant engagement and communication strategies were effective.

5.1.3 Data Collection Practicality and Feasibility of the Study Design

The participant data collection procedures were clear and practical. On average, the completion time for the demographic questionnaire was approximately 10 minutes, while the screen-time questionnaire required about 5 minutes. Similarly, the daily sleep diary questionnaires for both parents and children took approximately 5 minutes each for every day. The completion time for the CRSP questionnaire ranged from 10 to 15 minutes per participant, and the actigraphy devices were consistently worn without interruption throughout the entire seven-day study period. Additionally, each dietary recall procedure took approximately 35 minutes. Overall, the participant burden for completing the questionnaires was low and no participants reported that the process was overly burdensome.

Similarly, the wearing of an actigraph-device for 7-days was not considered burdensome or uncomfortable by the participants or their parents. Therefore, a larger cohort or intervention study could practically use both the paper-based questionnaire/diary and wearable device approach for data collection. While the actigraph data reliably records both the activity and sleep of the child participants, the diaries offer additional secondary information and context that can be used to interpret anomalies or variations in the actigraph data.

For dietary data collection, ASA24 proved to be an extremely successful tool in our pilot study and feasibility study. There was a high response rate among participants, emphasizing their engagement and willingness to participate. The easy-to-use feature of ASA24 that enables returning and editing responses as necessary, assuring correctness and completeness, received especially positive feedback from participants. Many participants complimented the addition of portion size photos in ASA24, saying that it made it much easier to record portion sizes and improved the accuracy of dietary evaluations. ASA24 has proven to be an efficient and effective tool to collect dietary data due to its favorable experiences and positive feedback from participants. Future cohort or interventions studies will use ASA24 for the collection of either dietary recall or food diary approaches to collection dietary intakes of participants.

5.1.4 Adherence to Study Protocols

A high level of commitment and adherence to study protocols was demonstrated by participants. All enrolled participants completed all data collection as instructed by the study team. No questionnaires, diaries, or ASA24 data were incomplete. Participants found the instructions provided during the consenting process and the material taken home to complete to be clear. As a result, there was minimal missing data in our data set.

5.1.5 Evaluate the Quality of the Data

Completeness, accuracy, and reliability of the data collected were assessed. Generally, the data were of good quality, with a high degree of completeness and a small amount of missing data. Some variables showed outliers, but they were deemed reasonable and consistent with prior research. As a result of standardization of the data collection procedure, the data were reliable and consistent. The data cleaning process revealed some minor errors, such as data entry mistakes. Overall, the quality of the collected data was high and suitable for analysis. Food frequency questionnaires or self-reported sleep data are commonly used in studies exploring the relationship between sleep and food intake in children. Compared to previous studies, the accuracy and validity of dietary data may be considered high in the present study. This is likely due to the ASA24 use of a multi-pass approach with numerous text and visual cues to ensure completeness of responses There was a high level of acceptance of this method among children and parents for recording food intakes on both weekdays and weekends for the children. Therefore, I have high confidence for exploring the relationships between diet and sleep in children when using the highly reliable GA actigraph data and ASA24 dietary data.

5.1.6 Logistic Challenges

Despite careful recruitment procedures, unforeseen events caused participant recruitment delays on occasion (e.g., changes in parent or child schedules, illnesses). Similar delays could be experienced with participants completing their 7-day period. The research personnel for this study included me and several undergraduate research assistants who assisted with the consenting procedures. Participant contact was therefore limited since the only full-time research personnel was responsible for recruiting, consenting, scheduling, reminder contacts with on-going participants and data entry. While this limited number of personnel was sufficient for this size study, a larger study would require a full-time employee to manage recruitment and follow-up so the research students could focus on data collection, entry, and analysis.

5.2 Pilot Study Outcomes

Generally, this section focuses on quantitative findings, which include results of various statistical tests, variability (standard deviation or range), and significant correlations or differences between variables.

5.2.1 Summary of Demographic Characteristics

The study enrolled 22 children between the ages of 9 and 12, with a mean age of 10.6 years (1.2) **(Table 1)**. There were nine boys (41%) and thirteen girls (59%) among participants. In terms of ethnicity, 68% of the participants identified as Caucasian, 9% as South Asian, 5% as East Asian, 5% as Afro-Canadian, 5% as Latino or Hispanic, 5% as Middle Eastern, and 5% as North African, or in another word 32% were non- Caucasian **(Table 2)**. Out of a group of 22 participants, 46% were given an allowance from their parents while the remaining 55% were not given any allowance.

The household income was divided into four categories: less than \$25,000 (4.5%), \$25,000-\$50,000 (9.1%), \$50,000-\$75,000 (18.2%), and over \$75,000 (68.2%).

The relationship status of the parents was categorized married (82.8%), divorced (4.5%), separated (4.5%), and domestic partnership (9.1%).

Table 1. Participant[1] demographic characteristics

Ethnicity	**Frequency**	**Percent (%)**
Caucasian	15	68
South Asian	2	9
East Asian	1	5
Afro Canadian	1	5
Latino or Hispanic	1	5
Middle East	1	5
North Africa	1	5
Current School Grade		
Grade 3	1	5
Grade 4	9	41
Grade 5	3	14
Grade 6	4	18
Grade 7	5	23
Monetary Allowance		
Yes	10	46
No	12	54
Total Household Income		
Less than $25,000	1	5
$25,000-$50,000	2	9
$50,000-$75,000	4	18
More than $75,000	15	68
Current Parents' Relationship Status		
Married	18	82
Divorced	1	5
Separated	1	5
Domestic partnership	2	9

[1] Self-reported participant (parent-child dyads) demographic information, N = 22.

Table 2. Sub-demographic characteristics

Ethnicity	**Frequency**	**Percent (%)**
Caucasian	15	68
Non-Caucasian	7	32
Total Household Income		
Less than $75,000	7	32
More than 75,000	15	68

5.2.2 Anthropometric Data

Data on anthropometric factors were gathered from 22 participants **(Table 3)**, including the mean weight of 41.5 kg (8.7), mean height of 150.9 cm (9.4), mean body mass index (BMI) of 18.0 (2.3), and mean waist circumference of 65.7 cm (9.3). Of the 22 children included in the study, 100% had available BMI percentile data. The distribution of BMI percentiles within the sample was as follows: 0% of children were underweight (BMI percentile less than 5th), 77.3% were healthy weight (BMI percentile between 5th and 85th), 18.2% were overweight (BMI percentile between 85th and 95th), and 4.5% were obese (BMI percentile greater than 95th). The mean BMI percentile for the sample was 53.0 (27.8). Waist circumference and BMI percentile were significantly higher among boys than girls (p<0.05).

Table 3. Anthropometric measurements of study participants

Anthropometric Variables	**Total (n = 22)**		**P-value**
	Girls (n = 13) Mean ± SD	**Boys (n = 9) Mean ± SD**	
Age (years)	10.7 ± 0.4	10.3 ± 0.4	0.512
Weight (kg)	39.9 ± 2.1	43.6 ± 3.4	0.342
Height (cm)	151.4 ± 2.8	150.3 ± 2.9	0.793
Body Mass Index (BMI)	17.3 ± 0.5	19.1 ± 0.9	0.065
Waist Circumference (WC)	61.9 ± 2.2	71.1 ± 3.0	**0.018**
BMI Percentile (%)	41.5 ± 5.8	69.8 ± 9.7	**0.030**

Significance levels: P-values in **bold** are statistically significant at the 0.05 level

5.2.3 Sleep Data

Sleep duration was assessed using both questionnaires and actigraphy. The mean sleep duration measured by actigraphy was 7 h and 51 min (40 min), while the mean sleep duration reported on the child's questionnaire and parents' questionnaire was 9 h and 26 min (51 min) and 9 h and 24 min (46 min), respectively.

An ANOVA was conducted to compare the mean sleep duration determined by child-report questionnaire, parents report questionnaire, and actigraphy. There was a significant main effect (F (2, 63) = 30.7, $p < 0.001$), indicating the assessment of sleep duration differed by measurement method. Actigraphy measurements indicated a significantly shorter sleep duration compared to both child-reported ($p < 0.001$) and parents reported ($p < 0.001$) sleep duration. However, a post hoc test revealed that there was no significant difference between data from the self-report and parents' report ($p = 0.99$).

No relationship between sex and sleep duration was found with any of the three methods **(Table 4)**. According to our findings, sex did not significantly affect sleep duration across different measurement methods.

Table 4. Overview of subjective and objective measures of sleep among research participants

Sleep Duration (hh:mm)	**Total (n = 22)**		**P-value**
	Girls (n = 13) **Mean ± SD**	**Boys (n = 9)** **Mean ± SD**	
Parents-report	9:27±0:12	9:20±0:16	0.391
Child-report	9:35±0:14	9:15±0:17	0.741
Actigraphy-report	8:03±0:06	7:33±0:17	0.083

After searching for outliers among the outcome variables, there were only two outliers in sleep duration reported by actigraphy. As you can see in **Figure 5** there were two outliers in sleep duration one with mean sleep duration of 5:29 and the other one with mean sleep duration 8:48. As compared to the rest of the participants, one participant has a notably shorter sleep duration, while the other has a notably longer sleep duration. The lower outlier's differences from the mean sleep duration weas around 2 hours and 19 minutes, whereas the upper outlier's deviation was almost 52 minutes.

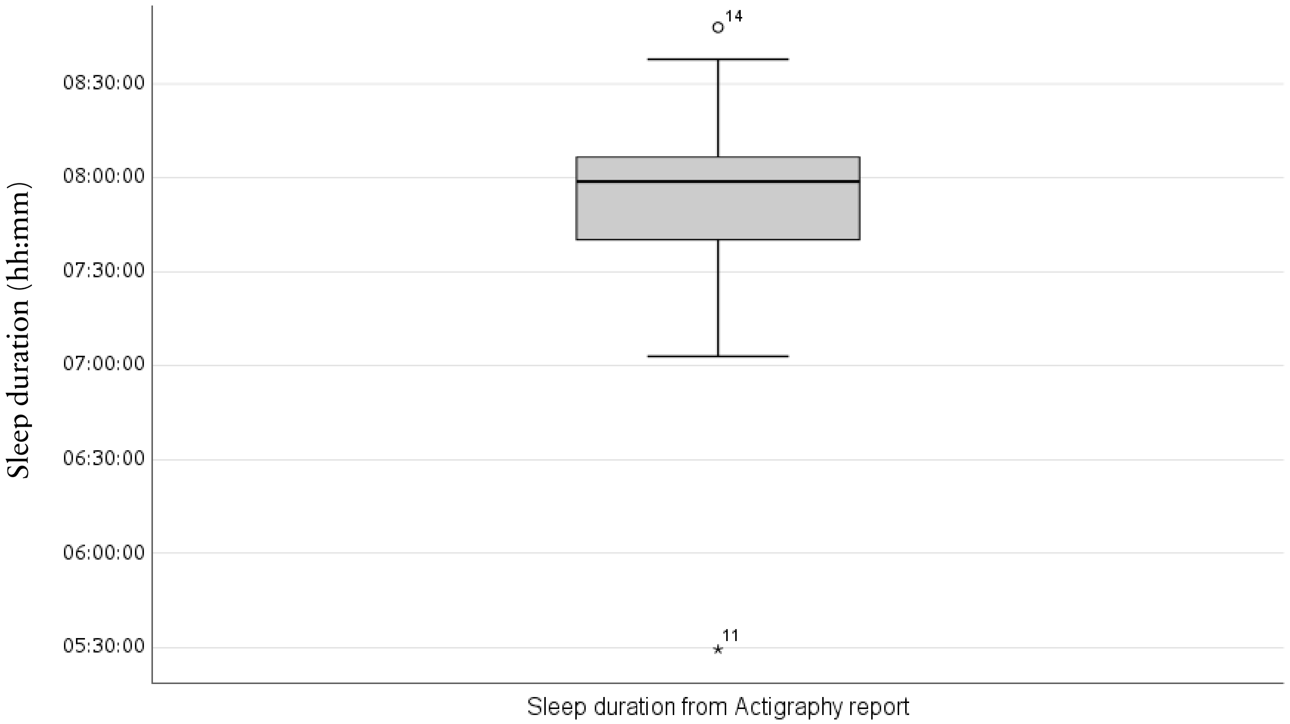


Figure 5. Box plot displaying sleep duration with outliers

The Bland and Altman method was used to examine the agreement between parental and self-reported values and actigraphy data (Bland et al., 1999, 2010). The mean differences for the data obtained by all three methods (Mean [self-reported – Actigraphy]), (Mean [parents-reported – Actigraphy]), as well as the superior and inferior limits of agreement (± 1.96 × SD), were calculated. **Figure 6** compares the differences in total sleep time between child-reported and actigraphy measurements, using the average of both methods, while **Figure 7** shows the differences between parent-reported and actigraphy measurements, also using the average of both methods.

The Bland-Altman plot shows a systematic discrepancy between three methods. The child-reported and parents-reported sleep duration was on average 95 min and 93 min, respectively, longer than actigraph-determined duration. Since actigraphy was assumed to be the reference method, the result suggests that the parent and child sleep diaries overestimated sleep duration.

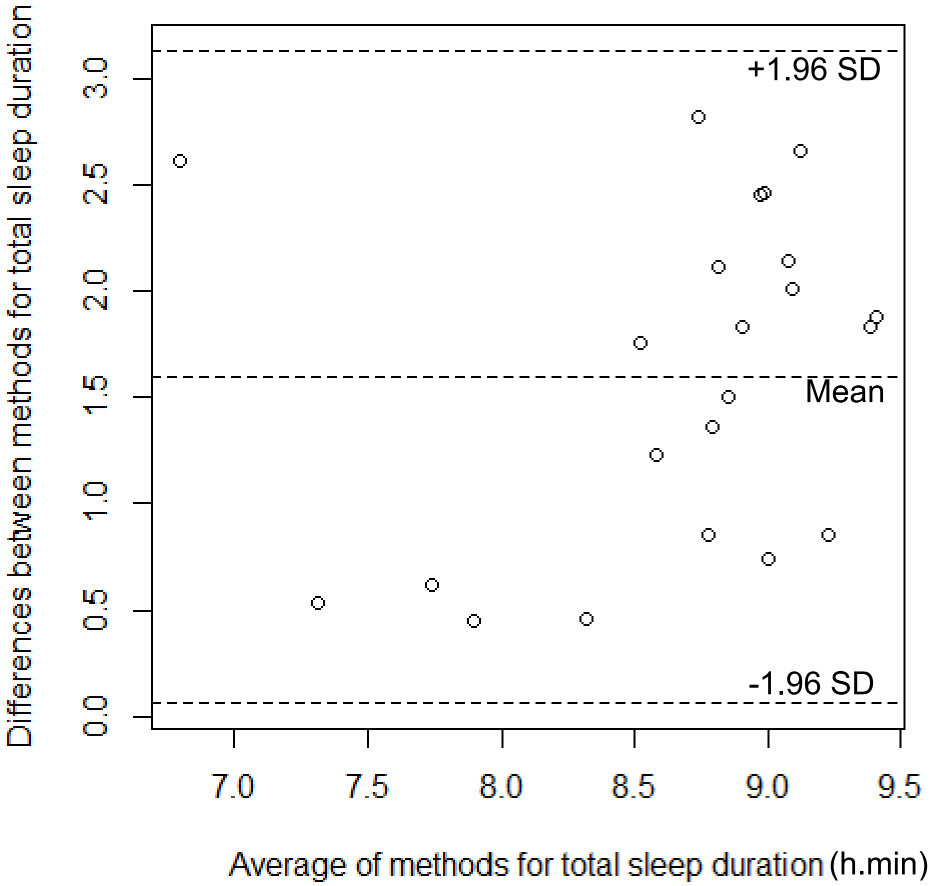


Figure 6. Bland-Altman plot of measurement differences between methods (self-report means - actigraphy means) as a function of the mean differences between methods for total sleep duration.

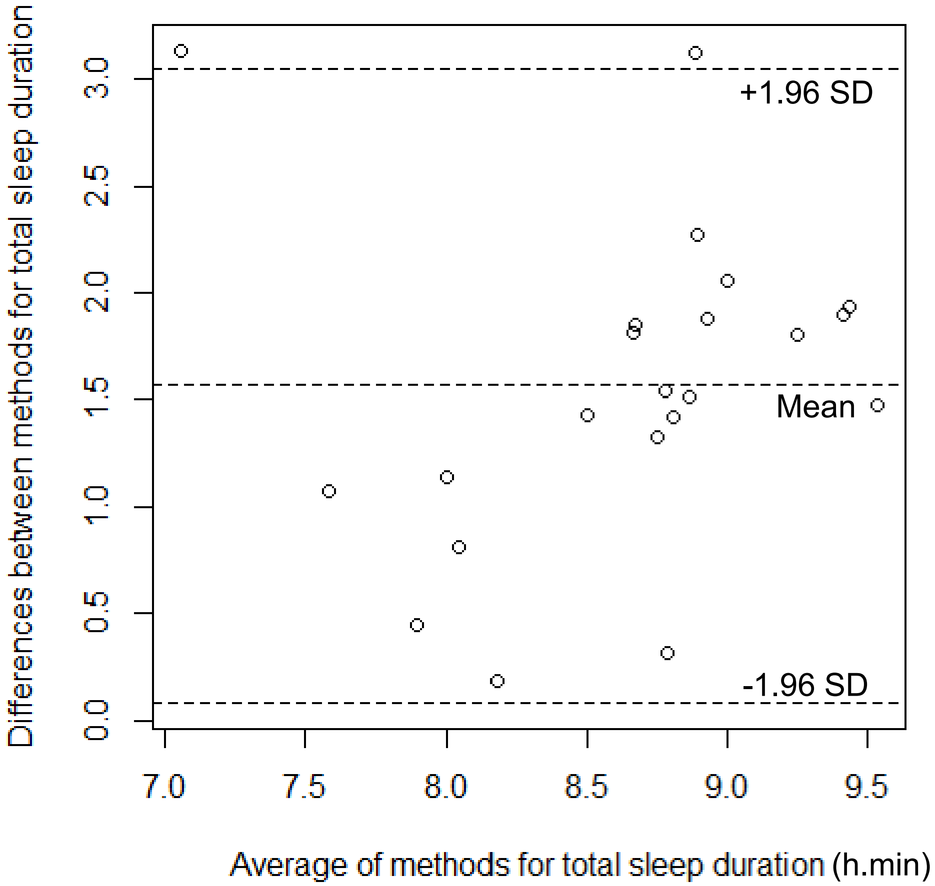


Figure 7. Bland-Altman plot of measurement differences between methods (parents-report means - actigraphy means) as a function of the mean differences between methods for total sleep duration.

Using the actigraphy report as a basis, mean sleep efficiency was 86.5% (3.2), mean number of awakenings per night was 21.7 (3.3), and the mean WASO was 73.5 minutes (18.9). Based on the actigraphy report **(Table 5)**, sleep parameters, including sleep duration, efficiency, number of awakenings, and wake after sleep onset (WASO), did not exhibit significant differences (P>0.05) between boys and girls across the entire sample.

Table 5. Comparison of objective sleep parameters by sex

Actigraphy Report	**Total (n = 22)**		**P-value**
	Girls (n = 13) Mean ± SD	**Boys (n = 9) Mean ± SD**	
Sleep Efficiency (%)	86.9±0.6	85.8±1.4	0.449
Number of Awakenings	21.8±0.9	21.5±1.2	0.843
WASO[1] (min)	72.8±4.1	74.7±8.2	0.849

[1] Wake After Sleep Onset

There was a significant positive correlation between sleep duration and number of awakenings (r=0.594, p=0.004), which indicates that longer sleep duration was associated with more awakenings.

No significant relationship was observed between sleep duration and WASO (r =0.023, p =0.920).

There was no statistically significant correlation found between sleep efficiency and the number of awakenings (r=-0.337, p=0.125).

The analysis showed a robust and statistically significant negative correlation between sleep efficiency and WASO, which suggests that individuals with higher sleep efficiency tend to have lower levels of WASO (r=-0.915, p<0.001). As an outcome of higher sleep efficiency, WASO levels tend to be lower since sleep efficiency is determined by how much sleep time is spent in actual sleep versus restlessness or being awake during sleep. As a result, individuals with higher sleep efficiency are more likely to remain in actual restorative sleep for longer periods, which is less likely to be interrupted by waking up. WASO is more likely to occur in individuals with lower sleep efficiency because they experience more periods of wakefulness throughout the night (Thurston et al., 2012).

5.2.4 Dietary Intake Data

Participants reported consuming an average of 1959 calories per day (296), with mean intake of 234 g (43) of carbohydrate, 80 g (18) of protein, and 78 g (21) of fat **(Table 6)**. The average amount of intrinsic sugar was 84 g (29), while the average amount of added sugar was 65 g (31), which was higher than 25 g recommendation for children (Vos et al., 2017). According to the ASA24, sugars are categorized to naturally occurring sugars and added sugars. In terms of food groups, participants reported consuming an average of 2.4 servings of fruits and vegetables per day (1.2), which is lower than the recommended daily intake of 3.5 servings for children aged 9-12. The average amount of energy consumed by boys was 1933 kcal (61 kcal), while for girls, it was 1978 kcal (100 kcal) (p=0.736). There were no significant differences in carbohydrate, fat, sugar, fruit, and vegetables consumption (p > 0.05) between sexes. However, there was a significant difference in protein intake (p<0.05) between sexes.

Table 6. Dietary intakes of macronutrients and food groups from ASA24: Comparison of mean daily intake among study participants

Dietary Intake	**Total (n = 22)**		**P-value**
	Girls (n = 13) **Mean ± SD**	**Boys (n = 9)** **Mean ± SD**	
Energy (Kcal)	1978±100	1933±61	0.736
Carbohydrate (g)	245.5±12.9	218.3±11.2	0.149
Protein (g)	73.9±4.4	89.9±6.5	**0.047**
Fat (g)	80.1±6.9	76.5±5.9	0.718
Intrinsic Sugar (g)	86.6±8.2	80.1±10.1	0.620
Added Sugar (g)	71.5±8.0	56.2±11.1	0.265
Average Sugar (g)	79.1±7.6	68.1±10.3	0.197
Fruit and Vegetable (serving)	2.53±0.3	2.30±0.4	0.691

Significance levels: P-values in **bold** are statistically significant at the 0.05 level

Energy intake, sugar consumption, and fruit & vegetable consumption are all considered key factors in predicting childhood overweight and obesity (Celis-Morales et al., 2018). As a result of the studies, these dietary factors are strongly associated with childhood overweight and obesity, supporting the rationale for including them in our analysis (Weker, 2006; Duvigneaud et al., 2007; Gil et al., 2015). Correlations were performed to examine the relationship between sleep parameters (duration, efficiency, number of awakenings, and WASO) and energy consumption, intrinsic and added sugars, and fruit and vegetable intakes. Sleep duration correlated positively with sugar consumption (r = 0.647, p=0.001). Other sleep parameters were not significantly correlated with intrinsic sugar, fruit, and vegetable intake **(Table 7)**. Using a sensitivity analysis after detecting outliers in the sleep duration variable to determine how eliminating outliers might affect correlations (**Table 8**).

Excluding outliers did not affect the direction or statistical significance of the correlation between sleep duration and energy intake. By excluding outliers, the Pearson correlation coefficient between sleep duration and intrinsic sugar intake decreased from 0.417 to 0.210. Similarly, the Pearson correlation coefficient between sleep duration and added sugar consumption decreased from 0.647 to 0.422. In particular, the previously observed statistical significance in the correlation with added sugar intake was no longer evident, as the p-value was greater than 0.05. The relationship between sleep duration and fruit and vegetable consumption changed direction., after excluding outliers. The correlation was initially negative but became positive after outliers were excluded. While the direction of the trend changed, the p-value remained non-significant.

Table 7. The correlation between sleep parameters from actigraphy and dietary intake

Variables	**r**	**P-value**
Sleep duration versus Energy	-0.081	0.718
Sleep efficiency versus Energy	0.180	0.423
Number of Awakenings versus Energy	-0.235	0.292
WASO versus Energy	-0.222	0.320
Sleep Duration versus Intrinsic Sugar	0.417	0.054
Sleep Efficiency versus Intrinsic Sugar	0.021	0.926
Number of Awakenings versus Intrinsic Sugars	0.210	0.348
WASO versus Intrinsic Sugar	0.157	0.484
Sleep Duration versus Added Sugar	0.647	**0.001**
Sleep Efficiency versus Added Sugar	0.52	0.108
Number of Awakenings versus Added Sugar	0.298	0.178
WASO versus Added Sugar	-0.113	0.617
Sleep Duration versus Fruit and Vegetable	-0.372	0.089
Sleep Efficiency versus Fruit and Vegetable	-0.247	0.268
Number of Awakenings versus Fruit and Vegetable	-0.249	0.264
WASO versus Fruit and Vegetable	0.075	0.742

[1] Wake After Sleep Onset

Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

Table 8. Sensitivity analysis results for correlation between sleep duration and dietary intake, excluding outliers

Variables	**r**	**P-value**
Sleep Duration versus Energy	-0.145	0.541
Sleep Duration versus Intrinsic Sugar	0.210	0.372
Sleep Duration versus Added Sugar	0.422	0.064
Sleep Duration versus Fruit and Vegetable	0.091	0.720

A multiple regression analysis that includes all data points was employed to investigate the relationship between sleep duration and dietary intake of added sugar, with considering covariates including age, sex, ethnicity, parents' relationship status and household income. A separate analysis was performed for each of the covariates to assess their individual effects on the energy, added sugar, fruit and vegetable consumption. Summaries of the regression coefficients, standard errors, and level of significance are shown in **Table 9**, **Table 10**, **Table 11**.

Table 9. Linear regression results for energy intake predicted by age, sex, ethnicity, parents' relationship status and household income

Variable	Coefficient	Std. Error	t-value	P-value
(Intercept)	-844.429	1333.598	-0.633	0.536
Sleep Duration	0.036	0.037	0.988	0.339
Age	172.950	61.330	2.820	**0.013**
Sex	-61.113	144.938	-0.422	0.679
Ethnicity	17.060	33.692	0.506	0.620
Parents Relationship Status	-43.616	43.056	-1.013	0.327
Household Income	21.029	53.761	0.391	0.701

Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

According to the coefficient mean of the age variable in the study, for each additional year of age, participants expected to consume approximately 173 more calories per day **(Table 9)**.

Table 10. Linear regression results for added sugar predicted by age, sex, ethnicity, parents' relationship status and household income

Variable	Coefficient	Std. Error	t-value	P-value
(Intercept)	-302.165	119.842	-2.521	0.023
Sleep Duration	0.010	0.003	2.894	**0.011**
Age	8.365	5.511	1.518	0.150
Sex	-3.096	13.025	-0.238	0.815
Ethnicity	0.050	3.028	0.017	0.987
Parents Relationship Status	-3.378	3.869	-0.873	0.396
Household Income	4.837	4.831	1.001	0.333

Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

The coefficients of 0.01 imply that the amount of added sugar is projected to rise by 0.01 grams for each additional hour increase in sleep duration (**Table 10)**. These positive coefficients imply a positive relationship between sleep duration and added sugar consumption.

Table 11. Linear regression results for fruit and vegetables predicted by age, sex, ethnicity, parents' relationship status and household income

Variable	Coefficient	Std. Error	t-value	P-value
(Intercept)	12.177	5.953	2.045	0.059
Sleep Duration	0.000	0.000	-1.975	0.067
Age	-0.148	0.274	-0.542	0.596
Sex	0.824	0.647	1.274	0.222
Ethnicity	-0.122	0.150	-0.814	0.428
Parents Relationship Status	0.153	0.192	0.794	0.440
Household Income	-0.076	0.240	-0.318	0.755

5.2.5 Screen Time Data

Descriptive statistics revealed that the children reported an average screen time of 3 h and 18 min per day (1 h and 11 min, range=1-6 hours). A total of 81.2% of the children reported spending more than two hours a day engaging with screens. The participants reported an average screen time of 2 h and 54 min (1 h and 22 min) on weekdays and 3 h and 42 min (1 h and 11 min) on weekends **(Table 12)**.

Table 12. Comparison of objective screen time by weekdays and weekends

Screen time (hh:mm)	**Total (n = 22)**		**P-value**
	Girls (n = 13) **Mean ± SD**	**Boys (n = 9)** **Mean ± SD**	
Average	3:19±0:22	3:16±0:18	0.249
Weekdays	3:02±0:25	2:43±0:24	0.446
Weekends	3:36±0:23	3:50±0:17	**0.014**

Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

Figure 8 depicts the distribution of screen time usage percentages, revealing that engagement with TV surpassed that of all other digital devices.

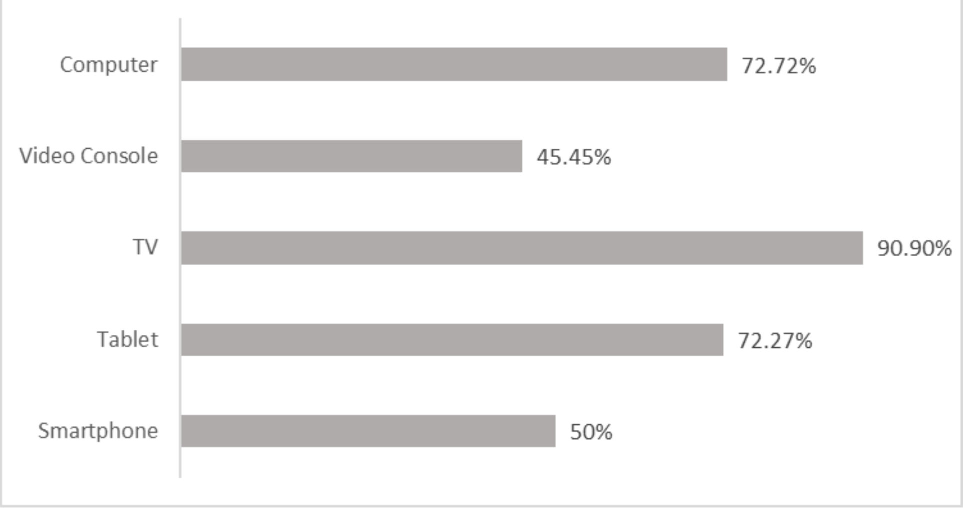


Figure 8. Distribution of screen types among participants

To examine the relationship between kids' and parents' beliefs about screen time, categorized as high, same, and low, a Chi-square test of independence was conducted. The results of the test showed that there was no significant difference between children's and parents' beliefs about screen time, (χ^2=0.672, df= 1, p=0.429) **(Table 13)**. Only 22.7% of children and parents (5 out of 22 participants) had similar beliefs about screen time. Interestingly, none of the children perceived their screen time as being high, and similarly, none of the parents perceived their children's screen time as low.

Table 13. Frequency of parents and children's belief about screen time by category

Childrens' belief about their ST[1](%)	**Parents' belief about their children's ST (%)**			
	High	Moderate	Low	Total
High	0	0	0	0
Moderate	22.7	22.7	0	45.4
Low	36.3	18.1	0	54.6
Total	59.1	40.9	0	100

[1]Screen Time

The relationship between sleep parameters and screen time was examined using Pearson correlation analysis **(Table 14)**.

Table 14. The correlation between screen time and sleep parameters

Variables	**r**	**P-value**
ST[1] versus Sleep Duration (Child-report)	-0.162	0.471
ST versus Sleep Duration (Parents-report)	-0.363	0.097
ST versus Sleep Duration (Actigraphy)	-0.240	0.283
ST versus Sleep Efficiency	0.055	0.806
ST versus Number of Awakenings	-0.384	0.077
ST versus WASO	-0.172	0.443

[1] Screen Time

5.2.6. Physical Activity Data

Based on the scores from the physical activity questionnaire, the sample obtained a mean score of 2.66 (0.45), indicating a relatively low level of physical activity. All participants were classified according to activity levels, 72.7% rated moderate activity (score 2-4), 22.7% rated high activity (score 5), and 4.5% rated low activity (score 1).

Results from GENEActiv showed that the average number of minutes of daily light activity was 132.5 (34.5), MVPA was 41.3 (30.9), and the mean daily step count was 11057 (3105). There were no significant differences in daily light activity between boys and girls, but the MVPA and steps counts were significantly higher in boys in comparison to girls **(Table 15**).

Table 15. Objective physical activity data

Physical activity	**Total (n = 22)**		**P-value**
	Girls (n = 13) **Mean ± SD**	**Boys (n = 9)** **Mean ± SD**	
Light Activity	132.8±29.5	132.1±42.5	0.959
MVPA[1]	26.5 ± 20.9	62.7 ± 31.5	**0.004**
Steps	9859 ± 2095	12786 ± 3609	**0.026**

[1]Moderate to Vigorous Physical Activity
Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

PAQ-C scores were positively correlated with number of steps (r = 0.45, p = 0.04). In contrast, there was no significant correlation between PAQ-C scores and light activity (r = 0.180, p = 0.424), and PAQ-C score and MVPA (r = 0.296, p = 0.18) **(Table 16)**.

Table 16. Correlation between objective and subjective measures of physical activity

Variables	**r**	**P-value**
PAQ-C[1] Score versus Light Activity	0.180	0.424
PAQ-C Score versus MVPA	0.296	0.181
PAQ-C Score versus Steps	0.450	**0.040**
Light Activity versus Steps	0.507	**0.016**
MVPA[2] versus Steps	0.776	**<0.001**

[1] Physical Activity Questionnaire-Children
[2] Moderate to Vigorous Physical Activity
Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

Interestingly, MVPA measured by actigraphy did not significantly correlate with PAQ-C scores, whereas steps measured by actigraphy was significantly correlated. A relationship between sleep parameters and different types of physical activity, including light, moderate, and vigorous, as well as steps taken, was also examined to assess any potential relationships. As shown in **(Table 17)**, no statistically significant correlation could be found between these variables based on the analysis of the data.

Table 17. The correlation between physical activity and sleep parameters

Variables	**r**	**P-value**
PAQ-C[1] Score versus Sleep Duration (Child-report)	0.060	0.792
PAQ-C Score versus Sleep Duration (Parents-report)	0.179	0.425
PAQ-C Score versus Sleep Duration (Actigraphy)	0.278	0.210
PAQ-C Score versus Sleep Efficiency	0.126	0.576
PAQ-C Score versus Number of Awakenings	-0.022	0.924
PAQ-C Score versus WASO	0.008	0.971
Light Activity versus Sleep Duration (Child-report)	0.357	0.102
Light Activity versus Sleep Duration (Parents-report)	0.100	0.657
Light Activity versus Sleep Duration (Actigraphy)	0.404	0.062
Light Activity versus Sleep Efficiency	0.159	0.480
Light Activity versus Number of Awakenings	0.339	0.123
Light Activity versus WASO	0.057	0.800
MVPA[2] versus Sleep Duration (Child-report)	0.221	0.322
MVPA versus Sleep Duration (Parents-report)	0.239	0.284
MVPA versus Sleep Duration (Actigraphy)	0.136	0.574
MVPA versus Sleep Efficiency	-0.150	0.506
MVPA versus Number of Awakenings	0.181	0.420
MVPA versus WASO	0.250	0.262
Steps versus Sleep Duration (Child-report)	0.285	0.198
Steps versus Sleep Duration (Parents-report)	0.244	0.274
Steps versus Sleep Duration (Actigraphy)	0.354	0.106
Steps versus Sleep Efficiency	0.007	0.977
Steps versus Number of Awakenings	0.357	0.103
Steps versus WASO	0.192	0.391

[1] Physical Activity Questionnaire-Children
[2] Moderate to Vigorous Physical Activity

5.2.7 Anthropometrics, demographic and study outcomes (sleep, diet, ST, and PA) connections

In **Table 18**, the results of Pearson correlation analyses were conducted to examine the associations between anthropometric variables (weight, waist circumference, and BMI percentile) and various study outcome variables, including sleep duration, energy, intrinsic sugar, added sugar, fruit and vegetable consumption, screen time, and physical activity. Notably, among these associations, the only significant findings were the positive correlation between weight and energy intake (r = 0.493, p = 0.020) and between waist circumference and energy intake (r= 0.477, p = 0.025).

Table 18. Correlation between anthropometric measures and study outcomes

Variables	r	P-value
Weight versus Sleep Duration	-0.120	0.594
Waist Circumference versus Sleep Duration	-0.040	0.910
BMI percentile versus Sleep Duration	-0.133	0.554
Weight versus Energy	0.493	**0.020**
Waist Circumference versus Energy	0.477	**0.025**
BMI percentile versus Energy	0.127	0.573
Weight Intrinsic versus Sugar	0.059	0.794
Waist Circumference versus Intrinsic Sugar	0.020	0.931
BMI percentile versus Intrinsic Sugar	-0.159	0.479
Weight versus Added Sugar	0.121	0.592
Waist Circumference versus Added Sugar	-0.015	0.974
BMI percentile versus Added Sugar	0.037	0.870
Weight versus Fruit and Vegetables	0.044	0.847
Waist Circumference versus Fruit and Vegetables	-0.122	0.590
BMI percentile versus Fruit and Vegetables	-0.156	0.488
Screen time versus Weight	0.144	0.523
Screen time versus Waist Circumference	0.173	0.442
Screen time versus BMI percentile	-0.172	0.445
Physical activity versus Weight	-0.127	0.573
Physical activity versus Waist Circumference	0.244	0.274
Physical activity versus BMI percentile	0.151	0.501

Significance levels: P-values in **bold** are statistically significant at the 0.05 level.

A one-way ANOVA was performed to assess the impact of categorical variables, including ethnicity, household income, and parents' relationship status, on various study outcomes, including sleep duration, energy intake, intrinsic and added sugar consumption, fruit and vegetable consumption, screen time, and physical activity **(Table 19**, **Table 20**, **Table 21)**. According to the ANOVA analysis, both ethnicity and family income significantly influenced sleep duration, whereas parental relationship status did not, however post hoc tests were not possible because of single participants in certain ethnic groups and income levels. Even so, a significant p-value indicates that disparities were observed across ethnic groups and income brackets of families collectively. A more comprehensive analysis may be possible if additional data are collected for the groups with one ethnicity and one level income.

Table 19. Overview of study outcomes according to ethnic group

Outcome Measure	F-value (df)	P-value
Sleep Duration	5.79, (6, 15)	**0.003**
Energy	1.07, (6, 15)	0.423
Intrinsic Sugar	2.49, (6, 15)	0.071
Added Sugar	2.71, (6, 15)	0.055
Fruit and Vegetables	2.03, (6,15)	0.125
Screen Time	0.37, (6, 15)	0.886
Physical Activity	0.51, (6, 15)	0.794

Table 20. Overview of study outcomes according to income level

Outcome Measure	F-value (df)	P-value
Sleep Duration	5.60, (3, 18)	**0.007**
Energy	0.42, (3, 18)	0.743
Intrinsic Sugar	0.97, (3, 18)	0.417
Added Sugar	1.67, (3, 18)	0.203
Fruit and Vegetables	0.80, (3, 18)	0.510
Screen Time	0.49, (3, 18)	0.694
Physical Activity	0.29, (3, 18)	0.828

Table 21. Overview of study outcomes according to parents' relationship status

Outcome Measure	F-value (df)	P-value
Sleep Duration	0.40, (3, 18)	0.755
Energy	0.72, (3, 18)	0.551
Intrinsic Sugar	0.83, (3, 18)	0.493
Added Sugar	0.26, (3, 18)	0.856
Fruit and Vegetables	0.32, (3,18)	0.809
Screen Time	0.37, (3, 18)	0.776
Physical Activity	0.60, (3, 18)	0.602

CHAPTER 6: DISCUSSION

6.1 Feasibly and Piloting of Methodologies in Children Aged 9-12

Pilot and feasibility studies are an important phase in developing research projects, playing as a foundation for improving methodology, detecting challenges, and determining the viability of larger-scale investigation. This early phase of our investigation was initiated with a primary objective of determining the feasibility of an upcoming interventional study targeted at understanding the complex link between lifestyle factors specifically sleep and dietary intakes.

The participant recruitment procedure, which is a critical stage in any study, provided insightful information and understanding of strategies for engagement and their impact. A lack of incentives and time limitations posed obstacles, and the engagement rate of 36.7% achieved through consistent email communication in a 2-month period. Its important to note that the initial target was 30 participants and we successfully enrolled 22 participants. A variety of strategies will be implemented for the larger study to address these challenges. To maximize recruitment for a larger study the study team will partner with community organizations to reach out to potential participants (e.g., schools, after school programs), use targeted online advertising to reach potential participants, provide financial incentives to participants to increase motivation.

The methodical approach to collecting data was feasible and effective and of the study's strengths. The average completion time for several questionnaires and assessments, ranging from demographic information to sleep habits and dietary recalls was not burdensome to the participants (parent or child). Also, participants' consistent adherence to actigraphy wear throughout the study period indicated that the objective measures of sleep and activity were a very reliability aspect of our methodology and data collection. Therefore, the combination of these questionnaire and digital devices could be effectively streamlined to improve compliance, and data quality in a larger trial.

The subjective and objective measures of sleep illustrated the need use both tools together and with clear purpose. Observed discrepancies in sleep reporting from questionnaires and GENEActiv support the use of GENEActiv for precise sleep assessment (Nascimento-Ferreira et al., 2016) but the sleep diaries provided context when interpreting the raw actigraphy data for each participant. Additionally, the two ASA24 diet recalls were a success in this study, confirming its continued use for a larger intervention study (Subar et al., 2020). The dietary data collected were generally reliable, accurate, and complete. The dietary data collected was used to assess specific energy and nutrient characteristics in this study but could have also been used to calculate dietary indices that describe overall dietary patterns. The robustness of the actigraphy and the dietary data allow for confident correlation and regression analysis in this small pilot study and future intervention studies.

Moving forward, actigraphy and diary methods can sometimes be used interchangeably in the context of sleep parameter measurements, such as sleep duration. However, they may only be equally suitable for some aspects of sleep assessment. Both approaches effectively capture sleep duration, making them viable options for this parameter. On the other hand, when it comes to measuring specific parameters like WASO, sleep efficacy, or the number of nighttime awakenings, the actigraphy method provides more accurate results. As a cost-effective approach, the diary method complements actigraphy data by offering additional insights into children's sleep duration and aiding in the interpretation of raw actigraphy data. Analysis presented in **Table 4** indicates that parental and child reports do not differ in estimating sleep duration. A single diary involving input from parents and the child is recommended to reduce participants' burden and improve sleep duration assessment accuracy. Using the single diary with both the parent and child input provides a guide that can be used to help interpret actigraphy data when either sleep or activity is recorded outside the usual pattern for an individual. Within the scope of PA, PAQ-C provides a single overall score, thereby offering a simplified summary of physical activity levels and also provides insights into the specific types of activities children engage with. By combining the PAQ-C and actigraphy for physical activity assessment, the research will have activity specific context when interpreting the intensity and duration of various activities. If an in-depth analysis of the types of activities a participant engages in that put their energy expenditure in the MVPA range, the combination of the PAQ-C and actigraphy provide this information. Overall, the use of both the sleep diary and PAQ-C improve the researcher's ability to make practical determinations and assessment of the objective data collected by actigraphy.

In summary, the main objective of this study aimed to determine if our subjective and objective data collection could feasibly describe sleep duration and quality in a convenient sample of children aged 9-12, while specifically elucidating the interrelation between sleep and dietary habits, particularly the consumption of energy and sugar. These goals were achieved and provide the research team with sufficient information to refine the recruitment of participants, data collection by digital actigraphy, questionnaire, and online dietary recall. While the results of this phase of the study do not lend themselves to typical scientific data presentation formats, a key contribution of this feasibly assessment is through the processes that were used to collect and analyze the secondary outcomes of this thesis. For example, the processing of the sleep data using the R statistical package and GGIR (Generalized Graded Intensity Representation) package that processes and analyzes accelerometer data collected from wearable devices. Determining if this process produced valid sleep and activity data for each individual and correctly mapped to the subjective data collected in the sleep diaries was critical to confirming the use of the GA actigraph in our larger studies. Additionally, confirming the use of the Van Hees algorithm versus other older but more common sleep determination algorithms for actigraphy (e.g. Sadeh 1994 or Cole-Kripke 1992) was important for this age group. While the samples size in this study is far too low to validate the use of Van Hees algorithm in this age group, we are prepared pre-emptively validate its use in a future larger study. Therefore, while not part of this thesis, the results of the pilot study and our team's assessment of the methods used will eventually be used to produce a trial manual for a larger intervention trial.

6.2 Secondary Outcome Analysis from the Pilot Study

Inadequate sleep can have negative effects on various aspects of health, such as obesity, heart disease, depression, academic performance, and overall well-being (Owens, 2014). Research by Lofthouse et al. (2009) has shown a connection between insomnia and depression in children and adolescents. Treating insomnia can improve the effectiveness of depression treatment. Additionally, there is substantial evidence linking lack of sleep to childhood obesity, which has long-lasting consequences (Owens, 2014). For instance, one study indicated that for every hour of lost sleep, adolescents had an 80% higher risk of obesity (Gupta et al., 2002). However, a study involving 13,568 adolescents contradicted this, suggesting that insufficient sleep is not linked to obesity (Calamaro et al., 2010).

A 2017 systematic review (Dutil et al., 2017) found that insufficient sleep could be associated with type 2 diabetes. It is worth noting, our results indicate that longer sleep duration is correlated with increased sugar consumption, which is not in line with previous research (Chaput et al., 2018; Morrissey et al., 2019). Moreover, Watson et al. (2018) discovered no connection between sugar consumption, behavioral issues, or sleep problems, and this was consistent across different subgroups. The discrepancies in results may be attributed to the small sample size or differences in the characteristics of the study population and data collection methods used to assess dietary habits and sleep patterns. The limited sample size may have failed to capture significant differences in the data, contributing to the disparities with previous studies.

However, it's important to note that including individuals with extremely short sleep durations is valuable for future research. While they may seem like outliers in our current sample, such individuals represent a realistic data point that may emerge in larger studies. Despite their shorter sleep duration, their inclusion provides crucial insights into the full spectrum of sleep patterns and their potential impact on energy and sugar consumption. Therefore, while the smaller sample size may highlight them as outliers, their data significantly contributes to our understanding of sleep-related outcomes. As our study expands to include a more diverse population, incorporating individuals with varying sleep patterns, particularly short sleepers, will be essential to enhance the generalizability of our findings. Additionally, variations in data collection methods for dietary habits and sleep patterns could explain the discrepancies between our study and previous ones. It's worth noting that most studies so far have been cross-sectional and unable to establish causality, although a randomized controlled trial included in our analysis did find a positive association between longer sleep duration in children and increased calorie intake (Hart et al., 2022).

This study showed that sleep duration is positively correlated to the amount of added sugar and average sugar, but after adjusting for covariates, no significant relationship was found. It has been shown in previous research that sugar intake and sleep duration generally have an inverse relationship among both children and adults (Fujiwara et al., 2019; Kjeldsen et al., 2014; Mozaffarian et al., 2020). In addition, Martinez and colleagues (Martinez et al., 2017) reported a unadjusted relation between total sugar and sleep duration. Similar findings were reported by Komada and collaborators (Komada et al., 2017) who concluded that there was no significant relationship between sleep duration and consumption of confectionery among Japanese women and men. Moreover, two studies (Hjorth, Quist, et al., 2014; Hunsberger et al., 2015) found no relationship between sleep duration and sugar intake. In addition, three studies (Hjorth, Chaput, et al., 2014; Labree et al., 2015; Ma et al., 2021) found no relationship between prolonged sleep duration and sugar-sweetened beverage intake. These results provide further evidence for the complex interplay between sleep duration and diet. The mechanism underlying these associations must be further investigated, along with potential moderators and mediators likely to play a role.

In addition, the findings from my study indicate that a high proportion of participants did not meet the recommended level of PA, with 70% having less than 60 minutes of PA per day. This result is consistent with the general statistic from the 2018 ParticipACTION Report Card on Physical Activity for Children and Youth (Tremblay et al., 2018), which showed that only 35% of Canadian children and adolescents between the ages of 5 and 17 met the Canadian Physical Activity Guidelines. This suggests a concerning trend of low levels of PA among children and youth. Engaging in PA can lead to a range of health benefits, including a reduction in hypertension, dyslipidemia, type 2 diabetes, metabolic syndrome, and some cancers. Furthermore, PA can contribute to other positive health outcomes, such as lowering body weight, improving mental health, and improving muscle, bone, and muscle strength that can prevent falls and improve daily living abilities (Anderson, 2004; Asigbee et al., 2018). Enhancing cognitive performance, increasing self-esteem, and reducing anxiety and stress are all associated with PA as well (Chomitz et al., 2009). A study has shown that PA is positively correlated with sleep (Sijtsma et al., 2015). Even though a larger sample size would have been preferable, it is crucial to note that the use of actigraphy as a data collection method reduced the variability of these measures when compared to questionnaires alone. Hence, we were able to obtain objective and reliable data about sleep and physical activity. Even though our sample size was smaller than that employed in some previous studies, actigraphy was beneficial in improving the quality and accuracy of the gathered data. The present study combined self-report questionnaires with objective measures of sleep and physical activity, but self-reported data may be inaccurate. As well as this, objective measures of sleep and physical activity may not yet capture all children's behaviors.

Most participants in my study exceeded the recommended screen time limit of 2 hours (81.2%). It is in line with the findings of the 2018 ParticipACTION Report Card on Physical Activity for Children and Youth (Tremblay et al., 2018), which reported that 51% of children between the ages of 5 and 17 exceeded the recommended screen time. The results of a systematic review of reviews found a strong evidence of associations between ST and depressive symptoms, with weak evidence of associations between ST and problem behaviors, anxiety, hyperactivity, and inattention (Stiglic et al., 2019). Sleep duration and quality are significantly affected by digital media from infancy through adolescence, with increased screen time associated with shorter sleep durations (Magee et al., 2014). As a result of inadequate sleep, daytime fatigue increases screen viewing and sedentary behavior the next day (Must et al., 2009). It has been shown that prolonged screen time is associated with obesity, dysfunction in HDL, and high blood pressure, all of which are cardiovascular health risk factors (Goldfield et al., 2011; Merghani et al., 2016). In agreement with these findings, our statistics indicate that 81.2% of our participants spent more than two hours on digital devices and use multiple devices at the same time. Considering the high prevalence of screen time and its potential impact on several aspects of health, including diet, it is important to realize the importance of screen time.

The 2018 ParticipACTION Report Card for Physical Activity for Children and Youth revealed that Canadian children and youth consume more added sugars than the recommended amount, which aligns with the present study's findings that 83% of participants exceeded the recommended added sugar intake. Intrinsic sugars refer to natural sugars found in fruits, vegetables, and dairy products. Sugars are present in this group inherently and are not added during processing. Added sugars is refer to the amount of sugar is added during food preparation, processing, or serving. Food products contain ingredients such as table sugar, high-fructose corn syrup, honey, and other sweeteners. For intrinsic sugars, there are no specific recommendations; however, there are various recommendations for added sugars. Dietary Guidelines for Americans recommend consuming less than 10% of energy from added sugars. A specific Dietary Reference Intake (DRI) for added sugar is not provided by the Dietary Reference Intake, but it is recommended that added sugars should not exceed 25 percent of your total energy intake. According to the World Health Organization (WHO), sugars from both added sugars and fruit juice must make up less than 10% of our total energy intake (Bailey et al., 2018). Similarly, my study found that 70% of participants consumed less than 3.5 servings of fruits and vegetables, which is consistent with the broader trend among Canadian children. Only 1 in 10 Canadian youth meet the recommended daily intake of fruits and vegetables (Minaker et al., 2016). Numerous health conditions have been associated with excessive sugar intake, such as dental caries, obesity, cardiovascular disease, type-2 diabetes, metabolic syndrome, and non-alcoholic fatty liver disease (Paglia, 2019). The health benefits of fruits and vegetables cannot be overstated. Fruits prevent heart disease, colon cancer, depression, and pancreatic diseases, while vegetables prevent colon and rectal cancer, hip fractures, strokes, depression, and pancreatic diseases (Angelino et al., 2019). It should be kept in mind that the dietary habits of an individual are influenced by various factors such as the community they belong to, their family, and personal considerations such as the accessibility and affordability of food options. Considering these different variables is central to understanding dietary patterns, such as those outlined in the 2019 Canada Food Guideline (CFG). As part of the 2019 CFG, evidence-based guidelines are offered regarding healthy eating, emphasizing whole meals and plant-based alternatives. Nutritional frameworks such as this provide a great resource for evaluating and informing eating choices.

In summary, this study explores sleep parameters and other aspects of lifestyle factors including PA and ST. . Deviating from established lifestyle guidelines can have negative impacts on various health outcomes. While we have a good understanding of healthy lifestyles, there is always room for improvement and further exploration. It is important to note that this pilot cross-sectional analysis assessed exposure and outcomes simultaneously, so we cannot infer causality or establish a chronological relationship. To determine causality, we need to conduct either a prospective cohort study or a randomized controlled trial with a specific lifestyle factor as the intervention. The findings from this pilot and feasibility study will help to develop such a trial that investigates the link between sleep and dietary patterns in children.

In the larger trial, participants will be randomly assigned to either an intervention group or a control group. The intervention group would receive sleep-promoting interventions like cognitive behavioral therapy for those with insomnia or multi-week sleep behavior coaching demonstrated to increase sleep duration, while the control group will maintain their regular sleep habits. This randomized design will help us assess the causal effect of the intervention improving the dietary pattern in children, providing stronger evidence to guide sleep recommendations for promoting healthy eating habits.

6.3 Strengths

This feasibility study, conducted on children aged 9 to 12 years, had several notable strengths. It employed a comprehensive approach to assess sleep and physical activity, utilizing both questionnaires and actigraphy. This approach allowed for a deeper understanding of the children's behaviors.

Additionally, the use of water-resistant actigraphy ensured uninterrupted monitoring of sleep and physical activity, increasing the accuracy and reliability of the data. Furthermore, the inclusion of the ASA24 tool for assessing dietary habits improved the reliability and precision of dietary assessments. ASA24 collected data over two days, covering both weekdays and weekends, offering a more comprehensive view of the children's food intake and accounting for variations between weekdays and weekends.

The study also considered screen time, these days an often-overlooked aspect of children's lives. With the growing prevalence of digital devices and streaming technologies, the use of screens while eating has become increasingly common across all age groups. Given the close relationship between passive eating and digital device use, it's crucial to factor in these variables when examining food intake, including the amounts and types of food consumed, in studies that investigate diet and other lifestyle factors.

Lastly, this study focused on an age group that has received relatively little attention in the research literature. By examining sleep, physical activity, screen time, and dietary habits in children aged 9-12 years over the course of seven days, it aimed to provide a more comprehensive assessment while minimizing potential bias. This research contributes valuable insights to the field by shedding light on the behaviors of this age group.

6.4 Limitations

The study was designed as a pilot and feasibility study, so 22 participants were recruited. This sample size was appropriate for this study design, because the study was observational, and the main objective was to determine whether it would be feasible to conduct a larger study in the future. Small sample sizes can limit the generalizability and reliability of study experimental results. Due to the smaller sample size, results may be biased or inaccurate to the extent that they are not representative of the population being studied. For example, the 22 participants do give us an expected range of data that will be collected using the actigraphy but with 22 individuals the normal distribution of these data points may not accurately describe the true distribution of these outcomes (e.g., sleep duration). To ensure the rigor of the study, several approaches were employed, including strict inclusion and exclusion criteria and a rigorous data analysis procedure. While we have taken measures to reduce the risk of type I error through strict statistical corrections, it's important to acknowledge that the small sample size may still contribute to this possibility.

One more factor to consider for future studies is collecting information about dietary habits when the child is engaged with screen time, specifically while watching TV, and data should also be gathered to ascertain whether participants have their own smartphones and tablets.

Another limitation of this study was that puberty was not assessed among participants. Because puberty is known to affect sleep patterns and physical activity patterns (Goran et al., 1998; Lucien et al., 2021), it is possible that the results were affected by puberty. Nonetheless, given the nature of this study, rather than aiming to draw definitive conclusions about lifestyle factors, its primary goal was to determine whether conducting a larger study on the subject was feasible. Puberty stages were not assessed to minimize participant burden and study resources. It would be helpful to determine the impact of puberty on children's lifestyle patterns in future studies. Our study, however, provides valuable information concerning the feasibility of obtaining data on sleep patterns and physical activity patterns in children ages 9-12 years as part of a pilot and feasibility study. This information can be used to develop a larger intervention study with more comprehensive measures, including puberty tests.

6.5 Future Direction

Following what was learned from the pilot and feasibility study, the research project plans to begin a new phase focused on intervention. Given that, the correlation between sleep duration and dietary intake as the most important results across outcomes in this study. The intervention study will focus on a more in-depth examination of the influence of sleep duration on dietary habits and its potential connection to obesity. Looking ahead, we see child specific Cognitive Behavioural Therapy for Insomnia (CBT-I) (Edinger et al., 2021) for children with insomnia or medium-term coaching approaches for extending sleep for short sleepers without insomnia (Baron et al., 2021; Baron et al., 2023) as a promising path for intervention.

An organized, evidence-based therapeutic method for treating sleep-related conditions is cognitive behavioral therapy for insomnia (CBT-I). Behavioral and cognitive strategies are combined to target the psychological factors contributing to sleep disturbances. In CBT-I, sleep habits are developed, dysfunctional thinking patterns about sleep are modified, and factors hindering sleep are managed. This therapy strategy frequently uses methods including sleep deprivation, stimuli control, cognitive restructuring, relaxation training, and sleep hygiene instruction. Overall, CBT-I aims to promoting a more regular and restorative sleep pattern (Alimoradi et al., 2022; Redeker et al., 2020). Across different age groups, CBT-I has been proven to be an effective approach to sleep difficulties (Dewald-Kaufmann et al., 2019). Where there is no indication that the children have insomnia a modified sleep coaching program will be employed.

To develop a comprehensive CBT-I or sleep coaching program, we intend to collaborate with sleep specialists and psychologists in our upcoming phase of research.

6.6 Conclusion

In conclusion, this pilot and feasibility study provides valuable insights into research design implementation, participant recruitment and retention, practical data collection, and overall study feasibility. High retention rates and effective participant engagement strategies affirm the study's feasibility. The data collection, including the use of ASA24 for dietary assessment, yielded high-quality data for analysis. The decision to focus on actigraphy and self-reported data for measuring sleep parameters in a future intervention study is a strategic one aimed at optimizing research efforts and resources.

This pilot study enhances our understanding of the intricate relationship between lifestyle factors, especially sleep and dietary intake. It aligns with our success criteria, which involve demonstrating study feasibility, gathering preliminary data, identifying challenges, generating recommendations, and informing future research decisions.

CHAPTER 7: Appendices

7.1 Consent Form

TITLE: Sleep Duration and Quality in Children: Interactions with Food Choices, Energy Balance and Digital Screen-Time (Sleep - FAST Study: Sleep, Foods, Activity, Screen Time)

RESEARCHER(S): Dr. Scott Harding **Phone Number:** 864-8539 / 864-4711

SUPERVISOR(S):

SPONSOR/FUNDER: Memorial University of Newfoundland/ Janeway Hospital

You have been invited to take part in a research study. Taking part in this study is voluntary. You may choose to take part or you may choose not to take part in this study. You also may change your mind at any time.

This consent form has important information to help you make your choice. It may use words that you do not understand. Please ask the [researcher(s)/study staff] to explain anything that you do not understand. It is important that you have as much information as you need and that all your questions are answered. Please take as much time as you need to think about your decision to participate or not, and ask questions about anything that is not clear. You may find it helpful to discuss it with your friends and family. The [researcher/study staff] will tell you about the study timelines for making your decision.

1. Why am I being asked to join this study?

You are being invited to join this study because our target age group is children 9 -12 years. This study is being done to find out more information about the relationship between sleep duration and quality and impact of it on food choices. Also, we are trying to find relationship between physical activity, screen time and food choices.

2. How many people will take part in this study?

This study will take place in Newfoundland, Canada, North America. The study will enroll a total of 30 people.

3. How long will I be in the study?

You will be expected to come to the Nutrition and Lifestyle Lab in Memorial University for 2 visits over the next 12 months. Each visit will last 1-2 hours.

4. What will happen if I take part in this study?

If you agree to take part in this study, the following tests and procedures will be done in addition to your usual care.

- Measuring height, weight, waist and hip circumference, blood pressure in the study.
- Ask you questions in demographic questionnaire like age, sex, ethnicity, parents' education level, household income, etc.
- Questionnaires about Physical Activity, Sleep, Screen Time, Food Habits twice per year (School year phase and summer phase which is optional) should be completed by participants and parents. The purpose of the questionnaire is to understand how four important factors of lifestyle is affect on obesity and health status. Each questionnaire will take about 5 minutes to complete. Food recall take about 45 minutes. Some of the questions are personal; you may choose not to answer these if you wish.
- Completing two 24-hour recalls using the US National Cancer Institute web-based, diet recording software.
- Wearing Actigraphy device for seven days.
- Participant Diaries - You will be asked to keep a diary of when you use Actigraphy. Please record the exact time of using Actigraphy in your daily diary.
- A detailed list of all tests and procedures may be found on a table after the Signature Page.

5. Are there risks to taking part in this study?

Actigraphy is a non-invasive method for measuring the amount of physical activity and sleep. Also, there are no reports that actigraphy has side effect. But, using the actigraphy for a week maybe bring the inconvenience for you.

During the study, there are several questionnaires which can be some discomfort answering and during the study you should attend twice to Nutrition and Lifestyle lab at Memorial University.

Despite protections being in place, there is a risk of unintentional release of information. Researchers will make every attempt to protect your privacy.

Just for your information you can contact in emergency:
Mental health resources – Doorways (709) 752-4903; Mobile Crisis Response Team (709) 437-4668; Child & Adolescent Mental Health Central Intake (709) 777-2200; bridgethegap.com; and any Hospital Emergency Room.

6. What are the possible benefits of participating in this study?

There may not be direct benefit to you from taking part in this study.
We hope that the information learned from this study can be used in the future to benefit other people with unhealthy lifestyle.

7. If I decide to take part in this study, can I stop later?

It is your choice to take part in this study, participation is voluntary. You can change your mind at any time during the research study. The study team may ask why you are withdrawing for reporting purposes, but you do not need to give a reason to withdraw from the study if you do not want to. If you decide to leave the study, you can contact your researcher. They will discuss other options with you.

You may fully withdraw from this study. This means that the researcher/study staff will no longer access your health records or use your data for research and all data collected about you will be destroyed.

We can remove your data up to the point of publishing the data or presenting it in abstract form at a conference.

8. What are my rights when participating in a research study?

You have the right to receive all information that could help you make a decision about participating in this study, in a timely manner. You also have the right to ask questions about this study at any time and to have them answered to your satisfaction.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form you do not give up any of your legal rights against the study doctor, sponsor or involved institutions for compensation, nor does this form relieve the study doctor, sponsor or their agents of their legal and professional responsibilities.

You have the right to be informed of the results of this study once the entire study is complete. A lay summary of results will be sent to each participant next six months after completing the data. Also, results with detail will publish through the conference and papers.

You will be given a copy of this signed and dated consent form prior to participating in this study.

9. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. If you decide to participate in this study, the researchers/study staff will collect and use information from your health records. They will only collect and use the information they need for this study, including:

- gender
- date of birth (1990)

- information from study interviews and questionnaires

The personal health information or personal information collected about you will have your directly identifiable information removed (i.e., name) and replaced with a code or with a "study number". There will be a master list linking the code numbers to names. The researcher is responsible for keeping it separate from the personal health information.

Study information collected during the study will kept at this site and stored in a secure, locked place that only the study staff will be able to access. After the study closes, study information will keep as long as required by law, which could be 7 years or more. This information will be stored in Memorial University of Newfoundland. Dr. Scott Harding is the person responsible for keeping it secure.

All information that identifies you will be kept confidential, and to the extent permitted by applicable laws, will not be disclosed or made publicly available, except as described in this consent document. Every effort to protect your privacy will be made. Even though the risk of identifying you from the study data is very small, it can never be completely eliminated. If there is a breach of your privacy anytime after your participation in this study you will be notified.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

10. Who will see my personal information?

Personal health information under the supervision of the study staff to check that the information collected for the study is correct and to make sure the study followed the required laws and guidelines:

- Principal investigator
- Study staff
- HREA staff

We may continue to review your study information that you have consented for the study to access for a period of time after your last study visit in order to check that the information, we collected is correct.

<u>Your access to records</u>
You have the right to see the information that has been collected about you for this study. If you wish to do so, please contact your study staff.

11. Commercialization:

In this study there is no possibility that a commercial product be developed.

13. What about questions or problems?

If you have any questions about taking part in this study, you can meet with the principal investigator who is in charge of the study. That person is:

Dr. Scott Harding

Phone Number: 864-8539 / 864-4711

Or you can talk to someone who is not involved with the study at all but can advise you on your rights as a participant in a research study. This person can be reached through:

Ethics Office at 709-777-6974

Email at info@hrea.ca

Signature Page

My signature on this consent form means:

- I have had enough time to think about the information provided and ask for advice if needed.
- All of my questions have been answered and I understand the information within this consent form.
- I understand that my participation in this study is voluntary.
- I understand that I am completely free at any time to refuse to participate or to withdraw from this study at any time, without having to give a reason, and that this will not change the quality of care that I receive.
- I understand that it is my choice to be in the study and there is no guarantee that this study will provide any benefits to me.
- I am aware of the risks of participating in this study.
- I do not give up any of my legal rights by signing this consent form.
- I understand that all the information collected will be kept confidential and that the results will only be used for the purposes described in this consent form.
- I agree, or agree to allow the person I am responsible for, to take part in this study

Signature of participant Printed name Day Month Year

Signature of person authorized as substitute decision maker Printed name Day Month Year

Signature of person conducting the consent discussion Name printed Day Month Year

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant/substitute decision maker fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of Researcher Name Printed Day Month Year

Signature Page for Parent/Guardian

My signature on this consent form means:

- I have had enough time to think about the information provided and ask for advice if needed.
- All of my questions have been answered and I understand the information within this consent form.
- I understand that my participation in this study is voluntary.
- I understand that I am completely free at any time to refuse for my child/ward to participate or to withdraw from this study at any time, without having to give a reason, and that this will not change the quality of care that my child/ward receives.
- I understand that it is my choice for my child/ward to be in the study and there is no guarantee that this study will provide any benefits to me.
- I am aware of the risks of my child/ward participating in this study.
- I do not give up any of my my child/ward's legal rights by signing this consent form.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the purposes described in this consent form.

I consent for my child/ward ______________________________________to take part in this study.

Signature of parent/guardian Name printed Day Month Year

Signature of person conducting Name printed Day Month Year the consent discussion

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the parent/guardian fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen for the child/ward to be in the study.

Signature of Investigator Printed Name Day Month Year

To be signed by the minor participant [if appropriate]

Assent of minor participant:

I understand the purpose of this research
I understand that it is my decision to take part in this study. I can stop taking part if I chose.
I understand that taking part in this research may not help me.
I understand that there may be risks to participating in this study.

I agree that I will take part in this study

Signature of minor participant Day Month Year

Name printed Age

Participant Assistance

Complete the following declaration only if the participant is unable to read:

- The informed consent form was accurately explained to, and apparently understood by, the participant, and
- Informed consent was freely given by the participant

Signature of Impartial Witness | Printed Name | Day Month Year

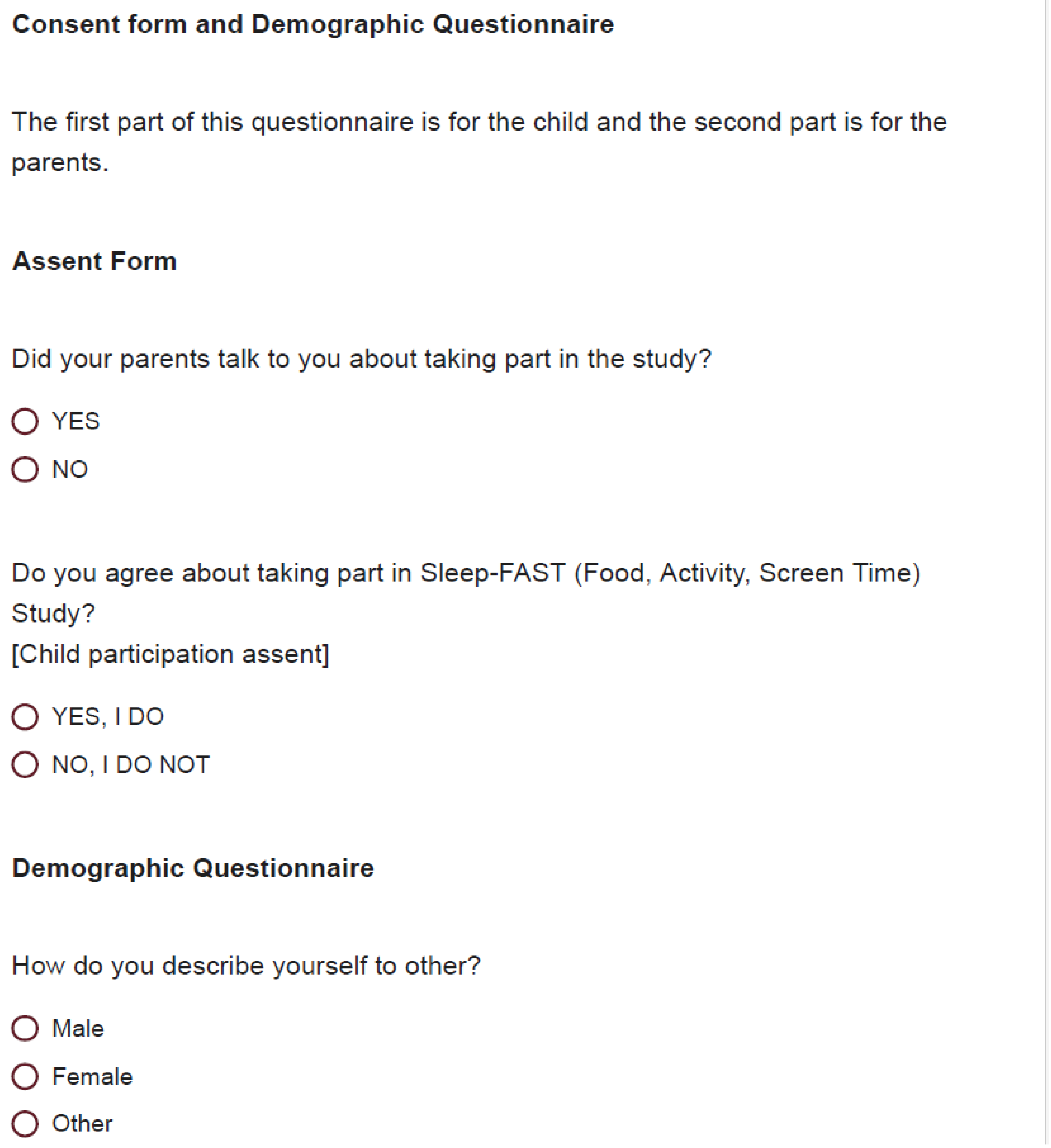
Complete the following declaration only if the participant has limited proficiency in the language in which the consent form is written and interpretation was provided as follows:

- The informed consent discussion was interpreted by an interpreter and
- A sight translation of this document was provided by the interpreter as directed by the research staff conducting the consent.

Interpreter Declaration and Signature:
By signing the consent form I attest that I provided a faithful interpretation for any discussion that took place in my presence, and provided a sight translation of this document as directed by the research staff conducting the consent.

Signature of Interpreter | Printed Name | Day Month Year

7.2 Demographic Questionnaire



Consent form and Demographic Questionnaire

The first part of this questionnaire is for the child and the second part is for the parents.

Assent Form

Did your parents talk to you about taking part in the study?

○ YES

○ NO

Do you agree about taking part in Sleep-FAST (Food, Activity, Screen Time) Study?
[Child participation assent]

○ YES, I DO

○ NO, I DO NOT

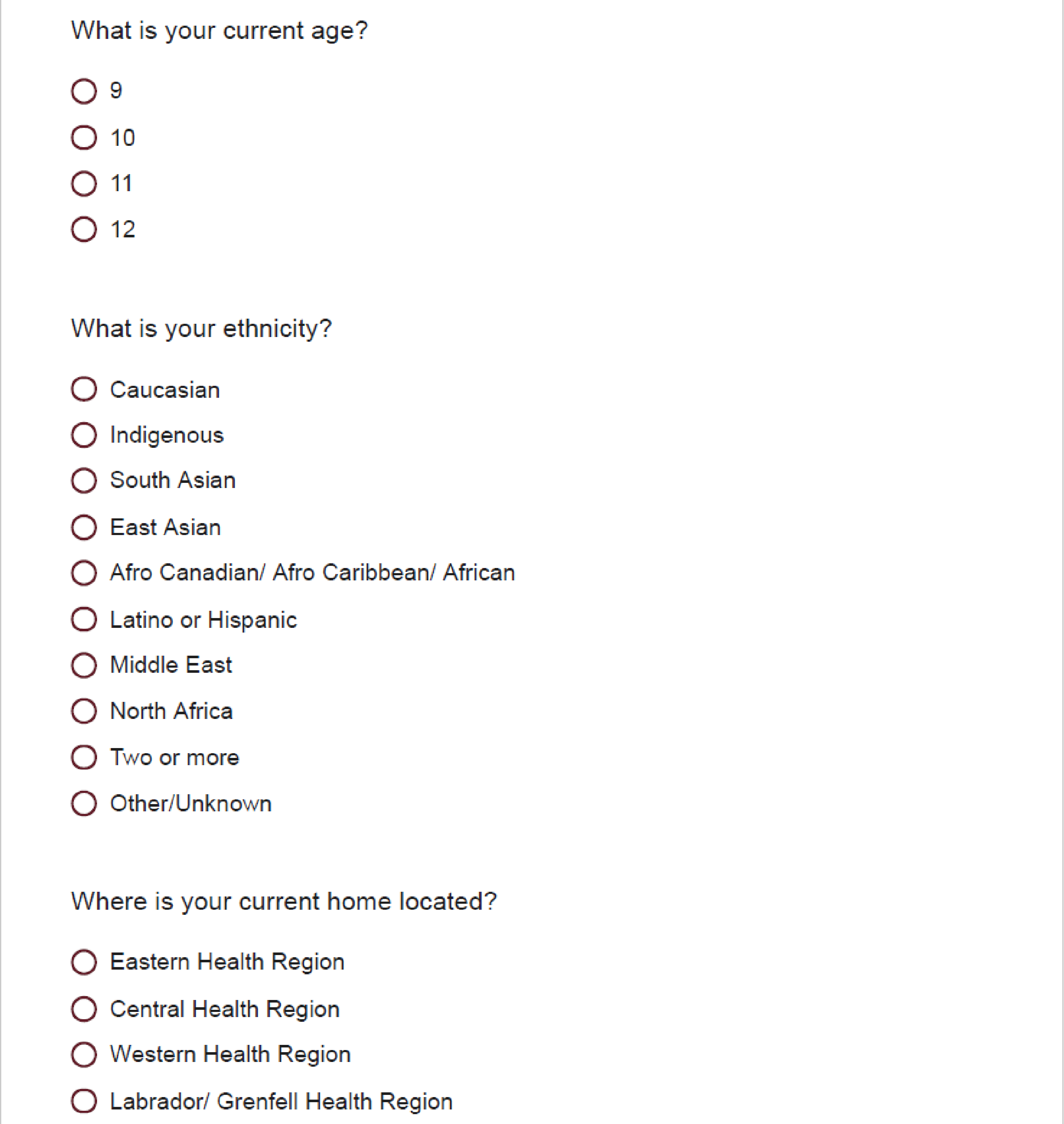
Demographic Questionnaire

How do you describe yourself to other?

○ Male

○ Female

○ Other



What is your current age?

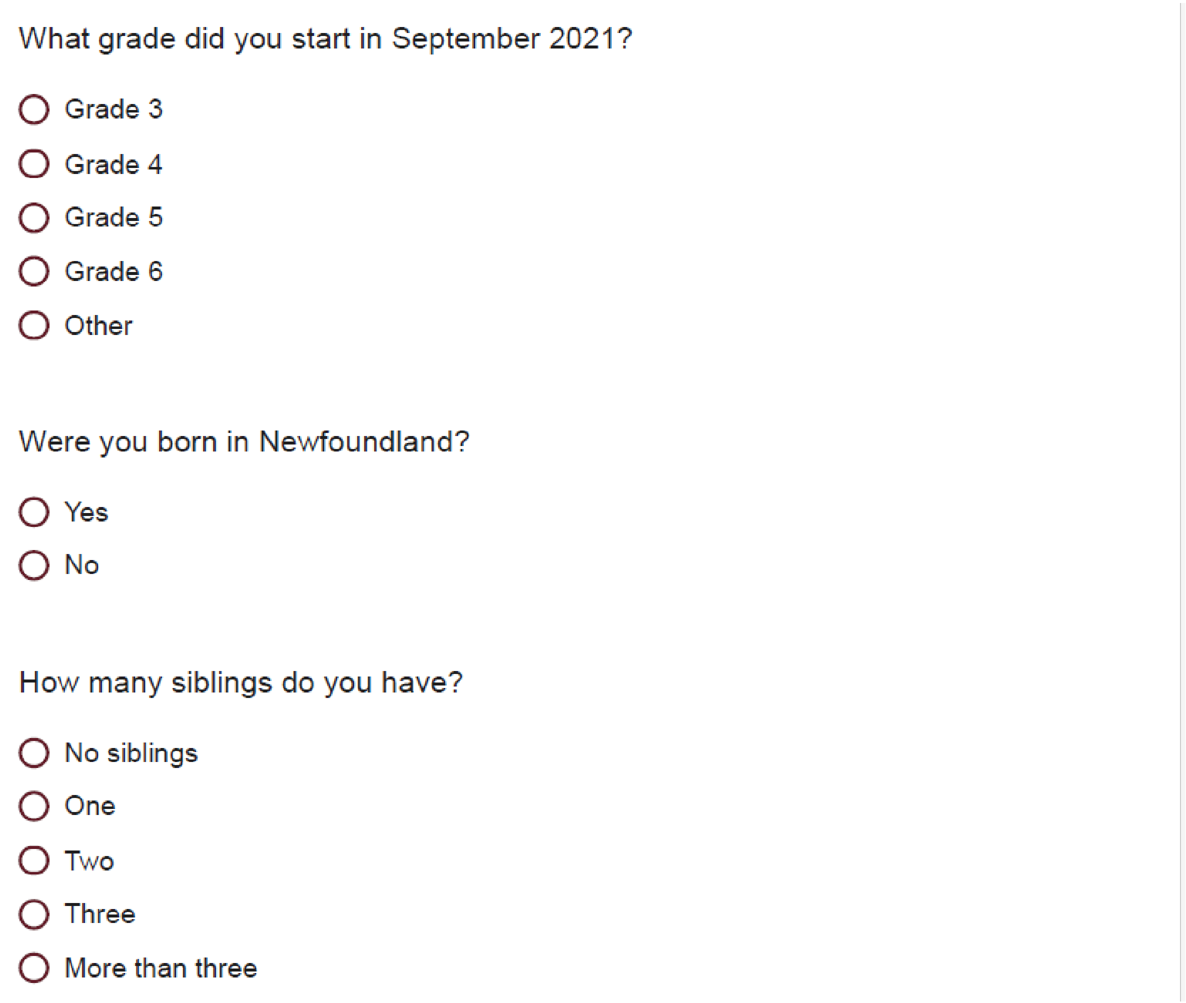
- ○ 9
- ○ 10
- ○ 11
- ○ 12

What is your ethnicity?

- ○ Caucasian
- ○ Indigenous
- ○ South Asian
- ○ East Asian
- ○ Afro Canadian/ Afro Caribbean/ African
- ○ Latino or Hispanic
- ○ Middle East
- ○ North Africa
- ○ Two or more
- ○ Other/Unknown

Where is your current home located?

- ○ Eastern Health Region
- ○ Central Health Region
- ○ Western Health Region
- ○ Labrador/ Grenfell Health Region



What grade did you start in September 2021?

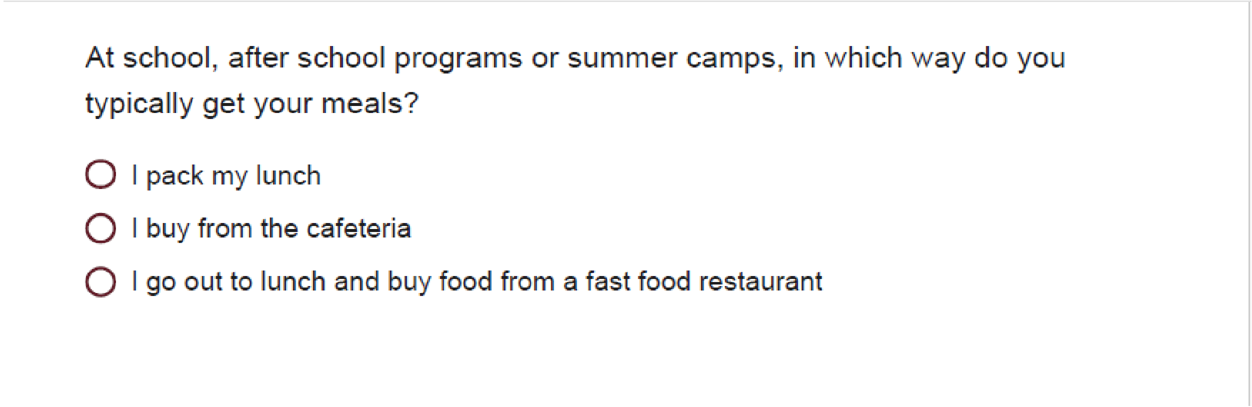
○ Grade 3
○ Grade 4
○ Grade 5
○ Grade 6
○ Other

Were you born in Newfoundland?

○ Yes
○ No

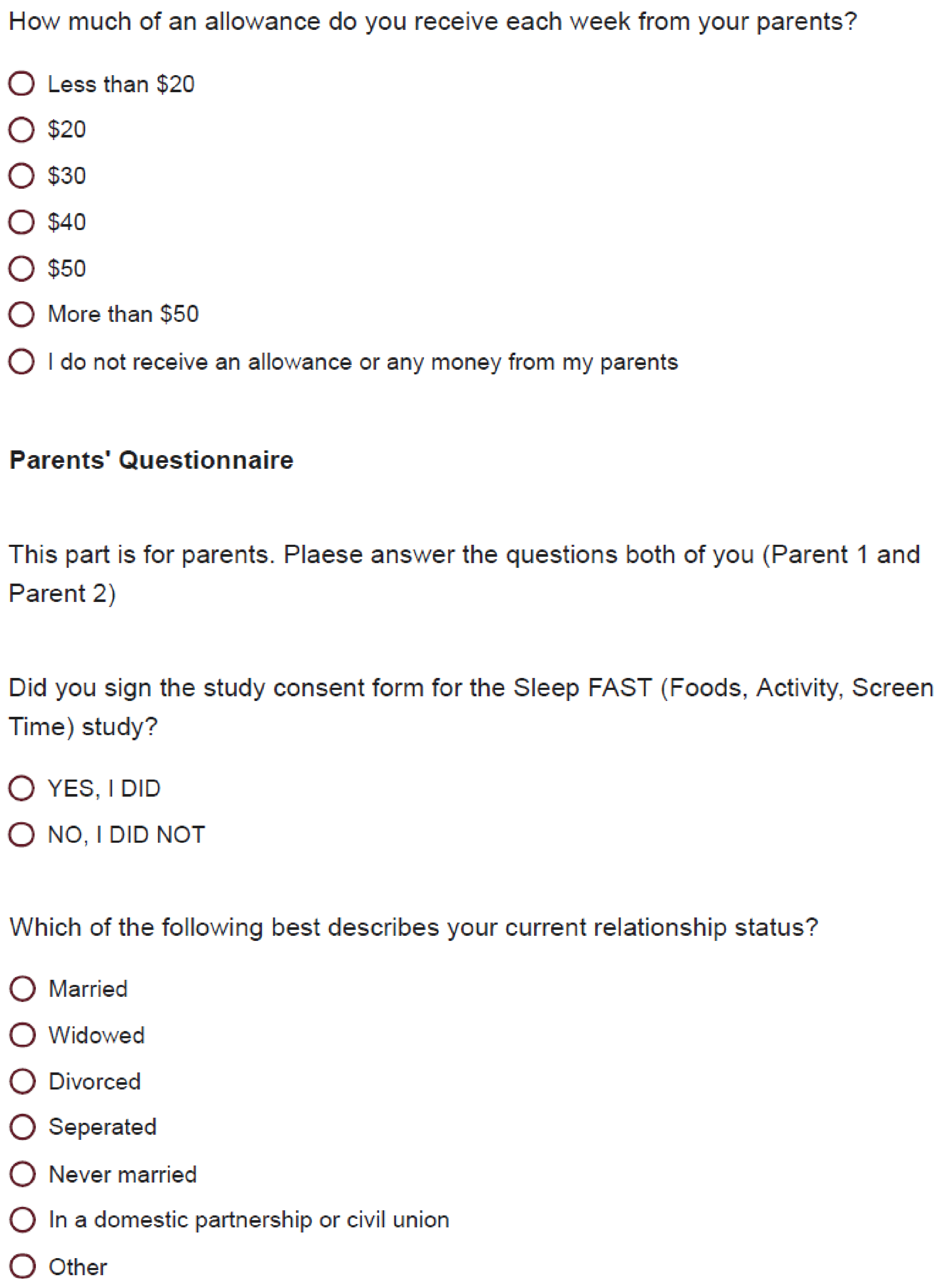
How many siblings do you have?

○ No siblings
○ One
○ Two
○ Three
○ More than three



At school, after school programs or summer camps, in which way do you typically get your meals?

○ I pack my lunch
○ I buy from the cafeteria
○ I go out to lunch and buy food from a fast food restaurant



How much of an allowance do you receive each week from your parents?

○ Less than $20
○ $20
○ $30
○ $40
○ $50
○ More than $50
○ I do not receive an allowance or any money from my parents

Parents' Questionnaire

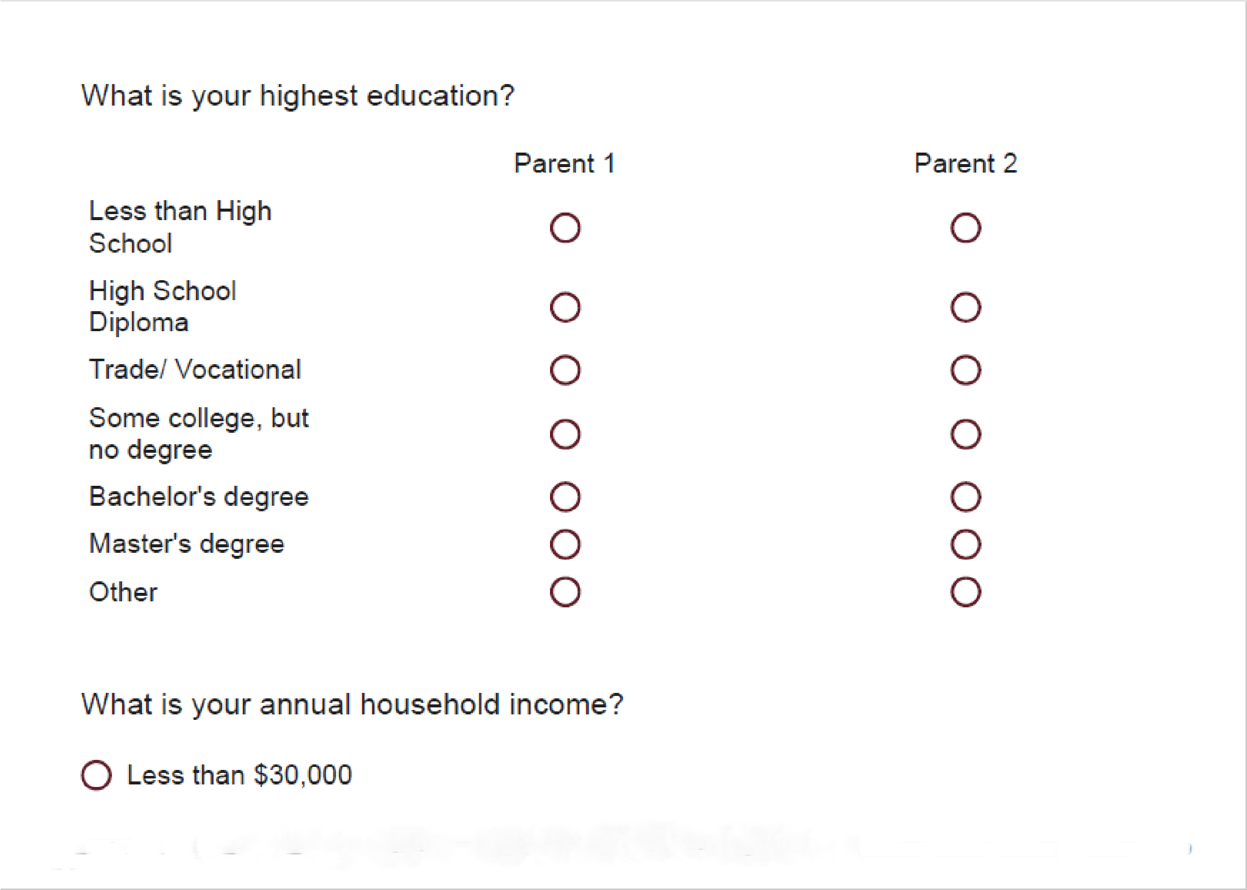
This part is for parents. Plaese answer the questions both of you (Parent 1 and Parent 2)

Did you sign the study consent form for the Sleep FAST (Foods, Activity, Screen Time) study?

○ YES, I DID
○ NO, I DID NOT

Which of the following best describes your current relationship status?

○ Married
○ Widowed
○ Divorced
○ Seperated
○ Never married
○ In a domestic partnership or civil union
○ Other



What is your highest education?

	Parent 1	Parent 2
Less than High School	○	○
High School Diploma	○	○
Trade/ Vocational	○	○
Some college, but no degree	○	○
Bachelor's degree	○	○
Master's degree	○	○
Other	○	○

What is your annual household income?

○ Less than $30,000

○ $30,000- $50,000

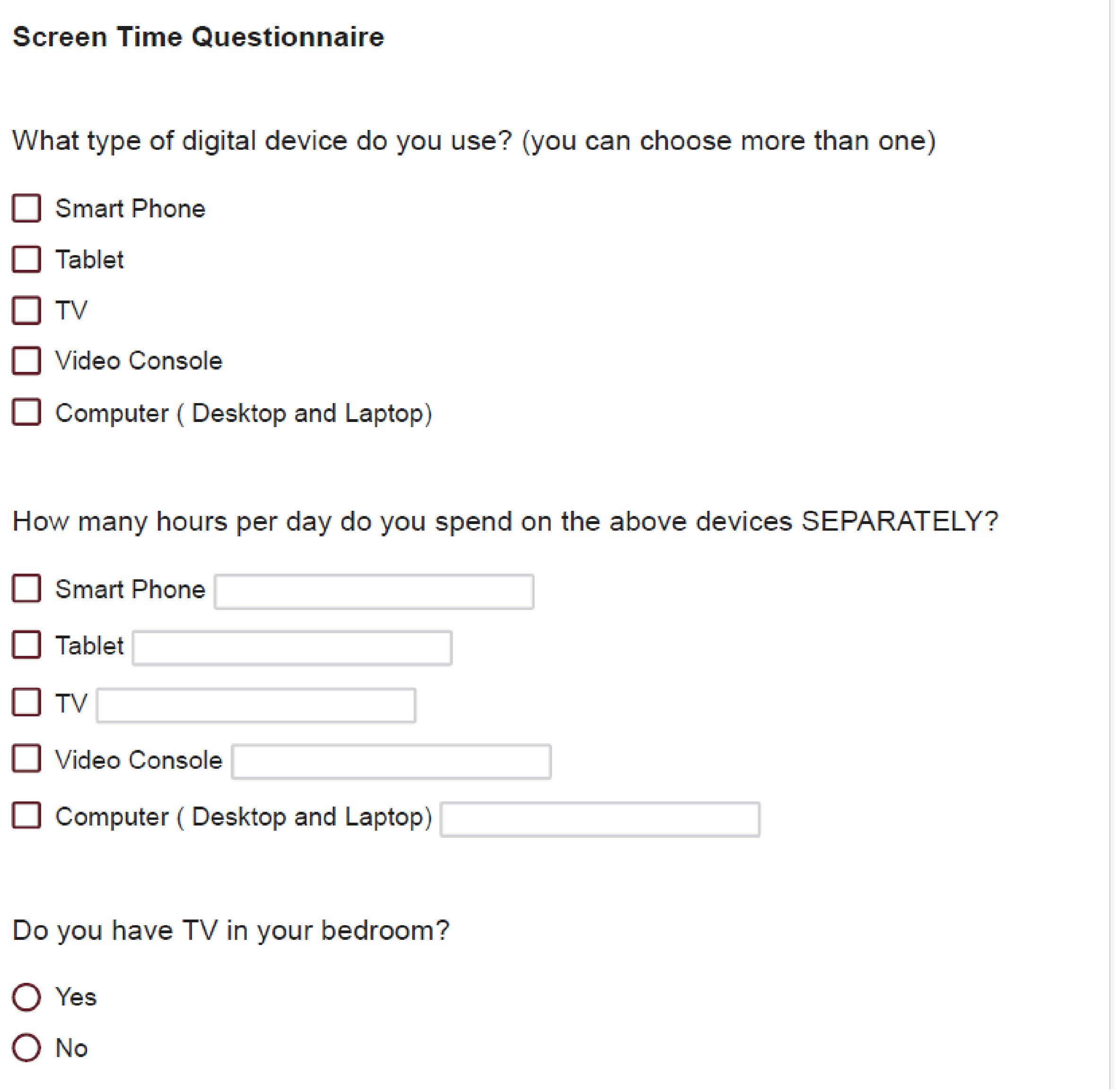
○ $50,000-$100,000

○ $100,000-$200,000

○ Greater than $200,000

○ Prefer not to answer

7.3 Screen Time Questionnaire



Screen Time Questionnaire

What type of digital device do you use? (you can choose more than one)

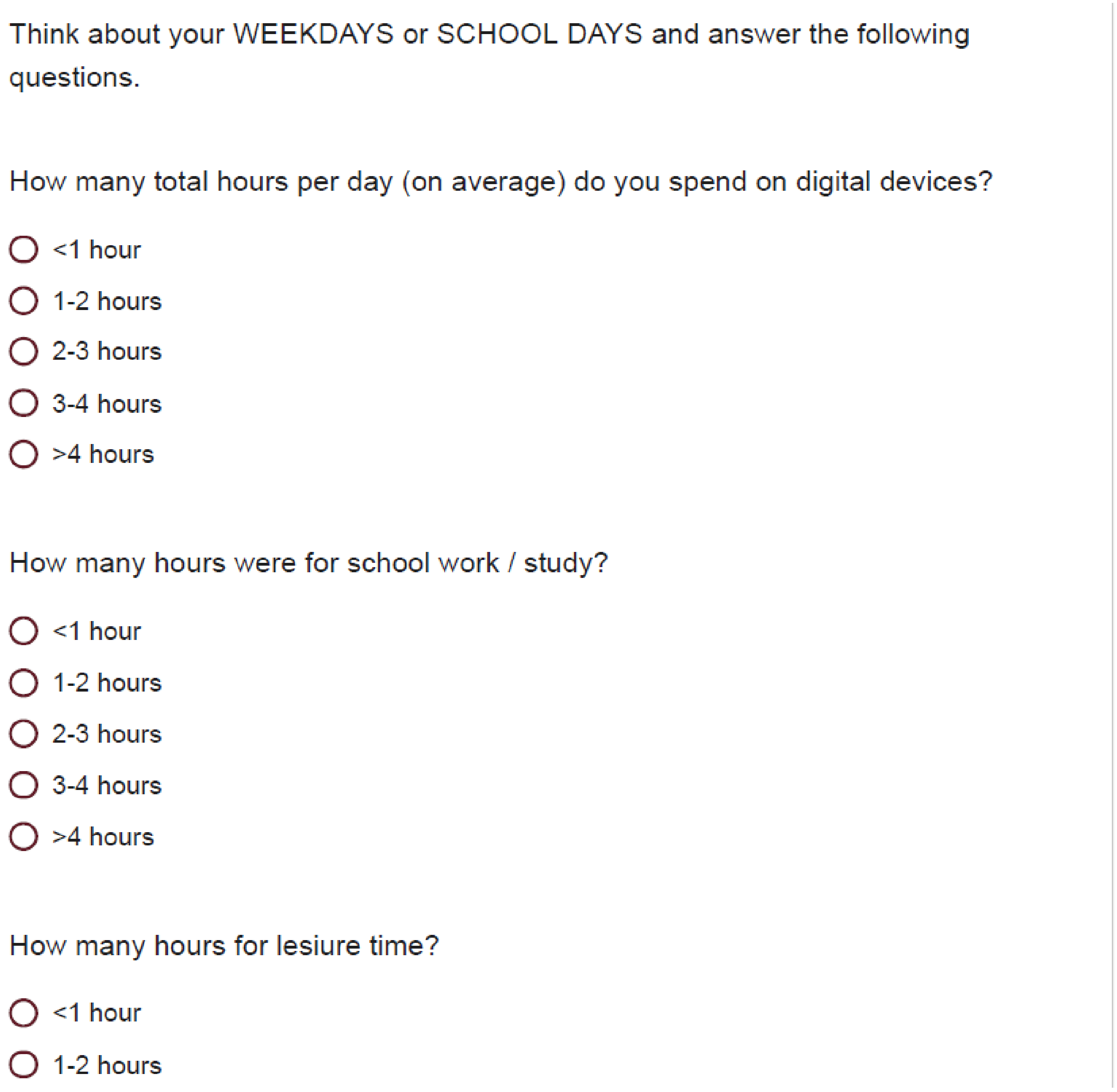
☐ Smart Phone
☐ Tablet
☐ TV
☐ Video Console
☐ Computer (Desktop and Laptop)

How many hours per day do you spend on the above devices SEPARATELY?

☐ Smart Phone
☐ Tablet
☐ TV
☐ Video Console
☐ Computer (Desktop and Laptop)

Do you have TV in your bedroom?

○ Yes
○ No



Think about your WEEKDAYS or SCHOOL DAYS and answer the following questions.

How many total hours per day (on average) do you spend on digital devices?

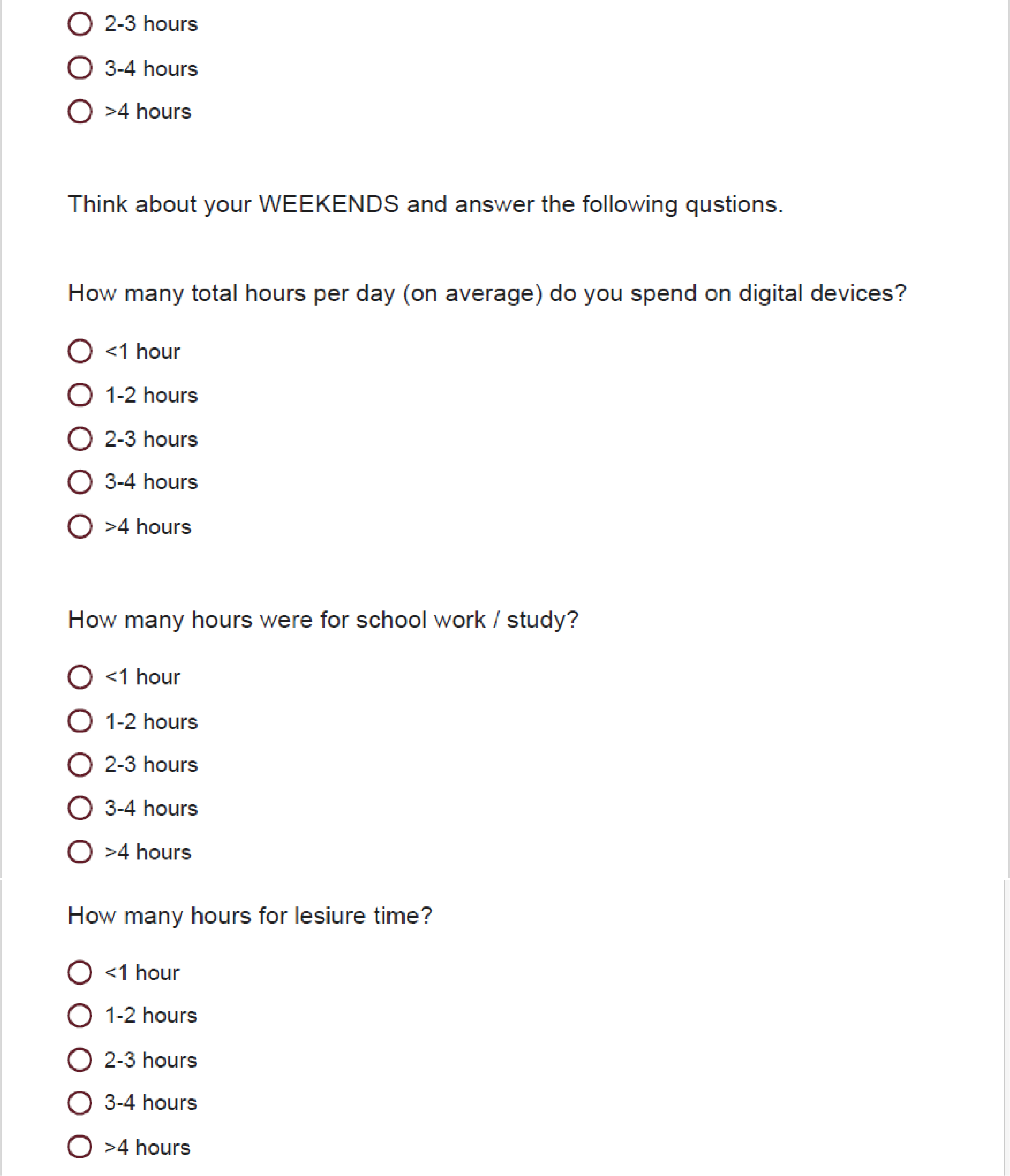
○ <1 hour
○ 1-2 hours
○ 2-3 hours
○ 3-4 hours
○ >4 hours

How many hours were for school work / study?

○ <1 hour
○ 1-2 hours
○ 2-3 hours
○ 3-4 hours
○ >4 hours

How many hours for lesiure time?

○ <1 hour
○ 1-2 hours



○ 2-3 hours

○ 3-4 hours

○ >4 hours

Think about your WEEKENDS and answer the following qustions.

How many total hours per day (on average) do you spend on digital devices?

○ <1 hour

○ 1-2 hours

○ 2-3 hours

○ 3-4 hours

○ >4 hours

How many hours were for school work / study?

○ <1 hour

○ 1-2 hours

○ 2-3 hours

○ 3-4 hours

○ >4 hours

How many hours for lesiure time?

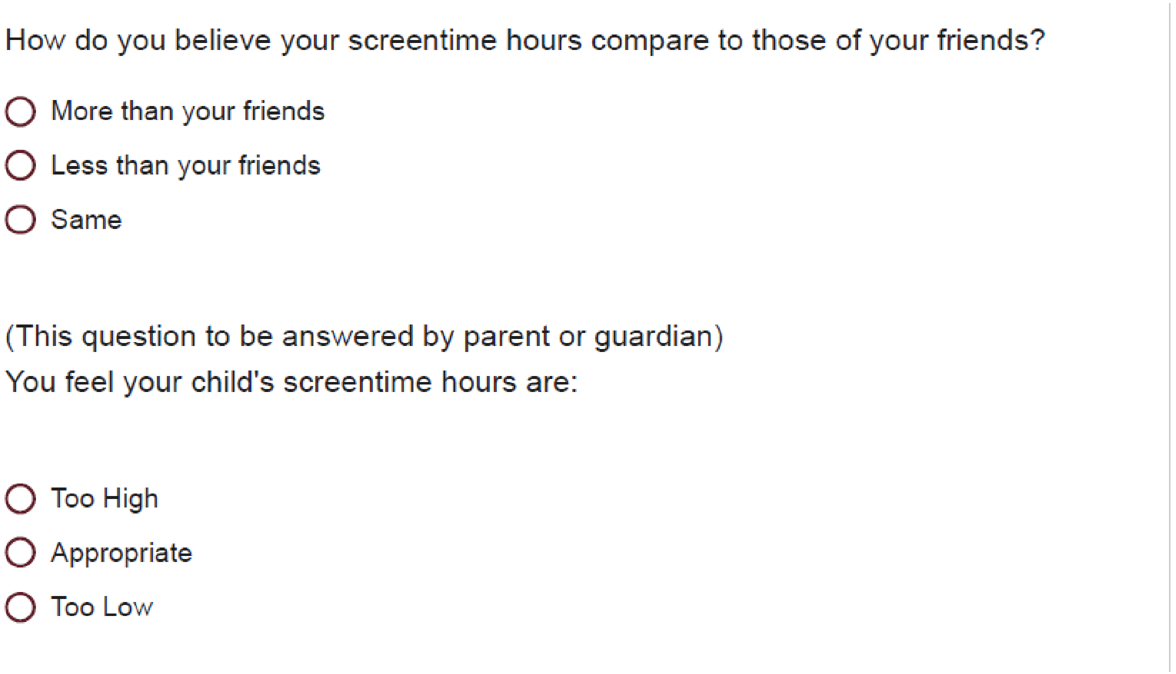
○ <1 hour

○ 1-2 hours

○ 2-3 hours

○ 3-4 hours

○ >4 hours



How do you believe your screentime hours compare to those of your friends?

○ More than your friends

○ Less than your friends

○ Same

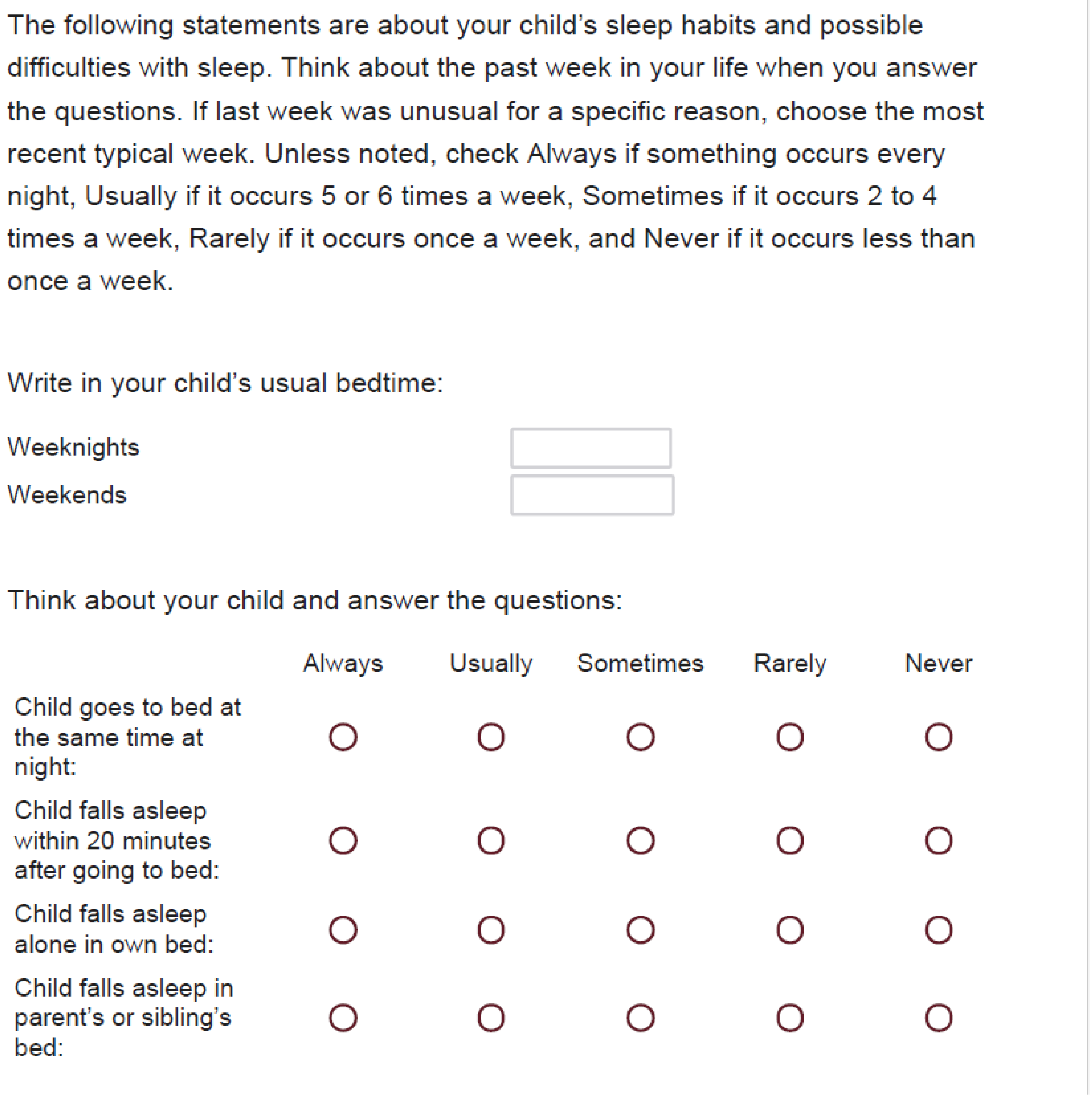
(This question to be answered by parent or guardian)
You feel your child's screentime hours are:

○ Too High

○ Appropriate

○ Too Low

7.4 Children Sleep Habit Questionnaire



The following statements are about your child's sleep habits and possible difficulties with sleep. Think about the past week in your life when you answer the questions. If last week was unusual for a specific reason, choose the most recent typical week. Unless noted, check Always if something occurs every night, Usually if it occurs 5 or 6 times a week, Sometimes if it occurs 2 to 4 times a week, Rarely if it occurs once a week, and Never if it occurs less than once a week.

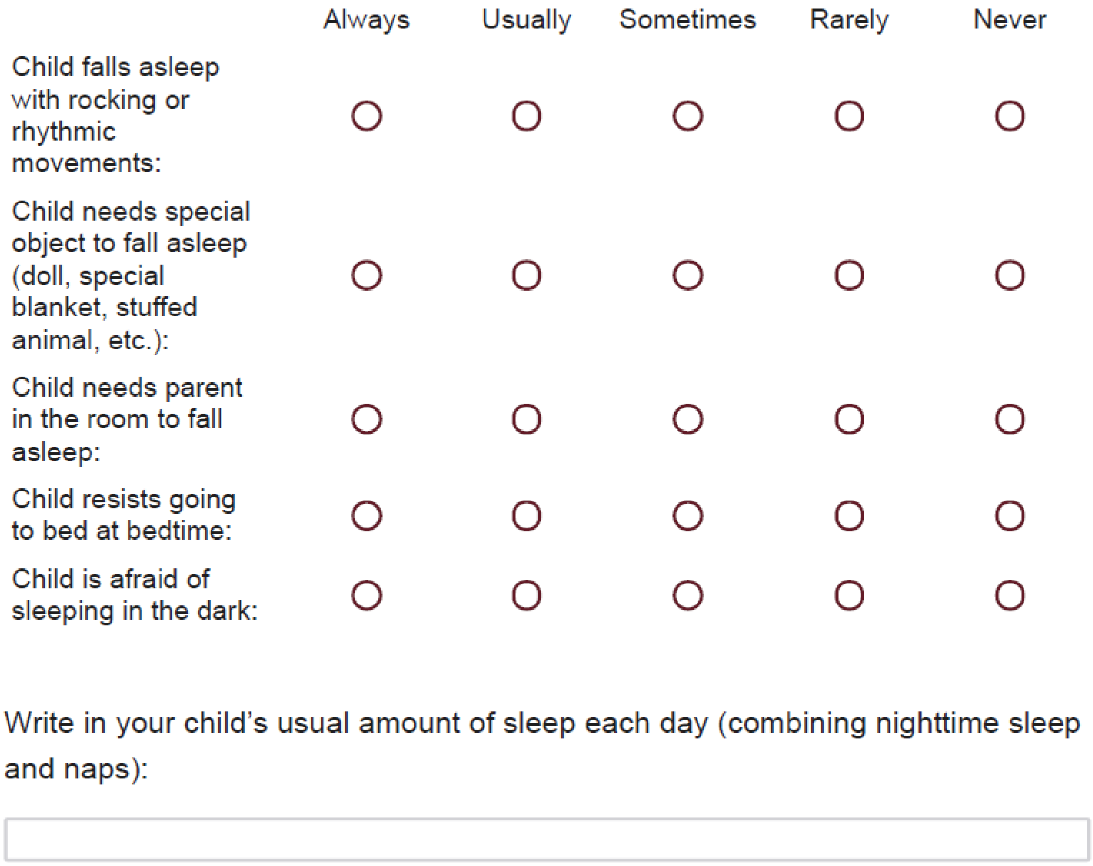
Write in your child's usual bedtime:

Weeknights

Weekends

Think about your child and answer the questions:

	Always	Usually	Sometimes	Rarely	Never
Child goes to bed at the same time at night:	○	○	○	○	○
Child falls asleep within 20 minutes after going to bed:	○	○	○	○	○
Child falls asleep alone in own bed:	○	○	○	○	○
Child falls asleep in parent's or sibling's bed:	○	○	○	○	○

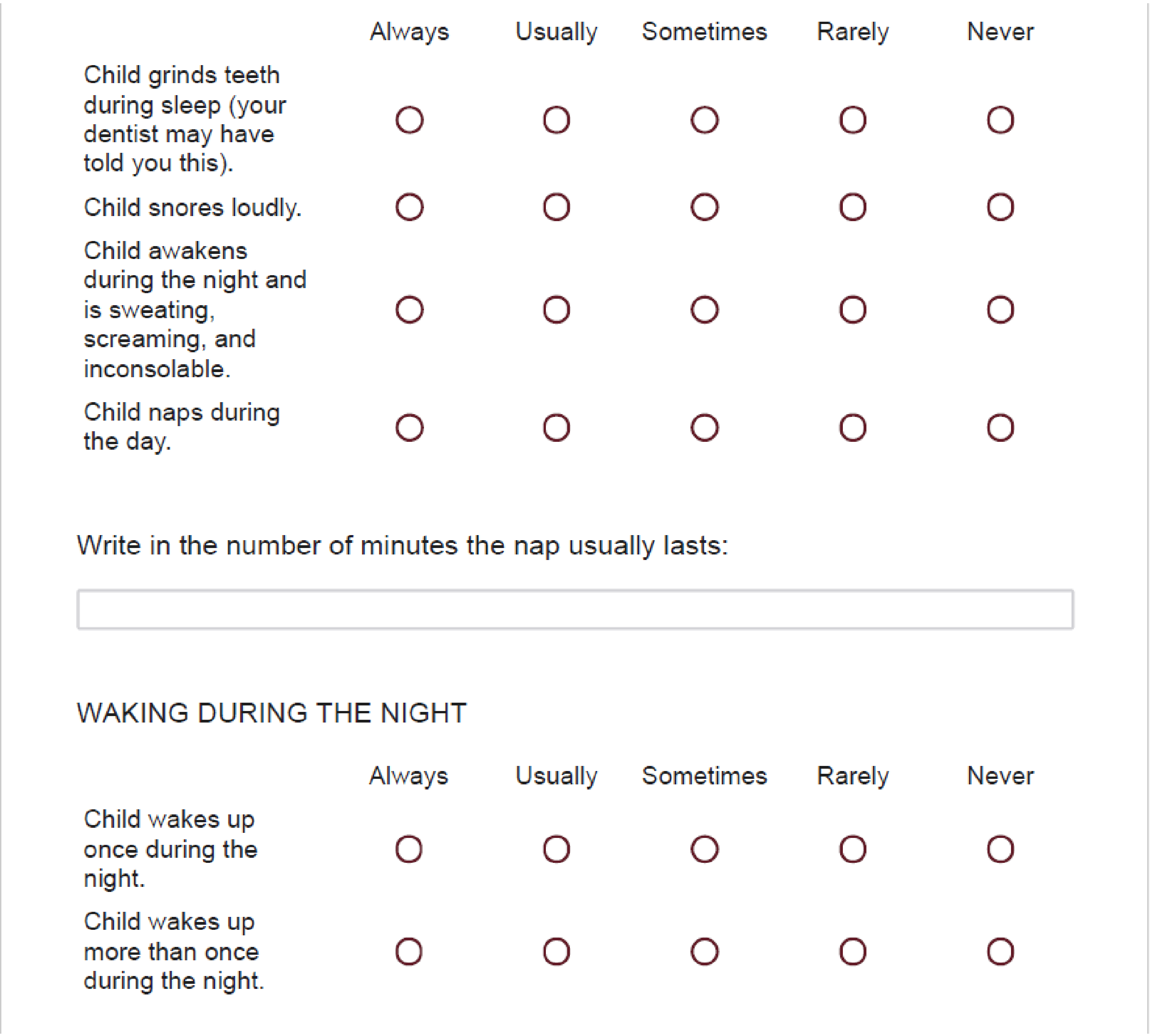


	Always	Usually	Sometimes	Rarely	Never
Child falls asleep with rocking or rhythmic movements:	○	○	○	○	○
Child needs special object to fall asleep (doll, special blanket, stuffed animal, etc.):	○	○	○	○	○
Child needs parent in the room to fall asleep:	○	○	○	○	○
Child resists going to bed at bedtime:	○	○	○	○	○
Child is afraid of sleeping in the dark:	○	○	○	○	○

Write in your child's usual amount of sleep each day (combining nighttime sleep and naps):

SLEEP BEHAVIOR

	Always	Usually	Sometimes	Rarely	Never
Child sleeps about the same amount each day.	○	○	○	○	○
Child is restless and moves a lot during sleep.	○	○	○	○	○
Child moves to someone else's bed during the night (parent, sibling, etc.).	○	○	○	○	○

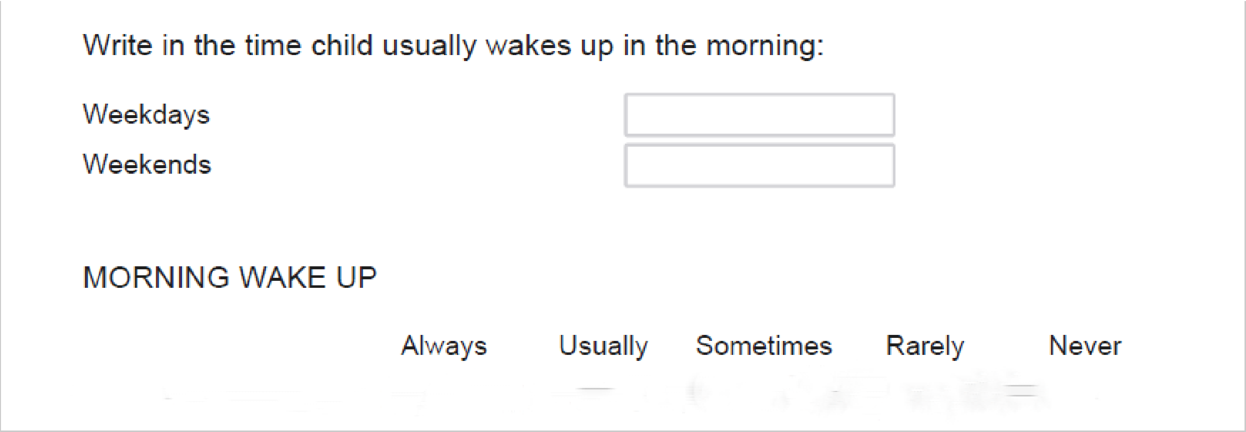


	Always	Usually	Sometimes	Rarely	Never
Child grinds teeth during sleep (your dentist may have told you this).	○	○	○	○	○
Child snores loudly.	○	○	○	○	○
Child awakens during the night and is sweating, screaming, and inconsolable.	○	○	○	○	○
Child naps during the day.	○	○	○	○	○

Write in the number of minutes the nap usually lasts:

WAKING DURING THE NIGHT

	Always	Usually	Sometimes	Rarely	Never
Child wakes up once during the night.	○	○	○	○	○
Child wakes up more than once during the night.	○	○	○	○	○



Write in the time child usually wakes up in the morning:

Weekdays ☐

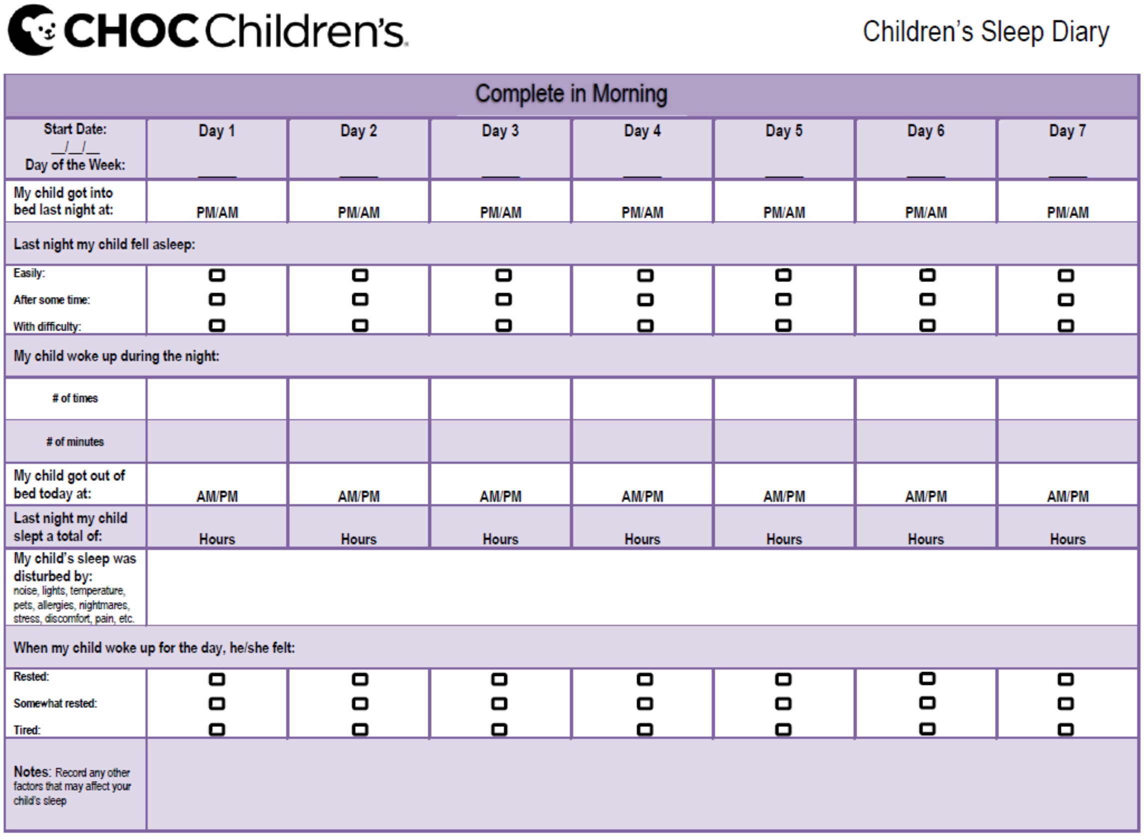
Weekends ☐

MORNING WAKE UP

	Always	Usually	Sometimes	Rarely	Never

	Always	Usually	Sometimes	Rarely	Never
Child wakes up by him/herself.	○	○	○	○	○
Child wakes up very early in the morning (or, earlier than necessary or desired).	○	○	○	○	○
Child seems tired during the daytime.	○	○	○	○	○
Child falls asleep while involved in activities.	○	○	○	○	○

7.5 Parents Report Sleep Diary



CHOC Children's

Children's Sleep Diary

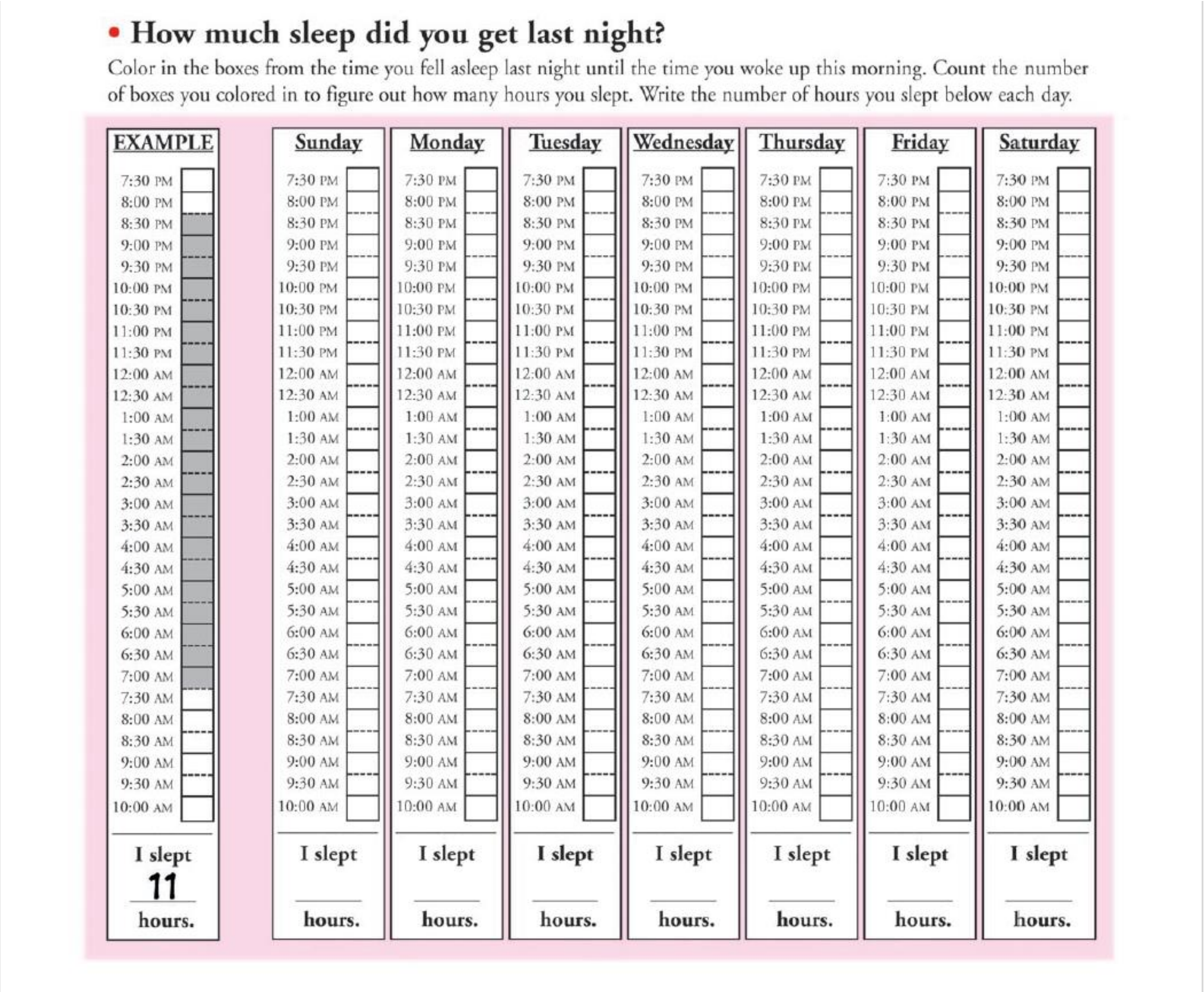
Complete in Morning

Start Date: __/__/__ Day of the Week:	Day 1 ____	Day 2 ____	Day 3 ____	Day 4 ____	Day 5 ____	Day 6 ____	Day 7 ____
My child got into bed last night at:	PM/AM	PM/AM	PM/AM	PM/AM	PM/AM	PM/AM	PM/AM
Last night my child fell asleep:							
Easily:	☐	☐	☐	☐	☐	☐	☐
After some time:	☐	☐	☐	☐	☐	☐	☐
With difficulty:	☐	☐	☐	☐	☐	☐	☐
My child woke up during the night:							
# of times							
# of minutes							
My child got out of bed today at:	AM/PM	AM/PM	AM/PM	AM/PM	AM/PM	AM/PM	AM/PM
Last night my child slept a total of:	Hours	Hours	Hours	Hours	Hours	Hours	Hours
My child's sleep was disturbed by: noise, lights, temperature, pets, allergies, nightmares, stress, discomfort, pain, etc.							
When my child woke up for the day, he/she felt:							
Rested:	☐	☐	☐	☐	☐	☐	☐
Somewhat rested:	☐	☐	☐	☐	☐	☐	☐
Tired:	☐	☐	☐	☐	☐	☐	☐
Notes: Record any other factors that may affect your child's sleep							

Complete at the End of the Day

Day of the week:	**Day 1** ____	**Day 2** ____	**Day 3** ____	**Day 4** ____	**Day 5** ____	**Day 6** ____	**Day 7** ____
My child consumed caffeinated items in the: (M)orning, (A)fternoon, (E)vening, (N/A) (e.g., chocolate, soda)							
M/A/E/NA How much?	____	____	____	____	____	____	____
My child exercised at least 20 minutes in the: (M)orning, (A)fternoon, (E)vening, (N/A)							
M/A/E/NA							
My child took these medications today:							
Took a nap? (circle one)	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If yes, for how long?							
During the day, how likely was your child to nod off or even fall asleep while performing daily tasks: No chance (NC), Slight chance (SC), Moderate chance (MC), High chance (HC)							
NC/SC/MC/HC							
Throughout the day, my child's mood was… Very pleasant (VP), Pleasant (P), Unpleasant (UP), Very unpleasant (VUP)							
VP/P/UP/VUP							
In the hour before going to sleep, my child's bedtime routine included: List activities including reading a book, taking a bath, doing relaxation exercises, etc.							

7.6 Child Report Sleep Diary

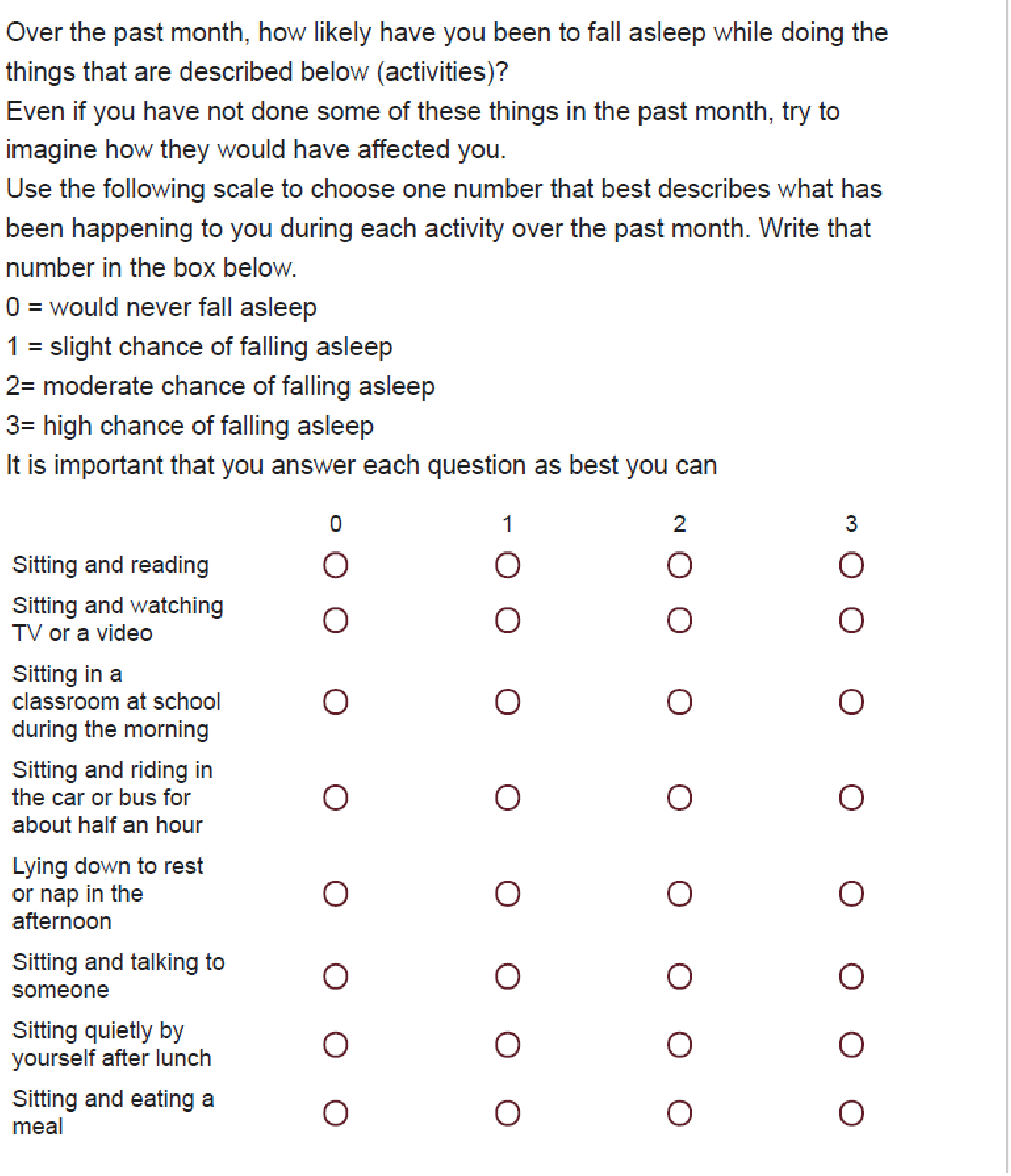


• How much sleep did you get last night?

Color in the boxes from the time you fell asleep last night until the time you woke up this morning. Count the number of boxes you colored in to figure out how many hours you slept. Write the number of hours you slept below each day.

EXAMPLE	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
7:30 PM ☐	7:30 PM ☐	7:30 PM ☐	7:30 PM ☐	7:30 PM ☐	7:30 PM ☐	7:30 PM ☐	7:30 PM ☐
8:00 PM ☐	8:00 PM ☐	8:00 PM ☐	8:00 PM ☐	8:00 PM ☐	8:00 PM ☐	8:00 PM ☐	8:00 PM ☐
8:30 PM ▨	8:30 PM ☐	8:30 PM ☐	8:30 PM ☐	8:30 PM ☐	8:30 PM ☐	8:30 PM ☐	8:30 PM ☐
9:00 PM ▨	9:00 PM ☐	9:00 PM ☐	9:00 PM ☐	9:00 PM ☐	9:00 PM ☐	9:00 PM ☐	9:00 PM ☐
9:30 PM ▨	9:30 PM ☐	9:30 PM ☐	9:30 PM ☐	9:30 PM ☐	9:30 PM ☐	9:30 PM ☐	9:30 PM ☐
10:00 PM ▨	10:00 PM ☐	10:00 PM ☐	10:00 PM ☐	10:00 PM ☐	10:00 PM ☐	10:00 PM ☐	10:00 PM ☐
10:30 PM ▨	10:30 PM ☐	10:30 PM ☐	10:30 PM ☐	10:30 PM ☐	10:30 PM ☐	10:30 PM ☐	10:30 PM ☐
11:00 PM ▨	11:00 PM ☐	11:00 PM ☐	11:00 PM ☐	11:00 PM ☐	11:00 PM ☐	11:00 PM ☐	11:00 PM ☐
11:30 PM ▨	11:30 PM ☐	11:30 PM ☐	11:30 PM ☐	11:30 PM ☐	11:30 PM ☐	11:30 PM ☐	11:30 PM ☐
12:00 AM ▨	12:00 AM ☐	12:00 AM ☐	12:00 AM ☐	12:00 AM ☐	12:00 AM ☐	12:00 AM ☐	12:00 AM ☐
12:30 AM ▨	12:30 AM ☐	12:30 AM ☐	12:30 AM ☐	12:30 AM ☐	12:30 AM ☐	12:30 AM ☐	12:30 AM ☐
1:00 AM ▨	1:00 AM ☐	1:00 AM ☐	1:00 AM ☐	1:00 AM ☐	1:00 AM ☐	1:00 AM ☐	1:00 AM ☐
1:30 AM ▨	1:30 AM ☐	1:30 AM ☐	1:30 AM ☐	1:30 AM ☐	1:30 AM ☐	1:30 AM ☐	1:30 AM ☐
2:00 AM ▨	2:00 AM ☐	2:00 AM ☐	2:00 AM ☐	2:00 AM ☐	2:00 AM ☐	2:00 AM ☐	2:00 AM ☐
2:30 AM ▨	2:30 AM ☐	2:30 AM ☐	2:30 AM ☐	2:30 AM ☐	2:30 AM ☐	2:30 AM ☐	2:30 AM ☐
3:00 AM ▨	3:00 AM ☐	3:00 AM ☐	3:00 AM ☐	3:00 AM ☐	3:00 AM ☐	3:00 AM ☐	3:00 AM ☐
3:30 AM ▨	3:30 AM ☐	3:30 AM ☐	3:30 AM ☐	3:30 AM ☐	3:30 AM ☐	3:30 AM ☐	3:30 AM ☐
4:00 AM ▨	4:00 AM ☐	4:00 AM ☐	4:00 AM ☐	4:00 AM ☐	4:00 AM ☐	4:00 AM ☐	4:00 AM ☐
4:30 AM ▨	4:30 AM ☐	4:30 AM ☐	4:30 AM ☐	4:30 AM ☐	4:30 AM ☐	4:30 AM ☐	4:30 AM ☐
5:00 AM ▨	5:00 AM ☐	5:00 AM ☐	5:00 AM ☐	5:00 AM ☐	5:00 AM ☐	5:00 AM ☐	5:00 AM ☐
5:30 AM ▨	5:30 AM ☐	5:30 AM ☐	5:30 AM ☐	5:30 AM ☐	5:30 AM ☐	5:30 AM ☐	5:30 AM ☐
6:00 AM ▨	6:00 AM ☐	6:00 AM ☐	6:00 AM ☐	6:00 AM ☐	6:00 AM ☐	6:00 AM ☐	6:00 AM ☐
6:30 AM ▨	6:30 AM ☐	6:30 AM ☐	6:30 AM ☐	6:30 AM ☐	6:30 AM ☐	6:30 AM ☐	6:30 AM ☐
7:00 AM ▨	7:00 AM ☐	7:00 AM ☐	7:00 AM ☐	7:00 AM ☐	7:00 AM ☐	7:00 AM ☐	7:00 AM ☐
7:30 AM ☐	7:30 AM ☐	7:30 AM ☐	7:30 AM ☐	7:30 AM ☐	7:30 AM ☐	7:30 AM ☐	7:30 AM ☐
8:00 AM ☐	8:00 AM ☐	8:00 AM ☐	8:00 AM ☐	8:00 AM ☐	8:00 AM ☐	8:00 AM ☐	8:00 AM ☐
8:30 AM ☐	8:30 AM ☐	8:30 AM ☐	8:30 AM ☐	8:30 AM ☐	8:30 AM ☐	8:30 AM ☐	8:30 AM ☐
9:00 AM ☐	9:00 AM ☐	9:00 AM ☐	9:00 AM ☐	9:00 AM ☐	9:00 AM ☐	9:00 AM ☐	9:00 AM ☐
9:30 AM ☐	9:30 AM ☐	9:30 AM ☐	9:30 AM ☐	9:30 AM ☐	9:30 AM ☐	9:30 AM ☐	9:30 AM ☐
10:00 AM ☐	10:00 AM ☐	10:00 AM ☐	10:00 AM ☐	10:00 AM ☐	10:00 AM ☐	10:00 AM ☐	10:00 AM ☐
I slept 11 **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**	**I slept** ______ **hours.**

7.7 Epworth Sleepiness Scale for Children and Adolescents Questionnaire



Over the past month, how likely have you been to fall asleep while doing the things that are described below (activities)?

Even if you have not done some of these things in the past month, try to imagine how they would have affected you.

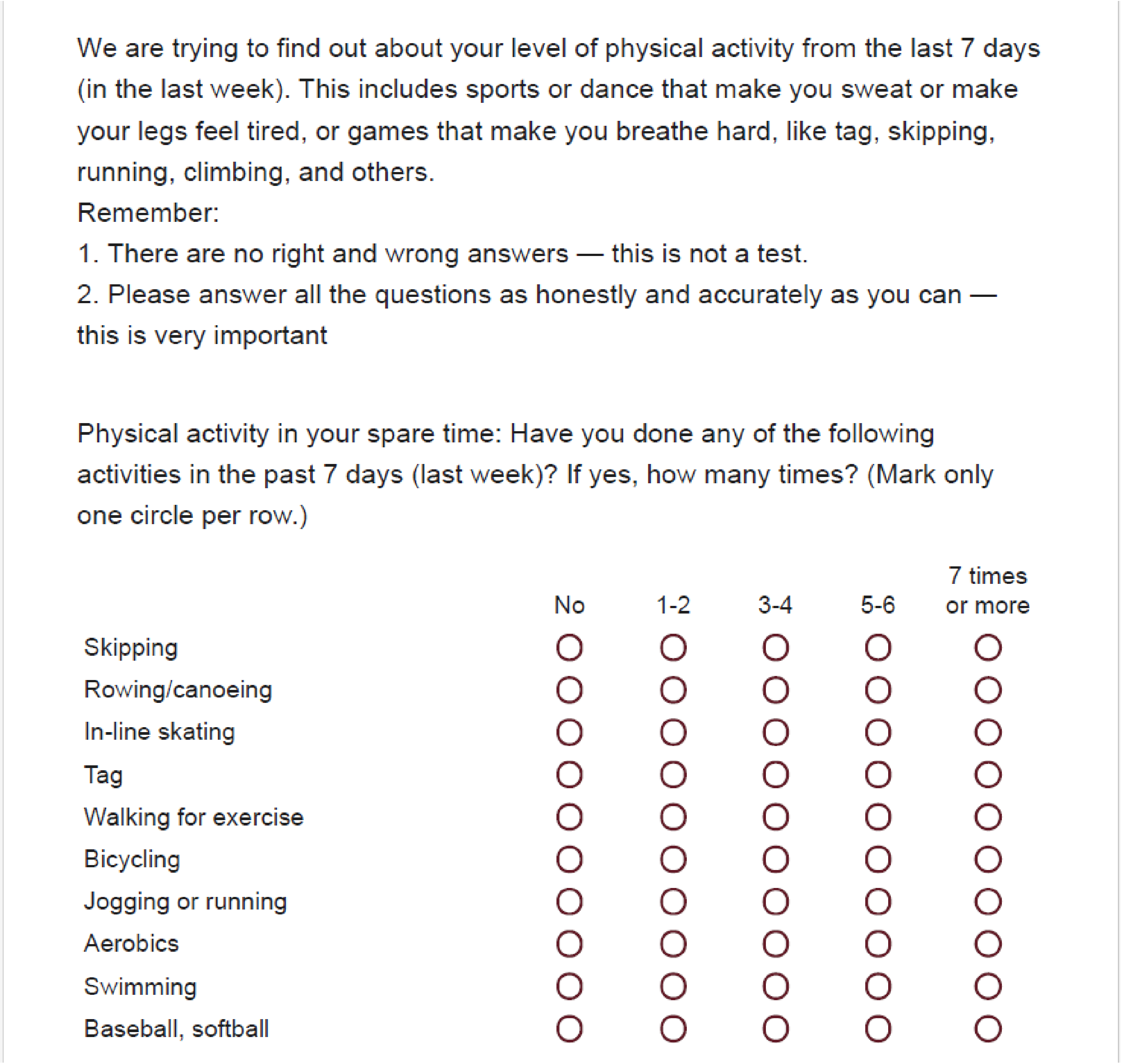
Use the following scale to choose one number that best describes what has been happening to you during each activity over the past month. Write that number in the box below.

0 = would never fall asleep
1 = slight chance of falling asleep
2= moderate chance of falling asleep
3= high chance of falling asleep

It is important that you answer each question as best you can

	0	1	2	3
Sitting and reading	○	○	○	○
Sitting and watching TV or a video	○	○	○	○
Sitting in a classroom at school during the morning	○	○	○	○
Sitting and riding in the car or bus for about half an hour	○	○	○	○
Lying down to rest or nap in the afternoon	○	○	○	○
Sitting and talking to someone	○	○	○	○
Sitting quietly by yourself after lunch	○	○	○	○
Sitting and eating a meal	○	○	○	○

7.8 Physical Activity Questionnaire



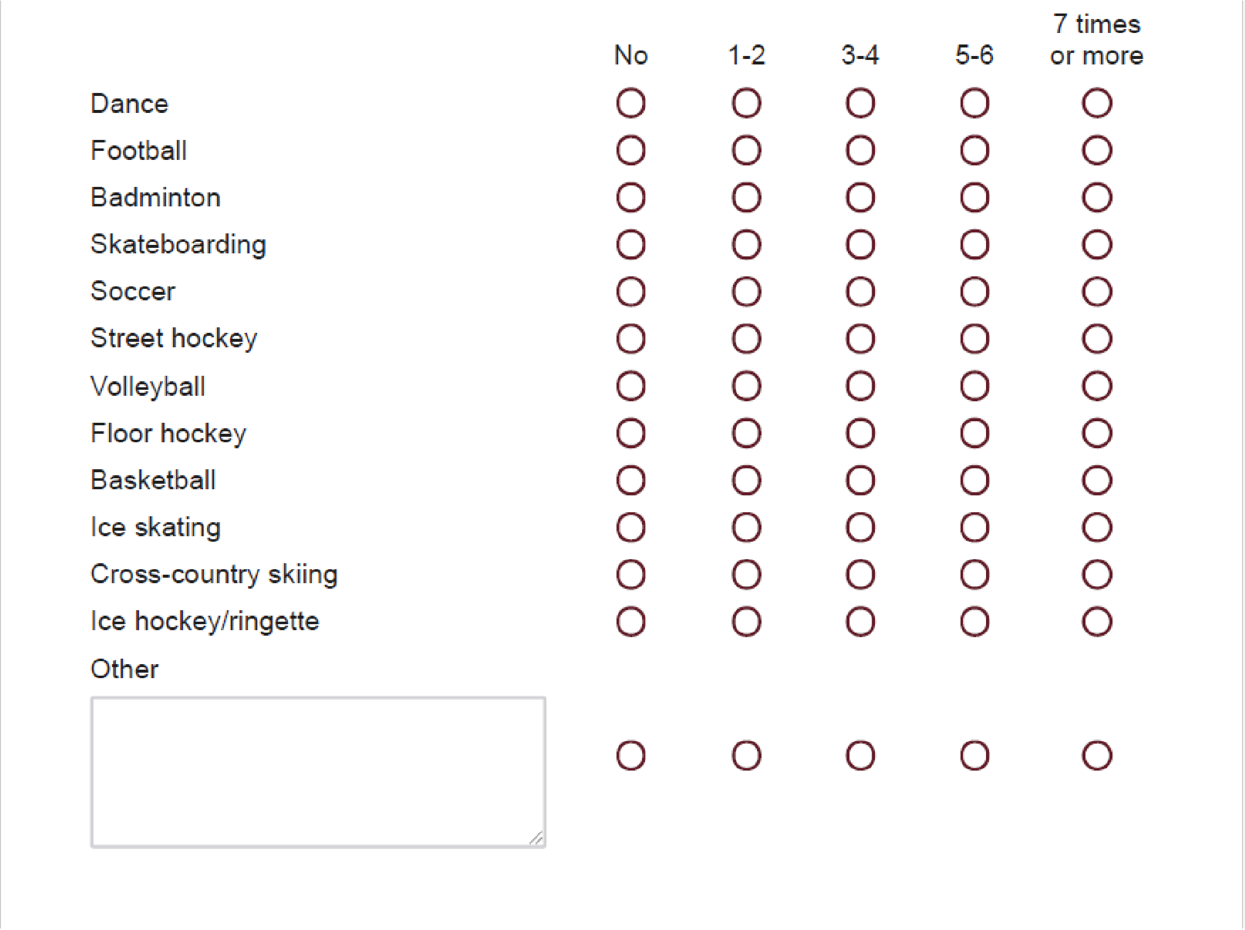
We are trying to find out about your level of physical activity from the last 7 days (in the last week). This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing, and others.

Remember:

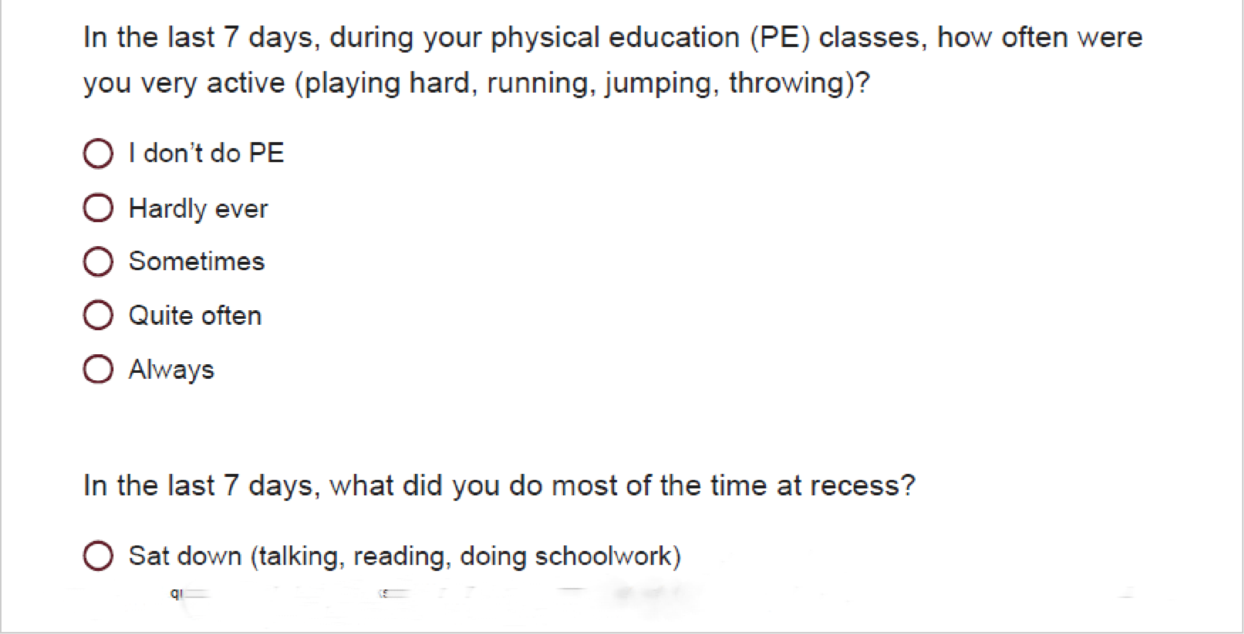
1. There are no right and wrong answers — this is not a test.
2. Please answer all the questions as honestly and accurately as you can — this is very important

Physical activity in your spare time: Have you done any of the following activities in the past 7 days (last week)? If yes, how many times? (Mark only one circle per row.)

	No	1-2	3-4	5-6	7 times or more
Skipping	○	○	○	○	○
Rowing/canoeing	○	○	○	○	○
In-line skating	○	○	○	○	○
Tag	○	○	○	○	○
Walking for exercise	○	○	○	○	○
Bicycling	○	○	○	○	○
Jogging or running	○	○	○	○	○
Aerobics	○	○	○	○	○
Swimming	○	○	○	○	○
Baseball, softball	○	○	○	○	○



	No	1-2	3-4	5-6	7 times or more
Dance	○	○	○	○	○
Football	○	○	○	○	○
Badminton	○	○	○	○	○
Skateboarding	○	○	○	○	○
Soccer	○	○	○	○	○
Street hockey	○	○	○	○	○
Volleyball	○	○	○	○	○
Floor hockey	○	○	○	○	○
Basketball	○	○	○	○	○
Ice skating	○	○	○	○	○
Cross-country skiing	○	○	○	○	○
Ice hockey/ringette	○	○	○	○	○
Other	○	○	○	○	○

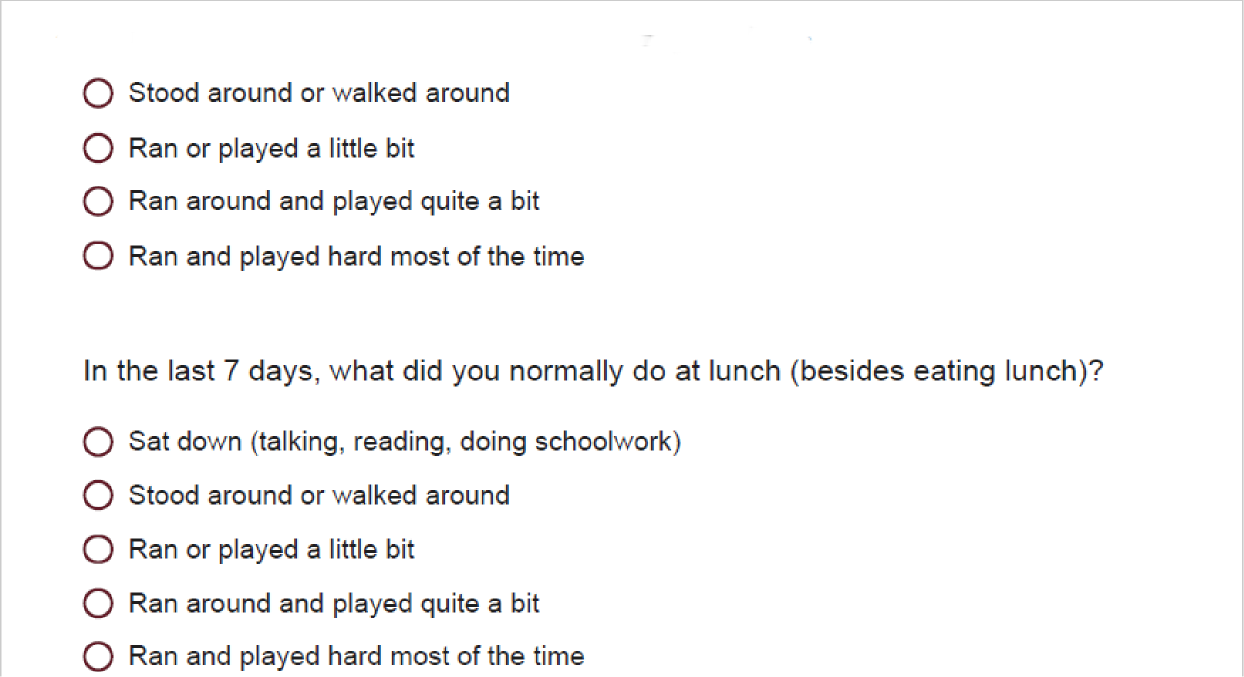


In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)?

- ○ I don’t do PE
- ○ Hardly ever
- ○ Sometimes
- ○ Quite often
- ○ Always

In the last 7 days, what did you do most of the time at recess?

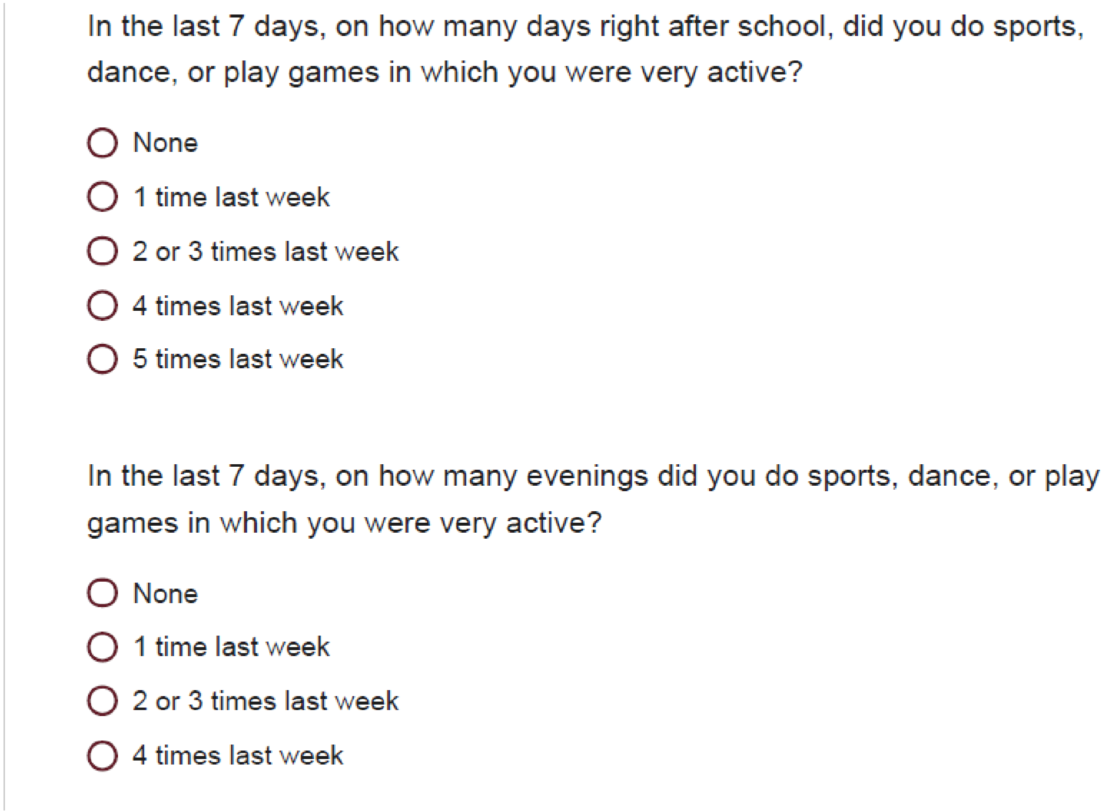
- ○ Sat down (talking, reading, doing schoolwork)



- ○ Stood around or walked around
- ○ Ran or played a little bit
- ○ Ran around and played quite a bit
- ○ Ran and played hard most of the time

In the last 7 days, what did you normally do at lunch (besides eating lunch)?

- ○ Sat down (talking, reading, doing schoolwork)
- ○ Stood around or walked around
- ○ Ran or played a little bit
- ○ Ran around and played quite a bit
- ○ Ran and played hard most of the time



In the last 7 days, on how many days right after school, did you do sports, dance, or play games in which you were very active?

○ None

○ 1 time last week

○ 2 or 3 times last week

○ 4 times last week

○ 5 times last week

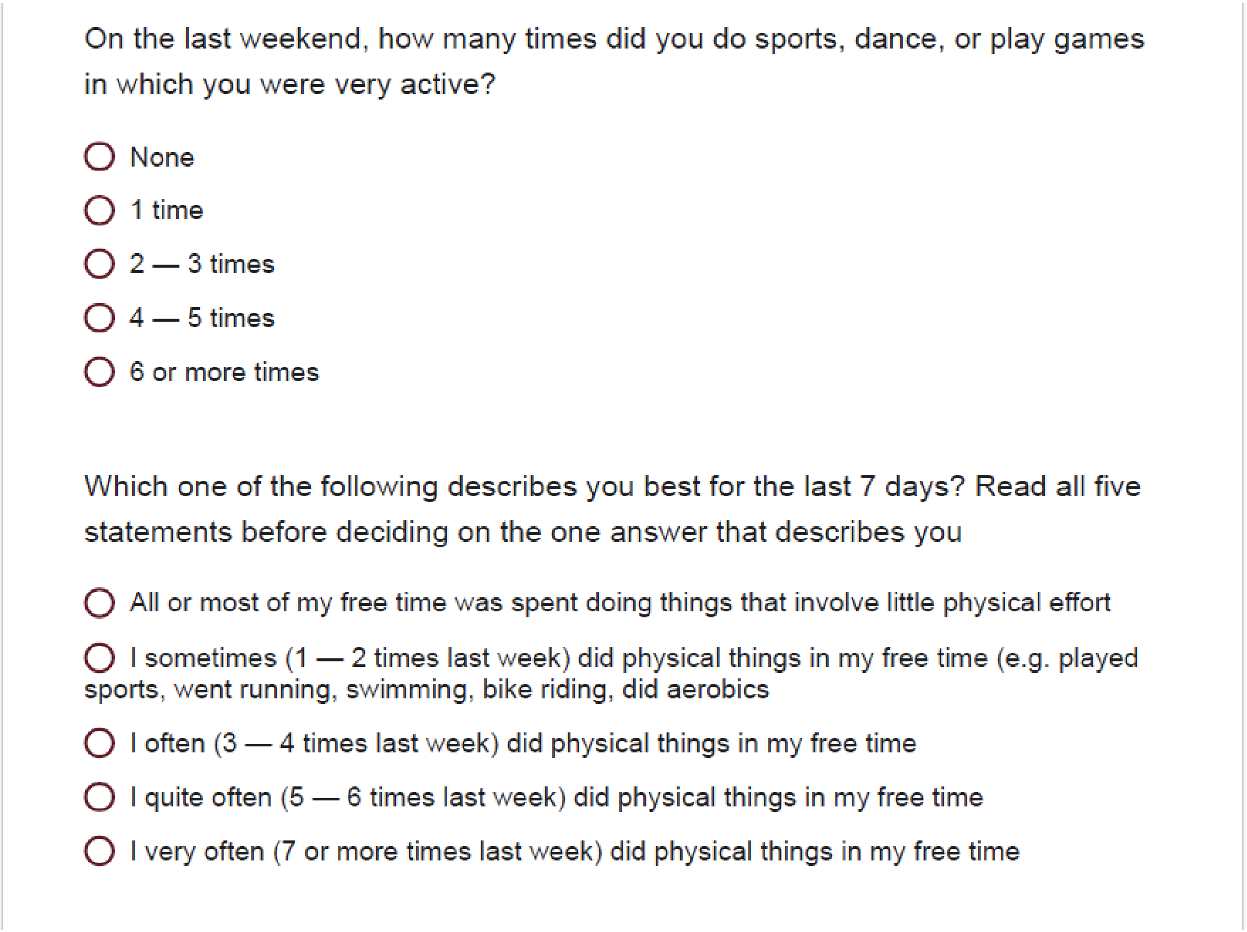
In the last 7 days, on how many evenings did you do sports, dance, or play games in which you were very active?

○ None

○ 1 time last week

○ 2 or 3 times last week

○ 4 times last week



On the last weekend, how many times did you do sports, dance, or play games in which you were very active?

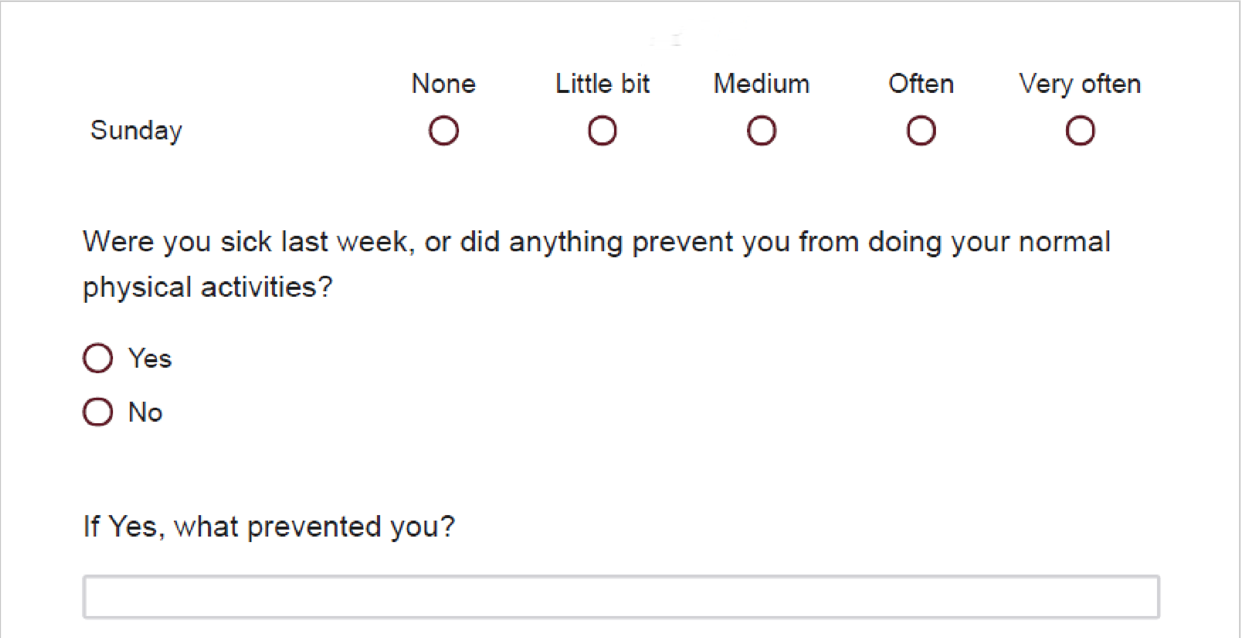
- ○ None
- ○ 1 time
- ○ 2 — 3 times
- ○ 4 — 5 times
- ○ 6 or more times

Which one of the following describes you best for the last 7 days? Read all five statements before deciding on the one answer that describes you

- ○ All or most of my free time was spent doing things that involve little physical effort
- ○ I sometimes (1 — 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics
- ○ I often (3 — 4 times last week) did physical things in my free time
- ○ I quite often (5 — 6 times last week) did physical things in my free time
- ○ I very often (7 or more times last week) did physical things in my free time

Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

	None	Little bit	Medium	Often	Very often
Monday	○	○	○	○	○
Tuesday	○	○	○	○	○
Wednesday	○	○	○	○	○
Thursday	○	○	○	○	○
Friday	○	○	○	○	○
Saturday	○	○	○	○	○



	None	Little bit	Medium	Often	Very often
Sunday	○	○	○	○	○

Were you sick last week, or did anything prevent you from doing your normal physical activities?

○ Yes

○ No

If Yes, what prevented you?

7.9 List of Variables Defined by Type

- Height: the unit is cm, continuous
- Weigh: the unit is kg, continuous
- Waist circumference: the unit is cm, continuous
- BMI: the unit is kg/m2, continuous
- BMI percentile: unitless, categorical
- Sleep duration: the unit is hh:mm, continuous
- Sleep efficiency: the unit is (%), continuous
- Wake after sleep onset: the unit is min, continuous
- Number of awakenings: unitless, continuous
- Energy intake: the unit is Kcal, continuous
- Macronutrients (carbohydrate, fat, protein): the unit is gram, continuous
- Fruits and vegetables: the unit is serving size description, continuous
- Intrinsic sugar, added sugar: the unit is gram, continuous
- Screen time: the unit is hh:mm, continuous
- Light, moderate to vigorous physical activity: the unit is min, continuous
- Steps: unitless, continuous

CHAPTER 8: REFERENCES

Abbasi, A., Juszczyk, D., van Jaarsveld, C. H. M., & Gulliford, M. C. (2017). Body Mass Index and Incident Type 1 and Type 2 Diabetes in Children and Young Adults: A Retrospective Cohort Study. *Journal of the Endocrine Society*, *1*(5), 524–537. https://doi.org/10.1210/js.2017-00044

Aggio, D., Smith, L., & Hamer, M. (2015). Effects of reallocating time in different activity intensities on health and fitness: a cross sectional study. *The International Journal of Behavioral Nutrition and Physical Activity*, *12*, 83. https://doi.org/10.1186/s12966-015-0249-6

Ahn, D., & Shin, D.-H. (2013). Is the social use of media for seeking connectedness or for avoiding social isolation? Mechanisms underlying media use and subjective well-being. *Computers in Human Behavior*, *29*(6), 2453–2462. https://doi.org/https://doi.org/10.1016/j.chb.2012.12.022

Al Khatib, H. K., Harding, S. V, Darzi, J., & Pot, G. K. (2017). The effects of partial sleep deprivation on energy balance: a systematic review and meta-analysis. *European Journal of Clinical Nutrition*, *71*(5), 614–624. https://doi.org/10.1038/ejcn.2016.201

Alblas, M. C., Mollen, S., Wennekers, A. M., Fransen, M. L., & van den Putte, B. (2021). Consuming media, consuming food: investigating concurrent TV viewing and eating using a 7-d time use diary survey. *Public Health Nutrition*, *26*(4), 1–10. https://doi.org/10.1017/S1368980021002858

Alimoradi, Z., Jafari, E., Broström, A., Ohayon, M. M., Lin, C.-Y., Griffiths, M. D., Blom, K., Jernelöv, S., Kaldo, V., & Pakpour, A. H. (2022). Effects of cognitive behavioral therapy for insomnia (CBT-I) on quality of life: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *64*, 101646. https://doi.org/10.1016/j.smrv.2022.101646

Anderson, N. B. (2004). *Encyclopedia of health and behavior* (Vol. 1). Sage.

Angelino, D., Godos, J., Ghelfi, F., Tieri, M., Titta, L., Lafranconi, A., Marventano, S., Alonzo, E., Gambera, A., Sciacca, S., Buscemi, S., Ray, S., Galvano, F., Del Rio, D., & Grosso, G. (2019). Fruit and vegetable consumption and health outcomes: an umbrella review of observational studies. *International Journal of Food Sciences and Nutrition*, *70*(6), 652–667. https://doi.org/10.1080/09637486.2019.1571021

Antczak, D., Lonsdale, C., del Pozo Cruz, B., Parker, P., & Sanders, T. (2021). Reliability of GENEActiv accelerometers to estimate sleep, physical activity, and sedentary time in children. *International Journal of Behavioral Nutrition and Physical Activity*, *18*(1), 73. https://doi.org/10.1186/s12966-021-01143-6

Arain, M., Campbell, M. J., Cooper, C. L., & Lancaster, G. A. (2010). What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Medical Research Methodology*, *10*(1), 67. https://doi.org/10.1186/1471-2288-10-67

Araujo, T., Wonneberger, A., Neijens, P., & de Vreese, C. (2017). How much time do you spend online? Understanding and improving the accuracy of self-reported measures of internet use. *Communication Methods and Measures*, *11*(3), 173–190.

Aris, I. M., & Block, J. P. (2022). Childhood Obesity Interventions—Going Beyond the Individual. *JAMA Pediatrics*, *176*(1), e214388–e214388. https://doi.org/10.1001/jamapediatrics.2021.4388

Asarnow, L. D., Greer, S. M., Walker, M. P., & Harvey, A. G. (2017). The impact of sleep improvement on food choices in adolescents with late bedtimes. *Journal of Adolescent Health*, *60*(5), 570–576.

Asigbee, F. M., Whitney, S. D., & Peterson, C. E. (2018). The Link Between Nutrition and Physical Activity in Increasing Academic Achievement. *The Journal of School Health*, *88*(6), 407–415. https://doi.org/10.1111/josh.12625

Atlantis, E., Barnes, E. H., & Singh, M. A. F. (2006). Efficacy of exercise for treating overweight in children and adolescents: a systematic review. *International Journal of Obesity (2005)*, *30*(7), 1027–1040. https://doi.org/10.1038/sj.ijo.0803286

Bailey, R. L., Fulgoni, V. L., Cowan, A. E., & Gaine, P. C. (2018). Sources of Added Sugars in Young Children, Adolescents, and Adults with Low and High Intakes of Added Sugars. *Nutrients*, *10*(1). https://doi.org/10.3390/nu10010102

Bakrania, K., Yates, T., Rowlands, A. V, Esliger, D. W., Bunnewell, S., Sanders, J., Davies, M., Khunti, K., & Edwardson, C. L. (2016). Intensity Thresholds on Raw Acceleration Data: Euclidean Norm Minus One (ENMO) and Mean Amplitude Deviation (MAD) Approaches. *PLOS ONE*, *11*(10), 1–16. https://doi.org/10.1371/journal.pone.0164045

Baron, K. G., Duffecy, J., Reutrakul, S., Levenson, J. C., McFarland, M. M., Lee, S., & Qeadan, F. (2021). Behavioral interventions to extend sleep duration: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *60*, 101532. https://doi.org/10.1016/j.smrv.2021.101532

Baron, K. G., & Reid, K. J. (2014). Circadian misalignment and health. *International Review of Psychiatry (Abingdon, England)*, *26*(2), 139–154. https://doi.org/10.3109/09540261.2014.911149

Baron, K. G., Trela-Hoskins, S. R., Duffecy, J., & Allen, C. M. (2023). A feasibility study to understand the components of behavioral sleep extension. *PEC Innovation*, *2*, 100114. https://doi.org/10.1016/j.pecinn.2022.100114

Barragán, R., Zuraikat, F. M., Tam, V., Scaccia, S., Cochran, J., Li, S., Cheng, B., & St-Onge, M.-P. (2021). Actigraphy-Derived Sleep Is Associated with Eating Behavior Characteristics. *Nutrients*, *13*(3). https://doi.org/10.3390/nu13030852

Bawaked, R. A., Fernández-Barrés, S., Navarrete-Muñoz, E. M., González-Palacios, S., Guxens, M., Irizar, A., Lertxundi, A., Sunyer, J., Vioque, J., Schröder, H., Vrijheid, M., & Romaguera, D. (2020). Impact of lifestyle behaviors in early childhood on obesity and cardiometabolic risk in children: Results from the Spanish INMA birth cohort study. *Pediatric Obesity*, *15*(3), e12590. https://doi.org/https://doi.org/10.1111/ijpo.12590

Berger, A. M., Parker, K. P., Young-McCaughan, S., Mallory, G. A., Barsevick, A. M., Beck, S. L., Carpenter, J. S., Carter, P. A., Farr, L. A., Hinds, P. S., Lee, K. A., Miaskowski, C., Mock, V., Payne, J. K., & Hall, M. (2005). Sleep wake disturbances in people with cancer and their caregivers: state of the science. *Oncology Nursing Forum*, *32*(6), E98-126. https://doi.org/10.1188/05.ONF.E98-E126

Bland, J. M., & Altman, D. G. (1999). Measuring agreement in method comparison studies. *Statistical Methods in Medical Research*, *8*(2), 135–160. https://doi.org/10.1177/096228029900800204

Bland, J. M., & Altman, D. G. (2010). Statistical methods for assessing agreement between two methods of clinical measurement. *International Journal of Nursing Studies*, *47*(8), 931–936.

Bosy-Westphal, A., Hinrichs, S., Jauch-Chara, K., Hitze, B., Later, W., Wilms, B., Settler, U., Peters, A., Kiosz, D., & Muller, M. J. (2008). Influence of partial sleep deprivation on energy balance and insulin sensitivity in healthy women. *Obesity Facts*, *1*(5), 266–273. https://doi.org/10.1159/000158874

Bradfield, J. P., Vogelezang, S., Felix, J. F., Chesi, A., Helgeland, Ø., Horikoshi, M., Karhunen, V., Lowry, E., Cousminer, D. L., Ahluwalia, T. S., Thiering, E., Boh, E. T.-H., Zafarmand, M. H., Vilor-Tejedor, N., Wang, C. A., Joro, R., Chen, Z., Gauderman, W. J., Pitkänen, N., … Grant, S. F. A. (2019). A trans-ancestral meta-analysis of genome-wide association studies reveals loci associated with childhood obesity. *Human Molecular Genetics*, *28*(19), 3327–3338. https://doi.org/10.1093/hmg/ddz161

Braig, S., Genuneit, J., Walter, V., Brandt, S., Wabitsch, M., Goldbeck, L., Brenner, H., & Rothenbacher, D. (2018). Screen Time, Physical Activity and Self-Esteem in Children: The Ulm Birth Cohort Study. *International Journal of Environmental Research and Public Health*, *15*(6). https://doi.org/10.3390/ijerph15061275

Brambilla, P., Giussani, M., Pasinato, A., Venturelli, L., Privitera, F., Miraglia del Giudice, E., Sollai, S., Picca, M., Di Mauro, G., & Bruni, O. (2017). Sleep habits and pattern in 1-14 years old children and relationship with video devices use and evening and night child activities. *Italian Journal of Pediatrics*, *43*(1), 1–11.

Brown, C. L., Halvorson, E. E., Cohen, G. M., Lazorick, S., & Skelton, J. A. (2015). Addressing Childhood Obesity: Opportunities for Prevention. *Pediatric Clinics of North America*, *62*(5), 1241–1261. https://doi.org/10.1016/j.pcl.2015.05.013

Browne, R. H. (1995). On the use of a pilot sample for sample size determination. *Statistics in Medicine*, *14*(17), 1933–1940. https://doi.org/10.1002/sim.4780141709

Bruni, O., Sette, S., Fontanesi, L., Baiocco, R., Laghi, F., & Baumgartner, E. (2015). Technology use and sleep quality in preadolescence and adolescence. *Journal of Clinical Sleep Medicine*, *11*(12), 1433–1441.

Byrne, R., Terranova, C. O., & Trost, S. G. (2021). Measurement of screen time among young children aged 0-6 years: A systematic review. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity*, *22*(8), e13260. https://doi.org/10.1111/obr.13260

Calamaro, C. J., Park, S., Mason, T. B. A., Marcus, C. L., Weaver, T. E., Pack, A., & Ratcliffe, S. J. (2010). Shortened sleep duration does not predict obesity in adolescents. *Journal of Sleep Research*, *19*(4), 559–566. https://doi.org/10.1111/j.1365-2869.2010.00840.x

Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J.-P., Saunders, T. J., Katzmarzyk, P. T., Okely, A. D., Connor Gorber, S., Kho, M. E., Sampson, M., Lee, H., & Tremblay, M. S. (2016). Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition et Metabolisme*, *41*(6 Suppl 3), S240-65. https://doi.org/10.1139/apnm-2015-0630

Carter, B., Rees, P., Hale, L., Bhattacharjee, D., & Paradkar, M. S. (2016). Association between portable screen-based media device access or use and sleep outcomes: a systematic review and meta-analysis. *JAMA Pediatrics*, *170*(12), 1202–1208.

Celis-Morales, C., Livingstone, K. M., Affleck, A., Navas-Carretero, S., San-Cristobal, R., Martinez, J. A., Marsaux, C. F. M., Saris, W. H. M., O'Donovan, C. B., Forster, H., Woolhead, C., Gibney, E. R., Walsh, M. C., Brennan, L., Gibney, M., Moschonis, G., Lambrinou, C.-P., Mavrogianni, C., Manios, Y., … Mathers, J. C. (2018). Correlates of overall and central obesity in adults from seven European countries: findings from the Food4Me Study. *European Journal of Clinical Nutrition*, *72*(2), 207–219. https://doi.org/10.1038/s41430-017-0004-y

Chaput, J.-P., Brunet, M., & Tremblay, A. (2006). Relationship between short sleeping hours and childhood overweight/obesity: results from the "Québec en Forme" Project. *International Journal of Obesity (2005)*, *30*(7), 1080–1085. https://doi.org/10.1038/sj.ijo.0803291

Chaput, J.-P., Leduc, G., Boyer, C., Bélanger, P., LeBlanc, A. G., Borghese, M. M., & Tremblay, M. S. (2014). Objectively measured physical activity, sedentary time and sleep duration: independent and combined associations with adiposity in canadian children. *Nutrition & Diabetes*, *4*(6), e117. https://doi.org/10.1038/nutd.2014.14

Chaput, J.-P., Tremblay, M. S., Katzmarzyk, P. T., Fogelholm, M., Hu, G., Maher, C., Maia, J., Olds, T., Onywera, V., Sarmiento, O. L., Standage, M., Tudor-Locke, C., & Sampasa-Kanyinga, H. (2018). Sleep patterns and sugar-sweetened beverage consumption among children from around the world. *Public Health Nutrition*, *21*(13), 2385–2393. https://doi.org/10.1017/S1368980018000976

Chehal, P. K., Shafer, L., & Cunningham, S. A. (2022). Examination of Sleep and Obesity in Children and Adolescents in the United States. *American Journal of Health Promotion*, *36*(1), 46–54. https://doi.org/10.1177/08901171211029189

Cheung, C. H. M., Bedford, R., Saez De Urabain, I. R., Karmiloff-Smith, A., & Smith, T. J. (2017). Daily touchscreen use in infants and toddlers is associated with reduced sleep and delayed sleep onset. *Scientific Reports*, *7*(1), 1–7.

Chinapaw, M. J. M., Mokkink, L. B., van Poppel, M. N. M., van Mechelen, W., & Terwee, C. B. (2010). Physical activity questionnaires for youth: a systematic review of measurement properties. *Sports Medicine (Auckland, N.Z.)*, *40*(7), 539–563. https://doi.org/10.2165/11530770-000000000-00000

Chomitz, V. R., Slining, M. M., McGowan, R. J., Mitchell, S. E., Dawson, G. F., & Hacker, K. A. (2009). Is there a relationship between physical fitness and academic achievement? Positive results from public school children in the northeastern United States. *The Journal* *of School Health*, *79*(1), 30–37. https://doi.org/10.1111/j.1746-1561.2008.00371.x

Crocker, P. R., Bailey, D. A., Faulkner, R. A., Kowalski, K. C., & McGrath, R. (1997). Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Medicine and Science in Sports and Exercise*, *29*(10), 1344–1349.

Dabas, A., & Seth, A. (2018). Prevention and Management of Childhood Obesity. *The Indian Journal of Pediatrics*, *85*(7), 546–553. https://doi.org/10.1007/s12098-018-2636-x

De Bourdeaudhuij, I., Verloigne, M., Maes, L., Van Lippevelde, W., Chinapaw, M. J. M., Te Velde, S. J., Manios, Y., Androutsos, O., Kovacs, E., Dössegger, A., & Brug, J. (2013). Associations of physical activity and sedentary time with weight and weight status among 10- to 12-year-old boys and girls in Europe: a cluster analysis within the ENERGY project. *Pediatric Obesity*, *8*(5), 367–375. https://doi.org/10.1111/j.2047-6310.2012.00117.x

De Nys, L., Anderson, K., Ofosu, E. F., Ryde, G. C., Connelly, J., & Whittaker, A. C. (2022). The effects of physical activity on cortisol and sleep: A systematic review and meta-analysis. *Psychoneuroendocrinology*, *143*, 105843. https://doi.org/10.1016/j.psyneuen.2022.105843

de Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, *85*(9), 660–667. https://doi.org/10.2471/blt.07.043497

Dehghan, M., Akhtar-Danesh, N., & Merchant, A. T. (2005). Childhood obesity, prevalence and prevention. *Nutrition Journal*, *4*(1), 1–8.

Dennison, B. A., Erb, T. A., & Jenkins, P. L. (2002). Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics*, *109*(6), 1028–1035.

Dewald-Kaufmann, J., de Bruin, E., & Michael, G. (2019). Cognitive Behavioral Therapy for Insomnia (CBT-i) in School-Aged Children and Adolescents. *Sleep Medicine Clinics*, *14*(2), 155–165. https://doi.org/10.1016/j.jsmc.2019.02.002

Ding, C., Fan, J., Yuan, F., Feng, G., Gong, W., Song, C., Ma, Y., Chen, Z., & Liu, A. (2022). Association between Physical Activity, Sedentary Behaviors, Sleep, Diet, and Adiposity among Children and Adolescents in China. *Obesity Facts*, *15*(1), 26–35. https://doi.org/10.1159/000519268

Duraccio, K. M., Krietsch, K. N., Chardon, M. L., Van Dyk, T. R., & Beebe, D. W. (2019). Poor sleep and adolescent obesity risk: a narrative review of potential mechanisms. *Adolescent Health, Medicine and Therapeutics*, 117–130.

Dutil, C., & Chaput, J.-P. (2017). Inadequate sleep as a contributor to type 2 diabetes in children and adolescents. *Nutrition & Diabetes*, *7*(5), e266. https://doi.org/10.1038/nutd.2017.19

Duvigneaud, N., Wijndaele, K., Matton, L., Philippaerts, R., Lefevre, J., Thomis, M., Delecluse, C., & Duquet, W. (2007). Dietary factors associated with obesity indicators and level of sports participation in Flemish adults: a cross-sectional study. *Nutrition Journal*, *6*, 26.

https://doi.org/10.1186/1475-2891-6-26

Edinger, J. D., Arnedt, J. T., Bertisch, S. M., Carney, C. E., Harrington, J. J., Lichstein, K. L., Sateia, M. J., Troxel, W. M., Zhou, E. S., Kazmi, U., Heald, J. L., & Martin, J. L. (2021). Behavioral and psychological treatments for chronic insomnia disorder in adults: an American Academy of Sleep Medicine clinical practice guideline. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *17*(2), 255–262. https://doi.org/10.5664/jcsm.8986

Eisenmann, J. C., Bartee, R. T., & Wang, M. Q. (2002). Physical activity, TV viewing, and weight in US youth: 1999 Youth Risk Behavior Survey. *Obesity Research*, *10*(5), 379–385.

Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA*, *307*(7), 704–712. https://doi.org/10.1001/jama.2012.156

Epstein, L. H., Roemmich, J. N., Robinson, J. L., Paluch, R. A., Winiewicz, D. D., Fuerch, J. H., & Robinson, T. N. (2008). A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Archives of Pediatrics & Adolescent Medicine*, *162*(3), 239–245. https://doi.org/10.1001/archpediatrics.2007.45

Fearnbach, S. N., Masterson, T. D., Schlechter, H. A., Ross, A. J., Rykaczewski, M. J., Loken, E., Downs, D. S., Thivel, D., & Keller, K. L. (2016). Impact of imposed exercise on energy intake in children at risk for overweight. *Nutrition Journal*, *15*(1), 92. https://doi.org/10.1186/s12937-016-0206-5

Fekedulegn, D., Andrew, M. E., Shi, M., Violanti, J. M., Knox, S., & Innes, K. E. (2020). Actigraphy-Based Assessment of Sleep Parameters. *Annals of Work Exposures and Health*, *64*(4), 350–367. https://doi.org/10.1093/annweh/wxaa007

Figueiro, M., & Overington, D. (2016). Self-luminous devices and melatonin suppression in adolescents. *Lighting Research & Technology*, *48*(8), 966–975.

Flodmark, C.-E., Lissau, I., Moreno, L. A., Pietrobelli, A., & Widhalm, K. (2004). New insights into the field of children and adolescents' obesity: the European perspective. *International Journal of Obesity and Related Metabolic Disorders : Journal of the International Association for the Study of Obesity*, *28*(10), 1189–1196. https://doi.org/10.1038/sj.ijo.0802787

Foster, E., Lee, C., Imamura, F., Hollidge, S. E., Westgate, K. L., Venables, M. C., Poliakov, I., Rowland, M. K., Osadchiy, T., Bradley, J. C., Simpson, E. L., Adamson, A. J., Olivier, P., Wareham, N., Forouhi, N. G., & Brage, S. (2019). Validity and reliability of an online self-report 24-h dietary recall method (Intake24): a doubly labelled water study and repeated-measures analysis. *Journal of Nutritional Science*, *8*, e29. https://doi.org/10.1017/jns.2019.20

Fujiwara, A., Murakami, K., Asakura, K., Uechi, K., Sugimoto, M., Wang, H.-C., Masayasu, S., & Sasaki, S. (2019). Association of free sugar intake estimated using a newly-developed food composition database with lifestyles and parental characteristics among Japanese children aged 3–6 years: DONGuRI study. *Journal of Epidemiology*, *29*(11), 414–423.

Gangwisch, J. E. (2009). Epidemiological evidence for the links between sleep, circadian rhythms and metabolism. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity*, *10 Suppl 2*(0 2), 37–45. https://doi.org/10.1111/j.1467-789X.2009.00663.x

Gil, Á., Martinez de Victoria, E., & Olza, J. (2015). Indicators for the evaluation of diet quality. *Nutricion Hospitalaria*, *31 Suppl 3*, 128–144. https://doi.org/10.3305/nh.2015.31.sup3.8761

Goldfield, G. S., Kenny, G. P., Hadjiyannakis, S., Phillips, P., Alberga, A. S., Saunders, T. J., Tremblay, M. S., Malcolm, J., Prud'homme, D., & Gougeon, R. (2011). Video game playing is independently associated with blood pressure and lipids in overweight and obese adolescents. *PloS One*, *6*(11), e26643.

Goran, M. I., Gower, B. A., Nagy, T. R., & Johnson, R. K. (1998). Developmental Changes in Energy Expenditure and Physical Activity in Children: Evidence for a Decline in Physical Activity in Girls Before Puberty. *Pediatrics*, *101*(5), 887–891. https://doi.org/10.1542/peds.101.5.887

Gulati, A. K., Kaplan, D. W., & Daniels, S. R. (2012). Clinical tracking of severely obese children: a new growth chart. *Pediatrics*, *130*(6), 1136–1140. https://doi.org/10.1542/peds.2012-0596

Gupta, N. K., Mueller, W. H., Chan, W., & Meininger, J. C. (2002). Is obesity associated with poor sleep quality in adolescents? *American Journal of Human Biology : The Official Journal of the Human Biology Council*, *14*(6), 762–768. https://doi.org/10.1002/ajhb.10093

Gurnani, M., Birken, C., & Hamilton, J. (2015). Childhood Obesity: Causes, Consequences, and Management. *Pediatric Clinics of North America*, *62*(4), 821–840. https://doi.org/10.1016/j.pcl.2015.04.001

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1· 6 million participants. *The Lancet Child & Adolescent Health*, *4*(1), 23–35.

Hale, L., & Guan, S. (2015). Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Medicine Reviews*, *21*, 50–58. https://doi.org/10.1016/j.smrv.2014.07.007

Harris, J. L., Bargh, J. A., & Brownell, K. D. (2009). Priming effects of television food advertising on eating behavior. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *28*(4), 404–413. https://doi.org/10.1037/a0014399

Hart, C. N., Carskadon, M. A., Considine, R. V, Fava, J. L., Lawton, J., Raynor, H. A., Jelalian, E., Owens, J., & Wing, R. (2013). Changes in children's sleep duration on food intake, weight, and leptin. *Pediatrics*, *132*(6), e1473–e1480.

Hart, C. N., Hawley, N. L., Coffman, D. L., Raynor, H. A., Carskadon, M. A., Jelalian, E., Owens, J. A., Spaeth, A., & Wing, R. R. (2022). Randomized controlled trial to enhance children's sleep, eating, and weight. *Pediatric Research*, *92*(4), 1075–1081. https://doi.org/10.1038/s41390-021-01870-3

Health Canada. (2019). Canada's Dietary Guidelines for Health Professionals and Policy Makers. In *Health Canada*. https://food-guide.canada.ca/static/assets/pdf/CDG-EN-2018.pdf

Herman, K. M., Sabiston, C. M., Mathieu, M.-E., Tremblay, A., & Paradis, G. (2014). Sedentary behavior in a cohort of 8- to 10-year-old children at elevated risk of obesity. *Preventive Medicine*, *60*, 115–120. https://doi.org/10.1016/j.ypmed.2013.12.029

Hills, A. P., Andersen, L. B., & Byrne, N. M. (2011). Physical activity and obesity in children. *British Journal of Sports Medicine*, *45*(11), 866–870. https://doi.org/10.1136/bjsports-2011-090199

Hills, A. P., Okely, A. D., & Baur, L. A. (2010). Addressing childhood obesity through increased physical activity. *Nature Reviews. Endocrinology*, *6*(10), 543–549. https://doi.org/10.1038/nrendo.2010.133

Hjorth, M. F., Chaput, J.-P., Ritz, C., Dalskov, S.-M., Andersen, R., Astrup, A., Tetens, I., Michaelsen, K. F., & Sjödin, A. (2014). Fatness predicts decreased physical activity and increased sedentary time, but not vice versa: support from a longitudinal study in 8- to 11-year-old children. *International Journal of Obesity (2005)*, *38*(7), 959–965. https://doi.org/10.1038/ijo.2013.229

Hjorth, M. F., Quist, J. S., Andersen, R., Michaelsen, K. F., Tetens, I., Astrup, A., Chaput, J., & Sjödin, A. (2014). Change in sleep duration and proposed dietary risk factors for obesity in D anish school children. *Pediatric Obesity*, *9*(6), e156–e159.

Hoffmann, S., Sander, L., Wachtler, B., Blume, M., Schneider, S., Herke, M., Pischke, C. R., Fialho, P. M. M., Schuettig, W., Tallarek, M., Lampert, T., & Spallek, J. (2022). Moderating or mediating effects of family characteristics on socioeconomic inequalities in child health in high-income countries – a scoping review. *BMC Public Health*, *22*(1), 338. https://doi.org/10.1186/s12889-022-12603-4

Huang, B.-H., Duncan, M. J., Cistulli, P. A., Nassar, N., Hamer, M., & Stamatakis, E. (2022). Sleep and physical activity in relation to all-cause, cardiovascular disease and cancer mortality risk. *British Journal of Sports Medicine*, *56*(13), 718–724. https://doi.org/10.1136/bjsports-2021-104046

Hughes, A. R., Summer, S. S., Ollberding, N. J., Benken, L. A., & Kalkwarf, H. J. (2017). Comparison of an interviewer-administered with an automated self-administered 24 h (ASA24) dietary recall in adolescents. *Public Health Nutrition*, *20*(17), 3060–3067. https://doi.org/10.1017/S1368980017002269

Hunsberger, M., Mehlig, K., Börnhorst, C., Hebestreit, A., Moreno, L., Veidebaum, T., Kourides, Y., Siani, A., Molnar, D., & Sioen, I. (2015). Dietary carbohydrate and nocturnal sleep duration in relation to children's BMI: findings from the IDEFICS study in eight European countries. *Nutrients*, *7*(12), 10223–10236.

Hysing, M., Pallesen, S., Stormark, K. M., Jakobsen, R., Lundervold, A. J., & Sivertsen, B. (2015). Sleep and use of electronic devices in adolescence: results from a large population-based study. *BMJ Open*, *5*(1), e006748.

Imaki, M., Hatanaka, Y., Ogawa, Y., Yoshida, Y., & Tanada, S. (2002). An epidemiological study on relationship between the hours of sleep and life style factors in Japanese factory workers. *Journal of Physiological Anthropology and Applied Human Science*, *21*(2), 115–120. https://doi.org/10.2114/jpa.21.115

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *The International Journal of Behavioral Nutrition and Physical Activity*, *7*, 40. https://doi.org/10.1186/1479-5868-7-40

Jean-Louis, G., Kripke, D. F., Mason, W. J., Elliott, J. A., & Youngstedt, S. D. (2001). Sleep estimation from wrist movement quantified by different actigraphic modalities. *Journal of Neuroscience Methods*, *105*(2), 185–191. https://doi.org/10.1016/s0165-0270(00)00364-2

Johns, M. W. (1991). A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep*, *14*(6), 540–545. https://doi.org/10.1093/sleep/14.6.540

Julious, S. A. (2005). Sample size of 12 per group rule of thumb for a pilot study. *Pharmaceutical Statistics*, *4*(4), 287–291. https://doi.org/https://doi.org/10.1002/pst.185

Katzmarzyk, P. T., Barreira, T. V, Broyles, S. T., Champagne, C. M., Chaput, J.-P., Fogelholm, M., Hu, G., Johnson, W. D., Kuriyan, R., Kurpad, A., Lambert, E. V, Maher, C., Maia, J., Matsudo, V., Olds, T., Onywera, V., Sarmiento, O. L., Standage, M., Tremblay, M. S., … Church, T. S. (2015). Physical Activity, Sedentary Time, and Obesity in an International Sample of Children. *Medicine and Science in Sports and Exercise*, *47*(10), 2062–2069. https://doi.org/10.1249/MSS.0000000000000649

Kim, J., & Lim, H. (2019). Nutritional Management in Childhood Obesity. *Journal of Obesity & Metabolic Syndrome*, *28*(4), 225–235. https://doi.org/10.7570/jomes.2019.28.4.225

Kjeldsen, J. S., Hjorth, M. F., Andersen, R., Michaelsen, K. F., Tetens, I., Astrup, A., Chaput, J. P., & Sjödin, A. (2014). Short sleep duration and large variability in sleep duration are independently associated with dietary risk factors for obesity in Danish school children. *International Journal of Obesity*, *38*(1), 32–39.

Klingenberg, L., Chaput, J.-P., Holmbäck, U., Jennum, P., Astrup, A., & Sjödin, A. (2012). Sleep restriction is not associated with a positive energy balance in adolescent boys. *The American Journal of Clinical Nutrition*, *96*(2), 240–248. https://doi.org/10.3945/ajcn.112.038638

Komada, Y., Narisawa, H., Ueda, F., Saito, H., Sakaguchi, H., Mitarai, M., Suzuki, R., Tamura, N., Inoue, S., & Inoue, Y. (2017). Relationship between self-reported dietary nutrient intake and self-reported sleep duration among Japanese adults. *Nutrients*, *9*(2), 134.

Koopman-Verhoeff, M. E., Serdarevic, F., Kocevska, D., Bodrij, F. F., Mileva-Seitz, V. R., Reiss, I., Hillegers, M. H. J., Tiemeier, H., Cecil, C. A. M., Verhulst, F. C., & Luijk, M. P. C. M. (2019). Preschool family irregularity and the development of sleep problems in childhood: a longitudinal study. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *60*(8), 857–865. https://doi.org/10.1111/jcpp.13060

Koplan, J. P., Liverman, C. T., & Kraak, V. I. (2005). Preventing childhood obesity: health in the balance: executive summary. *Journal of the American Dietetic Association*, *105*(1), 131–

138. https://doi.org/10.1016/j.jada.2004.11.023

Kovács, E., Siani, A., Konstabel, K., Hadjigeorgiou, C., De Bourdeaudhuij, I., Eiben, G., Lissner, L., Gwozdz, W., Reisch, L., & Pala, V. (2014). Adherence to the obesity-related lifestyle intervention targets in the IDEFICS study. *International Journal of Obesity*, *38*(2), S144–S151.

Kraak, V. I., Gootman, J. A., & McGinnis, J. M. (2006). *Food marketing to children and youth: threat or opportunity?* National Academies Press.

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: a meta-analytic review. *Journal of Behavioral Medicine*, *38*(3), 427–449. https://doi.org/10.1007/s10865-015-9617-6

Krehbiel, C. F., DuPaul, G. J., & Hoffman, J. A. (2017). A Validation Study of the Automated Self-Administered 24-Hour Dietary Recall for Children, 2014 Version, at School Lunch. *Journal of the Academy of Nutrition and Dietetics*, *117*(5), 715–724. https://doi.org/10.1016/j.jand.2016.10.028

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., Mei, Z., Curtin, L. R., Roche, A. F., & Johnson, C. L. (2000). CDC growth charts: United States. *Advance Data*, *314*, 1–27.

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., Wei, R., Curtin, L. R., Roche, A. F., & Johnson, C. L. (2002). 2000 CDC Growth Charts for the United States: methods and development. *Vital and Health Statistics. Series 11, Data from the National Health Survey*, *246*, 1–190.

Kumar, S., & Kelly, A. S. (2017). Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment. *Mayo Clinic Proceedings*, *92*(2), 251–265. https://doi.org/10.1016/j.mayocp.2016.09.017

Labree, W., Van de Mheen, D., Rutten, F., Rodenburg, G., Koopmans, G., & Foets, M. (2015). Differences in overweight and obesity among children from migrant and native origin: the role of physical activity, dietary intake, and sleep duration. *PloS One*, *10*(6), e0123672.

Laurson, K. R., Eisenmann, J. C., Welk, G. J., Wickel, E. E., Gentile, D. A., & Walsh, D. A. (2008). Combined influence of physical activity and screen time recommendations on childhood overweight. *The Journal of Pediatrics*, *153*(2), 209–214. https://doi.org/10.1016/j.jpeds.2008.02.042

Laurson, K. R., Lee, J. A., Gentile, D. A., Walsh, D. A., & Eisenmann, J. C. (2014). Concurrent Associations between Physical Activity, Screen Time, and Sleep Duration with Childhood Obesity. *ISRN Obesity*, *2014*, 204540. https://doi.org/10.1155/2014/204540

Lee, V., Mikkelsen, L., Srikantharajah, J., & Cohen, L. (2008). Promising strategies for creating healthy eating and active living environments. *A Document from the Prevention Institute*.

Littleton, S. H., Berkowitz, R. I., & Grant, S. F. A. (2020). Genetic Determinants of Childhood Obesity. *Molecular Diagnosis & Therapy*, *24*(6), 653–663. https://doi.org/10.1007/s40291-020-00496-1

Lofthouse, N., Gilchrist, R., & Splaingard, M. (2009). Mood-related sleep problems in children and adolescents. *Child and Adolescent Psychiatric Clinics of North America*, *18*(4), 893–916. https://doi.org/10.1016/j.chc.2009.04.007

Loprinzi, P. D., Cardinal, B. J., Lee, H., & Tudor-Locke, C. (2015). Markers of adiposity among children and adolescents: implications of the isotemporal substitution paradigm with sedentary behavior and physical activity patterns. *Journal of Diabetes and Metabolic Disorders*, *14*, 46. https://doi.org/10.1186/s40200-015-0175-9

Lucien, J. N., Ortega, M. T., & Shaw, N. D. (2021). Sleep and puberty. *Current Opinion in Endocrine and Metabolic Research*, *17*, 1–7. https://doi.org/https://doi.org/10.1016/j.coemr.2020.09.009

Ma, J., Wang, Z., Song, Y., Hu, P., & Zhang, B. (2010). BMI percentile curves for Chinese children aged 7-18 years, in comparison with the WHO and the US Centers for Disease Control and Prevention references. *Public Health Nutrition*, *13*(12), 1990–1996. https://doi.org/10.1017/S1368980010000492

Ma, L., Ding, Y., Chiu, D. T., Wu, Y., Wang, Z., Wang, X., & Wang, Y. (2021). A longitudinal study of sleep, weight status, and weight-related behaviors: Childhood Obesity Study in China Mega-cities. *Pediatric Research*, *90*(5), 971–979.

Magee, C. A., Lee, J. K., & Vella, S. A. (2014). Bidirectional relationships between sleep duration and screen time in early childhood. *JAMA Pediatrics*, *168*(5), 465–470.

Magee, L., & Hale, L. (2012). Longitudinal associations between sleep duration and subsequent weight gain: a systematic review. *Sleep Medicine Reviews*, *16*(3), 231–241. https://doi.org/10.1016/j.smrv.2011.05.005

Markovich, A. N., Gendron, M. A., & Corkum, P. V. (2014). Validating the Children's Sleep Habits Questionnaire Against Polysomnography and Actigraphy in School-Aged Children. *Frontiers in Psychiatry*, *5*, 188. https://doi.org/10.3389/fpsyt.2014.00188

Markovich, A. N., Gendron, M. A., & Corkum, P. V. (2015). Validating the Children's Sleep Habits Questionnaire against polysomnography and actigraphy in school-aged children. *Frontiers in Psychiatry*, *5*, 188.

Markwald, R. R., Melanson, E. L., Smith, M. R., Higgins, J., Perreault, L., Eckel, R. H., & Wright, K. P. J. (2013). Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(14), 5695–5700. https://doi.org/10.1073/pnas.1216951110

Marshall, S. J., Biddle, S. J. H., Sallis, J. F., McKenzie, T. L., & Conway, T. L. (2002). Clustering of sedentary behaviors and physical activity among youth: a cross-national study. *Pediatric Exercise Science*, *14*(4), 401–417.

Martinez, S. M., Tschann, J. M., Butte, N. F., Gregorich, S. E., Penilla, C., Flores, E., Greenspan, L. C., Pasch, L. A., & Deardorff, J. (2017). Short sleep duration is associated with eating more carbohydrates and less dietary fat in Mexican American children. *Sleep*, *40*(2), zsw057.

Matricciani, L., Olds, T., & Petkov, J. (2012). In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. *Sleep Medicine Reviews*, *16*(3), 203–211. https://doi.org/10.1016/j.smrv.2011.03.005

Meltzer, L. J., Avis, K. T., Biggs, S., Reynolds, A. C., Crabtree, V. M., & Bevans, K. B. (2013). The Children's Report of Sleep Patterns (CRSP): a self-report measure of sleep for school-aged children. *Journal of Clinical Sleep Medicine*, *9*(3), 235–245.

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*(5), 463–475. https://doi.org/10.1016/j.smrv.2011.10.002

Meltzer, L. J., Walsh, C. M., Traylor, J., & Westin, A. M. L. (2012). Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep*, *35*(1), 159–166. https://doi.org/10.5665/sleep.1608

Merghani, A., Malhotra, A., & Sharma, S. (2016). The U-shaped relationship between exercise and cardiac morbidity. *Trends in Cardiovascular Medicine*, *26*(3), 232–240.

Migueles, J. H., Rowlands, A. V, Huber, F., Sabia, S., & van Hees, V. T. (2019). GGIR: a research community–driven open source R package for generating physical activity and sleep outcomes from multi-day raw accelerometer data. *Journal for the Measurement of Physical Behaviour*, *2*(3), 188–196.

Minaker, L., & Hammond, D. (2016). Low frequency of fruit and vegetable consumption among Canadian youth: findings from the 2012/2013 Youth Smoking Survey. *Journal of School Health*, *86*(2), 135–142.

Morelhão, P. K., Tufik, S., & Andersen, M. L. (2018). The Interactions Between Obesity, Sleep Quality, and Chronic Pain. *Journal of Clinical Sleep Medicine*, *14*(11), 1965–1966. https://doi.org/10.5664/jcsm.7510

Morrissey, B., Allender, S., & Strugnell, C. (2019). Dietary and Activity Factors Influence Poor Sleep and the Sleep-Obesity Nexus among Children. *International Journal of Environmental Research and Public Health*, *16*(10). https://doi.org/10.3390/ijerph16101778

Mozaffarian, N., Heshmat, R., Ataie-Jafari, A., Motlagh, M. E., Ziaodini, H., Shafiee, G., Taheri, M., Mansourian, M., Qorbani, M., & Kelishadi, R. (2020). Association of sleep duration and snack consumption in children and adolescents: The CASPIAN-V study. *Food Science & Nutrition*, *8*(4), 1888–1897.

Mühlig, Y., Antel, J., Föcker, M., & Hebebrand, J. (2016). Are bidirectional associations of obesity and depression already apparent in childhood and adolescence as based on high-quality studies? A systematic review. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity*, *17*(3), 235–249. https://doi.org/10.1111/obr.12357

Must, A., & Parisi, S. M. (2009). Sedentary behavior and sleep: paradoxical effects in association with childhood obesity. *International Journal of Obesity*, *33*(1), S82–S86.

MUTZ, D. C., ROBERTS, D. F., & VUUREN, D. P. van. (1993). Reconsidering the Displacement Hypothesis: Television's Influence on Children's Time Use. *Communication Research*, *20*(1), 51–75. https://doi.org/10.1177/009365093020001003

Narang, I., & Mathew, J. L. (2012). Childhood obesity and obstructive sleep apnea. *Journal of Nutrition and Metabolism*, *2012*, 134202. https://doi.org/10.1155/2012/134202

Nascimento-Ferreira, M. V, Collese, T. S., de Moraes, A. C. F., Rendo-Urteaga, T., Moreno, L. A., & Carvalho, H. B. (2016). Validity and reliability of sleep time questionnaires in children and adolescents: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *30*, 85–96. https://doi.org/https://doi.org/10.1016/j.smrv.2015.11.006

Neumark-Sztainer, D., Wall, M., Perry, C., & Story, M. (2003). Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. *Preventive Medicine*, *37*(3), 198–208. https://doi.org/10.1016/s0091-7435(03)00114-2

Ng, C., Young, T. K., & Corey, P. N. (2010). Associations of television viewing, physical activity and dietary behaviours with obesity in aboriginal and non-aboriginal Canadian youth. *Public Health Nutrition*, *13*(9), 1430–1437. https://doi.org/10.1017/S1368980010000832

Nicolucci, A., & Maffeis, C. (2022). The adolescent with obesity: what perspectives for treatment? *Italian Journal of Pediatrics*, *48*(1), 9. https://doi.org/10.1186/s13052-022-01205-w

Ohayon, M., Wickwire, E. M., Hirshkowitz, M., Albert, S. M., Avidan, A., Daly, F. J., Dauvilliers, Y., Ferri, R., Fung, C., Gozal, D., Hazen, N., Krystal, A., Lichstein, K., Mallampalli, M., Plazzi, G., Rawding, R., Scheer, F. A., Somers, V., & Vitiello, M. V. (2017). National Sleep Foundation's sleep quality recommendations: first report. *Sleep Health*, *3*(1), 6–19. https://doi.org/https://doi.org/10.1016/j.sleh.2016.11.006

Ohida, T., Kamal, A. M., Uchiyama, M., Kim, K., Takemura, S., Sone, T., & Ishii, T. (2001). The influence of lifestyle and health status factors on sleep loss among the Japanese general population. *Sleep*, *24*(3), 333–338. https://doi.org/10.1093/sleep/24.3.333

Organization, W. H. (2011). *Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008*.

Owens, J. (2014). Insufficient sleep in adolescents and young adults: an update on causes and consequences. *Pediatrics*, *134*(3), e921-32. https://doi.org/10.1542/peds.2014-1696

Owens, J. A., Spirito, A., & McGuinn, M. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep*, *23*(8), 1043–1051.

Paglia, L. (2019). The sweet danger of added sugars. *European Journal of Paediatric Dentistry*, *20*(2), 89. https://doi.org/10.23804/ejpd.2019.20.02.01

Pan, L., Li, R., Park, S., Galuska, D. A., Sherry, B., & Freedman, D. S. (2014). A longitudinal analysis of sugar-sweetened beverage intake in infancy and obesity at 6 years. *Pediatrics*, *134 Suppl*(Suppl 1), S29-35. https://doi.org/10.1542/peds.2014-0646F

Participaction, T., Card, R., & Activity, P. (2018). *Canadian kids need to move more to boost their brain health*.

Perez, O., Garza, T., Hindera, O., Beltran, A., Musaad, S. M., Dibbs, T., Singh, A., Chug, S., Sisson, A., & Kumar Vadathya, A. (2023). Validated assessment tools for screen media use: A systematic review. *Plos One*, *18*(4), e0283714.

Pfefferbaum, B., & Van Horn, R. L. (2022). Physical Activity and Sedentary Behavior in Children During the COVID-19 Pandemic: Implications for Mental Health. *Current Psychiatry Reports*, *24*(10), 493–501. https://doi.org/10.1007/s11920-022-01366-9

Phillips, L. R. S., Parfitt, G., & Rowlands, A. V. (2013). Calibration of the GENEA accelerometer for assessment of physical activity intensity in children. *Journal of Science and Medicine in Sport*, *16*(2), 124–128. https://doi.org/10.1016/j.jsams.2012.05.013

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Connor Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *The International Journal of Behavioral Nutrition and Physical Activity*, *5*, 56. https://doi.org/10.1186/1479-5868-5-56

Qatrunnada, R. D. (2022). Factors that Cause Overweight and Obesity in School-Age Children and Adult: A Literature Review. *Media Gizi Kesmas*, *11*(1), 318–326. https://doi.org/10.20473/mgk.v11i1.2022.318-326

Rao, D. P., Kropac, E., Do, M. T., Roberts, K. C., & Jayaraman, G. C. (2016). Childhood overweight and obesity trends in Canada. *Health Promotion and Chronic Disease Prevention in Canada : Research, Policy and Practice*, *36*(9), 194–198. https://doi.org/10.24095/hpcdp.36.9.03

Redeker, N. S., Conley, S., Anderson, G., Cline, J., Andrews, L., Mohsenin, V., Jacoby, D., & Jeon, S. (2020). Effects of Cognitive Behavioral Therapy for Insomnia on Sleep, Symptoms, Stress, and Autonomic Function Among Patients With Heart Failure. *Behavioral Sleep Medicine*, *18*(2), 190–202. https://doi.org/10.1080/15402002.2018.1546709

Reinehr, T., Hinney, A., de Sousa, G., Austrup, F., Hebebrand, J., & Andler, W. (2007). Definable somatic disorders in overweight children and adolescents. *The Journal of Pediatrics*, *150*(6), 618–622, 622.e1-5. https://doi.org/10.1016/j.jpeds.2007.01.042

Roberts, K. C., Shields, M., de Groh, M., Aziz, A., & Gilbert, J.-A. (2012). Overweight and obesity in children and adolescents: results from the 2009 to 2011 Canadian Health Measures Survey. *Health Reports*, *23*(3), 37–41.

Robinson, T. N., Banda, J. A., Hale, L., Lu, A. S., Fleming-Milici, F., Calvert, S. L., & Wartella, E. (2017). Screen Media Exposure and Obesity in Children and Adolescents. *Pediatrics*, *140*(Suppl 2), S97–S101. https://doi.org/10.1542/peds.2016-1758K

Rupp, T. L., & Balkin, T. J. (2011). Comparison of Motionlogger Watch and Actiwatch actigraphs to polysomnography for sleep/wake estimation in healthy young adults. *Behavior Research Methods*, *43*(4), 1152–1160. https://doi.org/10.3758/s13428-011-0098-4

Sabia, S., van Hees, V. T., Shipley, M. J., Trenell, M. I., Hagger-Johnson, G., Elbaz, A., Kivimaki, M., & Singh-Manoux, A. (2014). Association between questionnaire- and accelerometer-assessed physical activity: the role of sociodemographic factors. *American Journal of Epidemiology*, *179*(6), 781–790. https://doi.org/10.1093/aje/kwt330

Sadeh, A. (2007). Consequences of Sleep Loss or Sleep Disruption in Children. *Sleep Medicine Clinics*, *2*(3), 513–520. https://doi.org/https://doi.org/10.1016/j.jsmc.2007.05.012

Sarni, R. O. S., Kochi, C., & Suano-Souza, F. I. (2022). Childhood obesity: an ecological perspective. *Jornal de Pediatria*, *98*, S38–S46. https://doi.org/https://doi.org/10.1016/j.jped.2021.10.002

Saunders, T. J., Gray, C. E., Poitras, V. J., Chaput, J.-P., Janssen, I., Katzmarzyk, P. T., Olds, T., Connor Gorber, S., Kho, M. E., Sampson, M., Tremblay, M. S., & Carson, V. (2016). Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism*, *41*(6 (Suppl. 3)), S283–S293. https://doi.org/10.1139/apnm-2015-0626

Schaefer, C. A., Nigg, C. R., Hill, J. O., Brink, L. A., & Browning, R. C. (2014). Establishing and evaluating wrist cutpoints for the GENEActiv accelerometer in youth. *Medicine and Science in Sports and Exercise*, *46*(4), 826–833. https://doi.org/10.1249/MSS.0000000000000150

Shechter, A., Rising, R., Albu, J. B., & St-Onge, M.-P. (2013). Experimental sleep curtailment causes wake-dependent increases in 24-h energy expenditure as measured by whole-room indirect calorimetry. *The American Journal of Clinical Nutrition*, *98*(6), 1433–1439. https://doi.org/10.3945/ajcn.113.069427

Shochat, T., Cohen-Zion, M., & Tzischinsky, O. (2014). Functional consequences of inadequate sleep in adolescents: A systematic review. *Sleep Medicine Reviews*, *18*(1), 75–87. https://doi.org/https://doi.org/10.1016/j.smrv.2013.03.005

Shrivastava, D., Jung, S., Saadat, M., Sirohi, R., & Crewson, K. (2014). How to interpret the results of a sleep study. *Journal of Community Hospital Internal Medicine Perspectives*, *4*(5), 24983. https://doi.org/10.3402/jchimp.v4.24983

Sijtsma, A., Koller, M., Sauer, P. J. J., & Corpeleijn, E. (2015). Television, sleep, outdoor play and BMI in young children: the GECKO Drenthe cohort. *European Journal of Pediatrics*, *174*(5), 631–639. https://doi.org/10.1007/s00431-014-2443-y

Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2016). Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obesity Reviews*, *17*(2), 95–107.

Smith, R., Kelly, B., Yeatman, H., & Boyland, E. (2019). Food Marketing Influences Children's Attitudes, Preferences and Consumption: A Systematic Critical Review. *Nutrients*, *11*(4). https://doi.org/10.3390/nu11040875

Spiegel, K., Tasali, E., Penev, P., & Cauter, E. Van. (2004). Brief communication: sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Annals of Internal Medicine*, *141*(11), 846–850.

Spruyt, K. (2019). A review of developmental consequences of poor sleep in childhood. *Sleep Medicine*, *60*, 3–12. https://doi.org/https://doi.org/10.1016/j.sleep.2018.11.021

Stiglic, N., & Viner, R. M. (2019). Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews. *BMJ Open*, *9*(1). https://doi.org/10.1136/bmjopen-2018-023191

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., Hergenroeder, A. C., Must, A., Nixon, P. A., Pivarnik, J. M., Rowland, T., Trost, S., & Trudeau, F. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics*, *146*(6), 732–737. https://doi.org/10.1016/j.jpeds.2005.01.055

Subar, A. F., Potischman, N., Dodd, K. W., Thompson, F. E., Baer, D. J., Schoeller, D. A., Midthune, D., Kipnis, V., Kirkpatrick, S. I., Mittl, B., Zimmerman, T. P., Douglass, D., Bowles, H. R., & Park, Y. (2020). Performance and Feasibility of Recalls Completed Using the Automated Self-Administered 24-Hour Dietary Assessment Tool in Relation to Other Self-Report Tools and Biomarkers in the Interactive Diet and Activity Tracking in AARP (IDATA) Study. *Journal of the Academy of Nutrition and Dietetics*, *120*(11), 1805–1820. https://doi.org/10.1016/j.jand.2020.06.015

Subar, A. F., Thompson, F. E., Potischman, N., Forsyth, B. H., Buday, R., Richards, D., McNutt, S., Hull, S. G., Guenther, P. M., Schatzkin, A., & Baranowski, T. (2007). Formative research of a quick list for an automated self-administered 24-hour dietary recall. *Journal of the American Dietetic Association*, *107*(6), 1002–1007. https://doi.org/10.1016/j.jada.2007.03.007

Teare, M. D., Dimairo, M., Shephard, N., Hayman, A., Whitehead, A., & Walters, S. J. (2014). Sample size requirements to estimate key design parameters from external pilot randomised controlled trials: a simulation study. *Trials*, *15*(1), 264. https://doi.org/10.1186/1745-6215-15-264

Telama, R. (2009). Tracking of physical activity from childhood to adulthood: a review. *Obesity Facts*, *2*(3), 187–195. https://doi.org/10.1159/000222244

Thivel, D., Saunders, T. J., & Chaput, J.-P. (2013). Physical activity in children and youth may have greater impact on energy intake than energy expenditure. In *Journal of nutrition education and behavior* (Vol. 45, Issue 1, p. e1). https://doi.org/10.1016/j.jneb.2012.08.004

Thomas-Eapen, N. (2021). Childhood Obesity. *Primary Care: Clinics in Office Practice*, *48*(3), 505–515. https://doi.org/https://doi.org/10.1016/j.pop.2021.04.002

Thurston, R. C., Santoro, N., & Matthews, K. A. (2012). Are vasomotor symptoms associated with sleep characteristics among symptomatic midlife women? Comparisons of self-report and objective measures. *Menopause (New York, N.Y.)*, *19*(7), 742–748. https://doi.org/10.1097/gme.0b013e3182422973

Tremblay, M. S., Carson, V., Chaput, J.-P., Connor Gorber, S., Dinh, T., Duggan, M., Faulkner, G., Gray, C. E., Gruber, R., Janson, K., Janssen, I., Katzmarzyk, P. T., Kho, M. E., Latimer-Cheung, A. E., LeBlanc, C., Okely, A. D., Olds, T., Pate, R. R., Phillips, A., … Zehr, L. (2016). Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition et Metabolisme*, *41*(6 Suppl 3), S311-27. https://doi.org/10.1139/apnm-2016-0151

Tudor-Locke, C., Craig, C. L., Brown, W. J., Clemes, S. A., De Cocker, K., Giles-Corti, B., Hatano, Y., Inoue, S., Matsudo, S. M., Mutrie, N., Oppert, J.-M., Rowe, D. A., Schmidt, M. D., Schofield, G. M., Spence, J. C., Teixeira, P. J., Tully, M. A., & Blair, S. N. (2011). How many steps/day are enough? for adults. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 79. https://doi.org/10.1186/1479-5868-8-79

Utter, J., Scragg, R., & Schaaf, D. (2006). Associations between television viewing and consumption of commonly advertised foods among New Zealand children and young adolescents. *Public Health Nutrition*, *9*(5), 606–612. https://doi.org/10.1079/phn2005899

van Hees, V. T., Sabia, S., Anderson, K. N., Denton, S. J., Oliver, J., Catt, M., Abell, J. G., Kivimäki, M., Trenell, M. I., & Singh-Manoux, A. (2015). A Novel, Open Access Method to Assess Sleep Duration Using a Wrist-Worn Accelerometer. *PloS One*, *10*(11), e0142533. https://doi.org/10.1371/journal.pone.0142533

Vos, M. B., Kaar, J. L., Welsh, J. A., Van Horn, L. V, Feig, D. I., Anderson, C. A. M., Patel, M. J., Cruz Munos, J., Krebs, N. F., Xanthakos, S. A., & Johnson, R. K. (2017). Added Sugars and Cardiovascular Disease Risk in Children: A Scientific Statement From the American Heart Association. *Circulation*, *135*(19), e1017–e1034. https://doi.org/10.1161/CIR.0000000000000439

Wang, Y. G., Menno, D., Chen, A., Steininger, T. L., Morris, S., Black, J., Profant, J., & Johns, M. W. (2022). Validation of the Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) questionnaire in pediatric patients with narcolepsy with cataplexy aged 7–16 years. *Sleep Medicine*, *89*, 78–84. https://doi.org/https://doi.org/10.1016/j.sleep.2021.11.003

Wang, Y., Wattelez, G., Frayon, S., Caillaud, C., Galy, O., & Yacef, K. (2023). ABIPA: ARIMA-Based Integration of Accelerometer-Based Physical Activity for Adolescent Weight Status Prediction. *ACM Trans. Comput. Healthcare*, *4*(1). https://doi.org/10.1145/3561611

Watson, E. J., Coates, A. M., Banks, S., & Kohler, M. (2018). Total dietary sugar consumption does not influence sleep or behaviour in Australian children. *International Journal of Food Sciences and Nutrition*, *69*(4), 503–512. https://doi.org/10.1080/09637486.2017.1386628

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S. F., & Tasali, E. (2015). Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society on the Recommended Amount of Sleep for a Healthy Adult: Methodology and Discussion. *Sleep*, *38*(8), 1161–1183. https://doi.org/10.5665/sleep.4886

Wei, R., Ogden, C. L., Parsons, V. L., Freedman, D. S., & Hales, C. M. (2020). A method for calculating BMI z-scores and percentiles above the 95(th) percentile of the CDC growth charts. *Annals of Human Biology*, *47*(6), 514–521. https://doi.org/10.1080/03014460.2020.1808065

Weker, H. (2006). [Simple obesity in children. A study on the role of nutritional factors]. *Medycyna wieku rozwojowego*, *10*(1), 3–191.

Whiting, S., Buoncristiano, M., Gelius, P., Abu-Omar, K., Pattison, M., Hyska, J., Duleva, V., Musić Milanović, S., Zamrazilová, H., Hejgaard, T., Rasmussen, M., Nurk, E., Shengelia, L., Kelleher, C. C., Heinen, M. M., Spinelli, A., Nardone, P., Abildina, A., Abdrakhmanova, S., … Breda, J. (2021). Physical Activity, Screen Time, and Sleep Duration of Children Aged 6-9 Years in 25 Countries: An Analysis within the WHO European Childhood Obesity Surveillance Initiative (COSI) 2015-2017. *Obesity Facts*, *14*(1), 32–44. https://doi.org/10.1159/000511263

Wilkie, H. J., Standage, M., Gillison, F. B., Cumming, S. P., & Katzmarzyk, P. T. (2016). Multiple lifestyle behaviours and overweight and obesity among children aged 9-11 years: results from the UK site of the International Study of Childhood Obesity, Lifestyle and the Environment. *BMJ Open*, *6*(2), e010677. https://doi.org/10.1136/bmjopen-2015-010677

Yland, J., Guan, S., Emanuele, E., & Hale, L. (2015). Interactive vs passive screen time and nighttime sleep duration among school-aged children. *Sleep Health*, *1*(3), 191–196.

Zhang, Z., Adamo, K. B., Ogden, N., Goldfield, G. S., Okely, A. D., Kuzik, N., Crozier, M., Hunter, S., Predy, M., & Carson, V. (2022). Associations between screen time and cognitive development in preschoolers. *Paediatrics & Child Health*, *27*(2), 105–110. https://doi.org/10.1093/pch/pxab067

Zimberg, I. Z., Dâmaso, A., Del Re, M., Carneiro, A. M., de Sá Souza, H., de Lira, F. S., Tufik, S., & de Mello, M. T. (2012). Short sleep duration and obesity: mechanisms and future perspectives. *Cell Biochemistry and Function*, *30*(6), 524–529. https://doi.org/10.1002/cbf.2832