The Development of Healthy Lifestyle Behaviors Among US Children:

Early Predictors and Associated Outcomes

by

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ABSTRACT

Understanding the development of healthy lifestyle behaviors as well as its early predictors and associated outcomes is paramount, given the importance of healthy lifestyle behaviors in academic success, health, and well-being. In this dissertation, I conducted two studies to investigate the development of three modifiable lifestyle behaviors (i.e., physical activity, sedentary behavior, and sleep duration) in middle childhood, using a nationally representative sample of US children from the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11. Study 1 was designed to unpack the developmental associations among the three lifestyle behaviors by examining the transactional within-person associations and co-development. Moderate-to-vigorous physical activity (MVPA), video game use (as a measure of mentally active sedentary behavior), and sleep duration were reported by parents in 3rd through 5th grades. Results from the random intercept cross-lagged panel model showed that MVPA, video game use, and sleep duration were not transactionally related over time at the within-person level. Analysis with the multivariate latent growth curve model showed that changes in these lifestyle behaviors over time were not correlated either. These main findings were replicated across social contexts of socioeconomic status, gender, and race/ethnicity groups. Study 2 focused on investigating predictors and outcomes associated with developmental trajectories of the three lifestyle behaviors. Specifically, kindergarten self-regulation (rated by teachers) that reflects individual agency was examined as a predictor. Fifth grade externalizing and internalizing problems (rated by teachers), body mass index (assessed with weight and height), and academic achievement (assessed by reading, math, and science achievement) were included as mental health, physical health, and academic outcomes, respectively. Results showed that kindergarten self-regulation predicted initial levels (i.e., 3rd grade) of video game use and sleep duration. After controlling for the stability and other lifestyle behaviors, 5th grade externalizing problems and academic achievement were predicted by initial levels of sleep duration, and body mass index was predicted by initial levels of sleep duration and MVPA and changes in MVPA. Most of these findings were replicated in subsamples across social contexts. Overall, this dissertation provides important insight into the development of healthy lifestyle behaviors in US children.

DEDICATION

This dissertation is dedicated to the loving memory of my paternal grandmother, Fanggui Liu, who taught me to be a strong woman and always be myself.

To my parents, Lanfang Long and Changrong Li, who have always loved and supported me unconditionally and taught me the power of commitment, consistency, and persistence in achieving goals.

To my younger brother, Chao Li, who showed me that there are clouds and storms in life, but we should stay positive and never lose hope.

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CHAPTER 1

GENERAL INTRODUCTION

Health lifestyles have become an increasingly important field of research in psychology, sociology, and public health (Cockerham, 2005; Foster et al., 2018; Walsh, 2011). Adherence to health lifestyles, including being physically active, obtaining adequate sleep, having healthy eating habits, and no smoking, is crucial for health, well-being, and longevity (Cappuccio et al., 2011; Journath et al., 2020; Loef & Walach, 2012; Wang et al., 2021; Wiese et al., 2018). Unhealthy lifestyle behaviors, on the other hand, increase the risk of mortality and negative health consequences, such as chronic diseases (Asaria et al., 2007; Cecchini et al., 2010; McCullough et al., 2002; Roberts & Barnard, 2005; Willett et al., 2006). Chronic diseases, including diabetes, cardiovascular disease, and cancer, accounted for more than two-thirds of deaths worldwide and have become the leading causes of poor health, disabilities, and deaths in the United States (US) (Bauer et al., 2014; World Health Organization, 2014). Modifying unhealthy lifestyle behaviors and fostering health lifestyles are central focuses of public health intervention (Haveman-Nies et al., 2003; Leskinen et al., 2018; Nyberg et al., 2020). Intervention and prevention strategies that help individuals establish and maintain healthy lifestyle behaviors from an earlier age (e.g., childhood) are likely to be particularly beneficial to the individual and society. To advance the literature on the development of healthy lifestyle behaviors in childhood, two studies are conducted. Study 1 is focused on the developmental associations among three modifiable lifestyle behaviors—physical activity, sedentary behavior, and sleep. Study 2 is focused on early predictors and associated outcomes of developmental trajectories of these lifestyle behaviors.

Childhood represents a critical period of development during which individuals start to make their lifestyle choices and establish lifestyle habits that are likely to be resistant to change and, therefore, persist into adulthood (Hanson et al., 2019; Telama, 2009; Telama et al., 2005). Practicing health lifestyles is highly beneficial for children, as healthy lifestyle behaviors support children's optimal brain development and learning (Jirout et al., 2019; Urrila et al., 2017). Children who have higher levels of physical activity, lower screen time, longer sleep duration, and healthier diets tend to exhibit better cognitive performance and higher academic achievement, compared to their peers with unhealthy lifestyle behaviors (Burrows et al., 2017; Carson et al., 2015; Dewald et al., 2010; Faught et al., 2017; Hillman, 2014; Singh et al., 2012). Meeting lifestyle recommendations is also beneficial to children's mental health (Loewen et al., 2019; Zhang et al., 2021). This is especially important because many lifetime mental illnesses begin in childhood and adolescence and continue into adulthood (Kessler et al., 2005, 2007). Moreover, overweight and/or obesity in childhood, which is a global public health crisis and associated with subsequent negative outcomes (e.g., chronic diseases and psychosocial problems), is largely predicted by children's unhealthy lifestyle behaviors (Katzmarzyk et al., 2015; Liberali et al., 2021; Sahoo et al., 2015). Given the potential impact that childhood lifestyle behaviors have on later lifestyle behaviors, education, and health, there is a need to better understand the development of lifestyle behaviors in childhood and its early predictors and associated outcomes.

Most health lifestyles studies, however, have focused on adulthood. Research of childhood lifestyle behaviors is often limited in several ways. First, most studies employed single-point-in-time measures of lifestyle behaviors, failing to capture the change and continuity in lifestyle behaviors over time. A few existing studies examining trajectories of lifestyle behaviors show that on average children spend less time on physical activity and more time on screens and sleep less as they age (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016). Individual heterogeneities in these trajectories are observed, as the decrease or increase may be faster, slower, or not present among children who may also exhibit different initial levels (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016; Yoo, 2020). Examining individual differences in trajectories is important not only because it allows for a better understanding of the development of lifestyle behaviors, but also because it offers opportunities to investigate early predictors and associated outcomes of these trajectories. The latter would have important implications for early intervention and prevention.

Second, most studies focused on a specific lifestyle behavior, overlooking the interdependence of some lifestyle behaviors. This is particularly true for lifestyle behaviors that are associated with 24-hour time-use. Researchers have suggested that activities performed throughout a 24-hour cycle, including physical activity, sedentary behavior, and sleep, are interdependent, with the increase in time use on one activity potentially reducing the time use on at least one other activity (Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay et al., 2016). The interdependent relationship highlights the need to control for the possible confounding effects of other lifestyle behaviors when examining developmental consequences of a specific lifestyle behavior (Pedišić, 2014; Rosenberger et al., 2019). Additionally, it may indicate reciprocal associations and co-development of these daily activities over time. However, only a few studies have examined transactional relations between these activities, and even fewer studies have investigated whether these activities co-develop, particularly in childhood.

A third limitation concerns the lack of studies investigating how children actively monitor and regulate their lifestyle behaviors. Studies of childhood lifestyle behaviors often predict children's lifestyle behaviors with structural factors, ignoring that children as active agents are able to construct, control, and modify their lifestyle behaviors. As children gradually gain independence over their lifestyle behaviors (Mollborn et al., 2014), the role of agency in shaping lifestyle behaviors may become more salient. There is some evidence that children who have better self-regulatory skills are able to make healthier lifestyle choices and practice health lifestyles (e.g., Hall, 2012; Hofmann et al., 2009; Kroese et al., 2016), and their increased agency may therefore protect them from negative social structural factors (Bronfenbrenner & Morris, 2006; Cockerham, 2005, 2013). More longitudinal studies are needed to better understand how early self-regulation is associated with subsequent development of lifestyle behaviors.

The fourth limitation involves the generalizability of findings in past work. The majority of previous studies had relatively small sample sizes or used regional samples, making their findings difficult to generalize to the population.

To begin to overcome these limitations, I use a nationally representative sample of children in the US to investigate whether physical activity, sedentary behavior, and sleep duration are longitudinally, transactionally related from 3rd grade to 5th grade, how these lifestyle behaviors develop over time, and whether their developmental trajectories are correlated. In a second study, I examine self-regulation as an early predictor of trajectories of lifestyle behaviors across social contexts and investigate later outcomes associated with each lifestyle behavior after adjusting for other lifestyle behaviors.

Definition of Lifestyle Behaviors

According to Cockerham (2005, 2013), health lifestyles are defined as, "collective patterns of health-related behavior based on choices from options available to people according to their life chances" (Cockerham, 2013, p.138; see also Cockerham, 2005). This definition is based on the framework of the agency-structure debate, indicating that health lifestyles are determined by the interplay of agency (life choices) and structure (life chances) (Cockerham, 2005, 2013). Likewise, Mollborn et al. (2021) defined health lifestyles as, "constellations of health behaviors underpinned by group-level identities and norms that are consequential for health and well-being" (p. 388). Health lifestyles often reflect the shared norms, values, and ideas of the group to which an individual belongs. To this end, health lifestyles are both individual-level characteristics and group-level phenomena (Mollborn et al., 2021).

Among various lifestyle behaviors, the 24-hour time-use behaviors of physical activity, sedentary behavior, and sleep have received attention. These time-use behaviors have been found to be important for children's academic success, cognitive function, physical and mental health, and well-being (Carson et al., 2017; Marciano & Camerini, 2021; Sampasa-Kanyinga et al., 2017; Tremblay et al., 2016; Walsh et al., 2018).

Physical Activity

Physical activity is often defined as, "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985, p.126). The energy cost of physical activities is quantified by the metabolic equivalent of task (MET) values, which are computed as the ratio of work metabolic rate to a standard resting metabolic rate of 1.0 kcal/kg/h (Ainsworth et al., 1993, 2011). One MET is considered the resting metabolic rate and is the energy cost of a person sitting quietly (Ainsworth et al., 1993). Based on the rate of energy expenditure (i.e., intensity), physical activities can be broadly classified into three categories: *light-intensity* (1.5-3.0 METs; e.g., walking slowly), *moderate-intensity* (3.0-6.0 METs; e.g., walking briskly), and *vigorous-intensity* (≥ 6.0 METs; e.g., swimming) activities (2018 Physical Activity Guidelines Advisory Committee, 2018). Children and adolescents aged between 5 and 17 years are recommended to have at least 60 minutes per day of moderate- to vigorous-intensity physical activity (2018 Physical Activity Guidelines Advisory Committee, 2018; Tremblay et al., 2016; World Health Organization, 2020).

Sedentary Behavior

Sedentary behaviors are waking behaviors characterized by an energy expenditure of 1.5 METs or fewer, while in a sitting, reclining, or lying posture (Tremblay et al., 2017). Sedentary behavior during leisure time, particularly recreational screen-based sedentary behavior, has recently received significant scholarly attention. The time that an individual spends watching television (TV), computer, and mobile devices is *sedentary screen time*. A similar term is *recreational screen time*, which is the time an individual spends watching screens (e.g., TV, computer, mobile devices) for purposes other than education/study or work (World Health Organization, 2020). Researchers also distinguish between passive (e.g., TV viewing) and active (e.g., video game use) screen time or mentally passive and active sedentary behavior (Hallgren et al., 2020; Kikuchi et al., 2014; Kim et al., 2020; Mazzer et al., 2018; Peracchia & Curcio, 2018; Sweetser et al., 2012). Estimates show that about 60% of the US population spends at least 2 hours per day sitting watching TV and about 43%-57% of children and adolescents spend 1 hour or more per day using a computer outside school or work (Yang et al., 2019). From 2007 to 2016, the total sitting time per day increased from 5.5 hours to 6.4 hours in adults and from 7.0 hours to 8.2 hours in adolescents (Yang et al., 2019). During the height of the COVID-19 pandemic, recreational screen time increased significantly (Xiang et al., 2020). The Canadian 24-hour movement guidelines recommend that children and adolescents aged between 5 and 17 years have no more than 2 hours of recreational screen time (Tremblay et al., 2016).

Sleep

Sleep as a lifestyle activity concerns the timing (e.g., bedtime, wake-up time) and amount of sleep. The amount of sleep, namely sleep duration, is widely believed to relate to health and well-being across the life span (Cappuccio et al., 2011; Chaput et al., 2017; Itani et al., 2017; Matricciani et al., 2017; Morgan & Hartescu, 2019; St-Onge et al., 2016). *Sleep duration* is the total amount of sleep per 24 hours (Buysse, 2014). Technically, total sleep duration is the sum of nocturnal sleep duration and daytime nap duration. However, sleep duration, when used alone, often refers to nocturnal sleep duration or the interval between sleep start time (usually at night) and sleep end time (usually in the morning) (Matricciani, 2013). Optimal sleep duration varies depending on children's age. For children aged 6 to 12 years, the American Academy of Sleep Medicine recommends 9-12 hours of sleep per 24 hours (Paruthi et al., 2016).

Theoretical Background and Conceptual Model

This dissertation uses a conceptual model that is primarily informed by health lifestyle theory (Cockerham, 2005, 2013) and the 24-hour activity cycle model (Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay, 2020; Tremblay et al., 2016).

Health Lifestyle Theory

Health lifestyle theory was constructed based on the agency-structure debate (Cockerham, 2005, 2013). Agency emphasizes that an individual has the capacity to choose behavior regardless of social structures and, therefore, lifestyle practices are simply individual choices (Weber, 1978). In contrast, structure indicates that social structures enable or constrain certain resources and options available to individuals and influence the way individuals rank available options via social rules or codes (Bauman, 1999). A considerable amount of literature provides evidence for structural influences on lifestyle behaviors (e.g., Cockerham et al., 2017; Huh et al., 2011; Mayne et al., 2020; Olson et al., 2017). An example is that children from families with higher socioeconomic status often have healthier lifestyles than those with lower socioeconomic status (Biggs et al., 2013; Drenowatz et al., 2010; Lampinen et al., 2017). There is also evidence for the associations between agency-related factors and lifestyle behaviors (e.g., Dohle et al., 2018; Kroese et al., 2014, 2016). For instance, researchers found that Dutch adults with high self-control were less likely to experience bedtime procrastination and insufficient sleep than those with low self-control (Kroese et al., 2016). Likewise, high inhibitory control is related to healthy diets (Hall, 2012; Hofmann et al., 2009). Children with better self-regulation are likely to be more physically active (Riggs et al., 2010), have lower media use (Cliff et al., 2018; Radesky et al., 2014), and sleep better (Bub et al., 2016). Hence, neither structure nor agency alone fully explains variations in lifestyle behaviors.

Influenced by past work (Bourdieu, 1987; Giddens, 1991; Weber; 1978), Cockerham (2005, 2013) proposed health lifestyle theory, suggesting that it is the interplay of life choices (agency) and life chances (structure) that shapes health lifestyles.

Life choices are described as a proxy of agency and are a process by which individuals critically evaluate and choose their behaviors (Cockerham, 2005, 2013). Life chances, on the other hand, are a proxy of structure and reflect the probabilities for finding satisfaction for needs, wants, and interests (Bourdieu, 1987; Cockerham, 2005, 2013). The interplay of life choices and chances is central as individuals align their needs, desires, and goals with the probabilities for realizing them and choose a lifestyle based on the assessments of their resources and class circumstances (Cockerham, 2005, 2013). Although health lifestyle theory suggests individual agency in lifestyle choices, it also indicates that structural variables, including class, age, gender, and race/ethnicity, provide social contexts for socialization and experience that affect life choices (Cockerham, 2005, 2013). Thus, health lifestyle theory favors structure, emphasizing structural influences on life choices and life chances and further on health lifestyles.

The 24-Hour Activity Cycle Model

Research on lifestyle behaviors associated with time use has shifted the focus from individual, isolated behaviors to an integrated approach which includes lifestyle behaviors throughout the 24-hour cycle, including physical activity (i.e., light-intensity, moderate- to vigorous-intensity), sedentary behavior, and sleep (Pedišić, 2014; Rosenberger et al., 2019; Tremblay et al., 2007). The new approach is termed the 24-hour movement behavior paradigm (Tremblay, 2020; Tremblay et al., 2016), the 24-hour time-use paradigm (Pedišić et al., 2017), or the 24-hour activity cycle model (Rosenberger et al., 2019). These terms are interchangeable (Falck et al., 2022). The new 24-hour paradigm assumes interrelationships among these lifestyle behaviors (Rosenberger et al., 2019) and thus encourages researchers to analyze these behaviors as a collection or to include all of them in analyses. Research has provided supportive evidence for this approach, suggesting that meeting all or more guidelines of physical activity, sedentary behavior, and sleep is related to higher academic achievement, better physical and mental health, and higher quality of life (Carson et al., 2017; Marciano & Camerini, 2021; Sampasa-Kanyinga et al., 2017, 2021).

Conceptual Model

Based on health lifestyle theory (Cockerham, 2005, 2013) and the 24-hour activity cycle model (Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay, 2020; Tremblay et al., 2016), I propose a conceptual framework to understand the developmental associations among three important lifestyle behaviors (i.e., physical activity, sedentary behavior, and sleep) as well as early predictors and associated outcomes of these lifestyle behaviors (see Figure 1).

Given the interdependence of physical activity, sedentary behavior, and sleep (Pedišić et al., 2017; Rosenberger et al., 2019), these lifestyle behaviors are hypothesized to be longitudinally, transactionally related over time. Their longitudinal trajectories are also expected to be correlated such that a faster increase in one lifestyle behavior over time, for example, may be correlated with a faster decrease in another lifestyle behavior across time.

Socioeconomic status, gender, and race/ethnicity are considered important social contexts within which lifestyle behaviors may show different patterns of development. In addition, I propose self-regulation as a critical psychosocial predictor of health lifestyles, and it reflects children’s agency to monitor and regulate their lifestyle behaviors based on rules and expectations in the household and children’s goals. Self-regulation plays a critical role in resisting temptations and practicing health lifestyles (Hofmann et al., 2009; Kroese et al., 2016). Healthy lifestyle behaviors, such as engaging in physical activity and eating healthy, may have immediate negative contingencies (e.g., efforts, discomfort) but long-term benefits if performed consistently (Booker & Mullan, 2013). In contrast, unhealthy lifestyle behaviors like screen use often have immediate satisfaction and pleasure but negative consequences in the long term (Booker & Mullan, 2013). Hence, better self-regulatory capacities may prevent children from unhealthy lifestyle behaviors and help maintain health lifestyles (Bub et al., 2016; Cliff et al., 2018; Riggs et al., 2010). Inspired by health lifestyle theory (Cockerham, 2005, 2013), I propose an interplay between self-regulation and social contexts in predicting the development of health lifestyles in childhood.

I focus on children's mental and physical health and academic performance as key developmental outcomes associated with health lifestyles. These outcome variables have important implications for later academic success and health (Garon-Carrier et al., 2018; Kessler et al., 2005, 2007; Simmonds et al., 2016). Based on previous studies, health lifestyles are hypothesized to be predictive of subsequent academic performance and health in children (Dewald et al., 2010; Faught et al., 2017; Liberali et al., 2021; Loewen et al., 2019).

Two Dissertation Studies

The overall goal of this work is to examine the developmental associations among three modifiable lifestyle behaviors as well as early predictors and associated developmental outcomes of these lifestyle behaviors. Data from the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (ECLS-K:2011) are used to test the relations outlined in Figure 1. Specifically, I conduct two studies to address six major research questions (RQs) listed below. Study 1 is designed to investigate RQs 1-3. Study 2 is focused on RQs 4-6.

RQ1: Are healthy lifestyle behaviors (i.e., physical activity, sedentary behavior, and sleep duration) transactionally related from 3rd grade to 5th grade?

RQ2: Are developmental trajectories of the three lifestyle behaviors correlated?

RQ3: Do the pattern of associations in RQ1 as well as developmental trajectories and their correlations in RQ2 vary across social contexts of socioeconomic status, gender, or race/ethnicity?

RQ4: Is children's self-regulation associated with developmental trajectories of the three lifestyle behaviors?

RQ5: Are developmental trajectories of the three lifestyle behaviors related to later outcomes, including externalizing and internalizing problems, body mass index, and academic achievement?

RQ6: Do the associations of the three lifestyle behaviors trajectories with self-regulation and developmental outcomes vary across social contexts of socioeconomic status, gender, or race/ethnicity?

CHAPTER 2

STUDY 1. DEVELOPMENTAL RELATIONSHIPS AMONG PHYSICAL ACTIVITY, SEDENTARY BEHAVIOR, AND SLEEP DURATION IN US CHILDREN

Introduction

Lifestyle behaviors across the 24-hour period of a day, including physical activity, sedentary behavior, and sleep, have important implications for children's brain development, academic success, health, and well-being (Marciano & Camerini, 2021; Sampasa-Kanyinga et al., 2017, 2021; Tremblay et al., 2016; Urrila et al., 2017). Modifiable lifestyle behaviors are important targets for intervention and prevention strategies aiming to promote health and well-being (Bauer et al., 2014; Champion et al., 2019; Gruber et al., 2016; Ringeval et al., 2020). Yet, little research has examined longitudinal associations among physical activity, sedentary behavior, and sleep as well as their developmental trajectories in childhood. Childhood is an important period to study lifestyle behaviors, given that children have increased control over their lifestyle behaviors as they age and lifestyle behaviors established early in life forecast later lifestyle behaviors and development (Hanson et al., 2019; Mollborn & Lawrence, 2018; Telama, 2009). Two main goals of this study are to investigate whether physical activity, sedentary behavior, and sleep duration are transactionally related from 3rd grade through 5th grade and how these lifestyle behaviors develop or co-develop over time. A third goal is to examine whether the longitudinal associations, trajectories, and correlations of trajectories are different across socioeconomic status (SES), gender, or race/ethnicity.

Researchers suggest that physical activity, sedentary behavior, and sleep are interdependent, as an increase in the time spent on one behavior potentially decreases the time spent on at least one other behavior within a fixed time frame (e.g., a 24-hour cycle) (Pedišić, 2014; Pedišić et al., 2017; Rosenberger et al., 2019). Hence, recent research has shifted the focus from individual, isolated behavior toward a collective, integrated approach. Global and national guidelines on these behaviors embraced this new approach (e.g., Australian Government Department of Health, 2019; New Zealand Ministry of Health, 2017; Tremblay et al., 2016; World Health Organization, 2019). In 2016, the Canadian Society for Exercise Physiology issued the first integrated 24-hour movement guidelines for children and youth (Tremblay et al., 2016), and recommended at least 60 minutes of moderate-to-vigorous physical activity (MVPA), no more than 2 hours of recreational screen-based sedentary behavior (hereafter referred to as screen time), and adequate sleep (i.e., 9-11 hours of sleep for children aged 5-13 years and 8-10 hours for children aged 14-17 years) among children aged 5-17 years. Cross-sectional findings suggest that meeting the 24-hour movement guidelines is associated with higher academic achievement (Marciano & Camerini, 2021), better cognitive functioning (Walsh et al., 2018), lower impulsivity (Guerrero et al., 2019), fewer externalizing and internalizing behaviors (Sampasa-Kanyinga et al., 2021), better physical health (Carson et al., 2017), and enhanced quality of life (Sampasa-Kanyinga et al., 2017) in children and adolescents.

Although physical activity, sedentary behavior, and sleep are suggested to be interdependent within a 24-hour time frame, it is less clear how these behaviors are related over time, particularly in childhood. This study aims to advance the understanding of the developmental relationships among these lifestyle behaviors in two approaches. The first approach concerns the longitudinal, transactional relationships among physical activity, sedentary behavior, and sleep in children. Main research questions regarding this approach are: Is the time use in one behavior at an earlier timepoint predictive of the time use in another behavior at a later timepoint? What is the directionality of these longitudinal relationships? Do these processes vary by SES, gender, or race/ethnicity? The second aim is to investigate the development and co-development of physical activity, sedentary behavior, and sleep over time. That is, what are developmental trajectories of these lifestyle behaviors? Are these trajectories correlated (e.g., is a faster increase in one behavior over time correlated with a faster decrease in another behavior), such that changes in these lifestyle behaviors are in a collective but not isolated way? Do these processes differ across SES, gender, or race/ethnicity? Addressing these questions provides important insights into the developmental relationships among the three lifestyle behaviors and subsequently can inform intervention and prevention programs to foster health lifestyles.

Relationships Among Physical Activity, Sedentary Behavior, and Sleep

Previous studies examining the associations among physical activity, sedentary behavior, and sleep often employ cross-sectional designs (e.g., Antczak et al., 2020; Chien et al., 2019; Dalene et al., 2018). A concurrent, negative correlation between screen time and sleep duration is generally supported in past work (Chien et al., 2019). In a systematic literature review predominantly on cross-sectional studies, Hale and Guan (2015) found that higher screen time, such as video game use, was related to shorter sleep duration and delayed bedtime in school-aged children and adolescents. The correlation between physical activity and sleep duration, however, is less supported. A recent meta-analysis largely based on cross-sectional studies suggested minimal positive relations between physical activity and sleep duration among healthy children (Antczak et al., 2020). In a cross-sectional study of Norwegian children and adolescents, sleep duration was not related to MVPA, whereas screen time was negatively associated with MVPA (Dalene et al., 2018). The concurrent, negative correlation between screen time and physical activity also was supported by other studies (e.g., Melkevik et al., 2010; Serrano-Sanchez et al., 2011).

A growing body of research has investigated daily temporal associations of physical activity and sedentary behavior with sleep duration. Higher levels of physical activity or lower levels of sedentary behavior predict longer sleep duration the subsequent night in children and youth, and longer sleep duration predicts lower sedentary behavior the next day (Lin et al., 2018; Martinez et al., 2019; Master et al., 2019; see Huang et al., (2021) for a review and meta-analysis). The association between sleep duration and the next day's physical activity is less consistent. Specifically, some research suggests that sleep duration positively predicts the next day's physical activity (e.g., Lin et al., 2018), some indicate a negative prediction (e.g., Armstrong et al., 2021; Martinez et al., 2019; Master et al., 2019), while others show no association (e.g., Kim et al., 2020).

Limited studies have investigated the longitudinal or transactional associations among physical activity, sedentary behavior, and sleep duration (e.g., Dalene et al., 2018; Mazzer et al., 2018; Straatmann et al., 2019; Tavernier & Willoughby, 2014). Additionally, these studies have yielded mixed findings, which may be due to differences in sample characteristics (e.g., country, age, gender), research designs, measures of these lifestyle behaviors, and adjustment of covariates. For example, Magee et al. (2014) found weak negative, yet significant, transactional relationships between sleep duration and screen time (i.e., television viewing and computer use) among Australian children aged 4, 6, and 8 years. Similarly, a study of Swedish adolescents suggested that higher screen time predicted shorter sleep duration and vice versa (Mazzer et al., 2018), whereas another study of university students in Canada showed that screen time and sleep duration were not related over time (Tavernier & Willoughby, 2014). A meta-analysis of experimental studies found that acute or regular exercise had small beneficial effects on total sleep time (Kredlow et al., 2015). Li et al. (2021) suggested that screen time, but not physical activity, was related to later sleep duration when controlling for covariates including earlier sleep duration. Dalene et al., (2018) found that sleep duration at 9 years old was not related to MVPA at 15 years old. In the same study, they found no association between screen time and later MVPA. Only one study investigated the transactional relations between physical activity and sedentary behavior (Straatmann et al., 2019), which showed that Brazilian female adolescents' television viewing was negatively related to later light physical activity and MVPA, and light physical activity was negatively associated with later video game/computer use. Relations were non-significant in Brazilian male adolescents (Straatmann et al., 2019).

Limitations of the Cross-Lagged Panel Model

Besides the lack of longitudinal studies and mixed findings in these studies, previous research examining the transactional relationships among physical activity, screen time, and sleep duration commonly employed the cross-lagged panel model (CLPM), an analytic approach that may lead to inaccurate or erroneous conclusions. The primary limitation of the traditional CLPM is that it conflates between- and within-person effects, making the estimated coefficients difficult to interpret meaningfully (Berry &

Willoughby, 2017; Curran et al., 2014; Hamaker et al., 2015). Notably, effects in the traditional CLPM are typically interpreted as between-person effects (Berry & Willoughby, 2017; Hamaker et al., 2015), suggesting whether a prior deviation from the *group* mean on one construct is associated with subsequent deviation from the group mean on the same (i.e., autoregressive effects) or another construct (i.e., cross-lagged effects). Within-person effects, on the other hand, indicate whether a temporal deviation from a *person*'s trait-level mean of one construct affects subsequent deviations from the person's trait-level mean of the same or a different construct. Within-person effects, which illuminate how a construct at an earlier time point is related to subsequent constructs within the same person, are of particular interest to longitudinal studies. The failure to separate between- and within-person effects in the traditional CLPM is problematic, as the two types of effects not only are conceptually different but also may be different in the magnitude and direction of values (Curran & Bauer, 2011; Dietvorst et al., 2018; Hamaker et al., 2015).

A second limitation of the traditional CLPM is that it does not allow for the examination of mean-level changes or developmental trends over time (Mund & Nestler, 2019). In addition to the rank-order stability, the mean-level stability or change is also of substantive interest to developmentalists. To overcome the limitations of the traditional CLPM, Curran et al. (2014) proposed an analytic approach—the latent curve model with structured residuals (LCM-SR), which can disaggregate between- and within-person effects and simultaneously model developmental trajectories of constructs. The LCM-SR represents an ideal analytic approach for examining the proposed research questions.

Developmental Trajectories of Physical Activity, Sedentary Behavior, and Sleep

Research of longitudinal changes in physical activity, sedentary behavior, and sleep duration indicates that on average, physical activity and sleep duration decline while sedentary behavior increases throughout childhood and adolescence (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016). For example, trajectory analyses of MVPA in England children revealed that MVPA declined on average from 7 years old through 15 years old (Farooq et al., 2018). Another study using the same sample reported that sedentary time increased from about 51% of waking hours at 7 years old to 74% at 15 years old (Janssen et al., 2016). Research of Estonian and Swedish children also showed that MVPA declined, whereas sedentary time increased, from childhood to adolescence (Ortega et al., 2013). Like physical activity, the nighttime sleep duration decreases with age, from about 12 hours at 1 year old to about 8 hours at 16 years old (Iglowstein et al., 2003). A meta-analysis of actigraphy-based nighttime sleep duration reported a similar decline, from about 10 hours at 3-5 years old to around 7 hours at 15-18 years old (Galland et al., 2018).

Despite these developmental trends, little is known about whether developmental trajectories of the three lifestyle behaviors are correlated over time. One study of Canadian adolescents suggested that although higher initial levels of physical activity were correlated with smaller increases in screen time during adolescence, changes in physical activity and screen time were not correlated (Gunnell et al., 2016). Similarly, changes in physical activity and sleep duration were not correlated in children and adolescents (Antczak et al., 2021; Vedøy et al., 2021). The increase in night-time mobile use from ages 8 to 10 was found to be positively related to the increase in poor sleep behaviors over time (Vernon et al., 2018). More research is needed to investigate whether and how initial levels of and longitudinal changes in physical activity, sedentary behavior, and sleep duration are related in childhood.

Lifestyle Behaviors Across Social Contexts

Levels of lifestyle behaviors, their associations, and their developmental trajectories may be different across social structural contexts of SES, gender, or race/ethnicity. As suggested by health lifestyle theory, social structural factors shape lifestyle behaviors via providing or limiting life chances/opportunities available to individuals and affecting life choices individuals would make (Cockerham, 2005, 2013). Indeed, the availability of lifestyle options may vary across social contexts. For instance, home environments of lower SES families may provide children with fewer opportunities for physical activity and more opportunities for sedentary behavior (Tandon et al., 2012). Moreover, among multiple lifestyle options, individuals are likely to choose lifestyles that are in accordance with the values, norms, and identities of the group that individuals belong to (Cockerham, 2005, 2013).

Empirical research has provided support for the mean differences in lifestyle behaviors across social contexts (Olson et al., 2017; Pampel et al., 2010; Petrov & Lichstein, 2016; Rhodes et al., 2012; Sosso et al., 2021). Generally, children from higher SES families likely have healthier lifestyles, such as regular physical activity, low sedentary behavior, and sufficient sleep, than children from lower SES families (Biggs et al., 2013; Drenowatz et al., 2010; Lampinen et al., 2017). Similarly, non-Hispanic White children are more likely to be physically active, have lower sedentary behavior, and report longer sleep duration than those who identify as racial/ethnic minorities (Anderson et al., 2008; Biggs et al., 2013). Compared to boys, girls tend to have sufficient sleep, lower sedentary behavior, but also lower physical activity (Anderson et al., 2008; Biggs et al., 2013; Chen et al., 2018).

There is some evidence that the associations among physical activity, sedentary behavior, and sleep duration as well as their developmental trajectories may vary across social contexts (Farooq et al., 2018; Li, Sheehan, Petrov, et al., 2021; Melkevik et al., 2010; Xu et al., 2019). For example, a study of low SES urban girls found no concurrent associations of physical activity and screen time with sleep duration (Greever et al., 2017). Serrano-Sanchez et al. (2011) suggested that higher total screen time was associated with lower likelihood of getting sufficient MVPA in Spanish male, but not female, adolescents. Boys and girls also exhibit different developmental trajectories of physical activities, sedentary behavior, and sleep duration (Farooq et al., 2018; Hanson et al., 2019; Riglea et al., 2021). Young children who are ethnic minorities and from lower SES families are more likely to display a high-persistent screen use trajectory than low-to-moderate screen use trajectory (McArthur et al., 2020). Despite the recent progress, research is needed to systematically examine the longitudinal relationships among these lifestyle behaviors and their developmental trajectories in different social contexts.

The Present Study

The aim of this study is to investigate the developmental relationships among physical activity, sedentary behavior, and sleep duration. MVPA was chosen as an index of physical activity and screen time was chosen for sedentary behavior because they were highlighted in global and national guidelines (e.g., Tremblay et al., 2016; World Health Organization, 2019). Additionally, this study is focused on video game use rather than other types of screen time or total screen time. This is because growing evidence suggests a need to distinguish between active (e.g., video game use) and passive (e.g., television viewing) screen time, playing video games is among the most popular recreational activities in children and adolescents, and it is less clear how video game use develops and is related to other lifestyle behaviors (Hallgren et al., 2020; Kikuchi et al., 2014; Kim et al., 2020; Mazzer et al., 2018; Peracchia & Curcio, 2018; Sweetser et al., 2012).

The first aim of the present study is to examine whether the MVPA, video game use, and sleep duration are longitudinally and transactionally related from 3rd grade to 5th grade. Given prior empirical findings (e.g., Li et al., 2021; Magee et al., 2014; Mazzer et al., 2018; Straatmann et al., 2019), these lifestyle behaviors are hypothesized to be transactionally related over time. The second goal is to investigate developmental trajectories of the three lifestyle behaviors as well as correlations among these trajectories. Based on past work (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016), MVPA and sleep duration are hypothesized to decline over time, whereas video game use is predicted to increase over time. Given the lack of studies, it is difficult to make firm predictions about how developmental trajectories of these lifestyle behaviors are correlated. I tentatively predict that initial levels and slopes/growth of trajectories of MVPA, video game use, and sleep duration are correlated. The third goal is to test whether the developmental relationships and trajectories of the three lifestyle behaviors vary depending on social contexts (i.e., SES, gender, and race/ethnicity). Based on health lifestyle theory (Cockerham, 2005, 2013), patterns of these associations and trajectories are excepted to be different across social contexts, but there are no specific hypotheses given the lack of studies.

Method

Data

Data for this study were from the public version of the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (ECLS-K:2011). The ECLS-K:2011 included a nationally representative sample of US children who entered kindergarten during the 2010-11 academic year. These children were continually assessed from kindergarten through 5th grade (Tourangeau et al., 2018). The ECLS-K:2011 employed a multistage, stratified, clustered sampling design with 3 stages. In the first stage of sampling, approximately 1,710 primary sampling units (PSUs) were created from a list of the 3,141 counties in the US (e.g., larger counties were treated as discrete PSUs and smaller contiguous counties were combined into one PSU). A sample of 90 PSUs was selected for the ECLS-K:2011. In the second stage, schools with kindergarten programs or kindergarten age (i.e., 5-year-old) students in the ungraded setting within the sampled PSUs were identified. Among these schools, a sample of around 1,320 schools was selected for the ECLS-K:2011. In the third stage, about 20,250 children were selected for the base-year (i.e., kindergarten) data collection, and approximately 18,170 children from 970 schools participated in the ECLS-K:2011.

The analyses of this study were limited to participants who had a valid kindergarten weight (i.e., the weight variable W1_2P0 had non-zero values) and at least one valid value on parent-reported MVPA, video game use, and sleep duration from 3rd through 5th grades. Around 2,090 participants were excluded due to missing data on the weight variable and then 4,840 participants were excluded due to missing data on all measures of lifestyle behaviors. The analytic sample consisted of 11,248 participants. The ECLS-K:2011 collected data from children, parents, teachers, and school administrators, but only the parent interviews were used in this study.

Given the complex sampling design and the fact that children had unequal chances to be selected to participate in the ECLS-K:2011, sampling weights are suggested to use when analyzing the ECLS-K:2011 data (Tourangeau et al., 2018). The ECLS-K:2011 provided both cross-sectional and longitudinal weights to account for nonresponse of participants and to ensure that estimates were nationally representative (Tourangeau et al., 2018). Because it is impractical to create weights for all possible combinations of waves and components (e.g., parent interviews, teacher questionnaires, children assessments) of the data, the ECLS-K:2011 team created 5th grade weights that are most likely to be useful for researchers. Unfortunately, there is not an appropriate 5th grade weight for the analyses of this study. Specifically, the longitudinal weights that adjusted for nonresponse of parent interviews in 3rd through 5th grades also adjusted for nonresponse of other waves and components. As a result, many participants were assigned invalid (i.e., zero) weight values due to nonresponse in at least one earlier wave and/or nonresponse to other components other than parent interviews. For this reason, a full sample weight in kindergarten was used to maximize the unweighted sample size. This approach was employed in other studies that included longitudinal samples of the ECLS-K:2011 data (e.g., Ansari & Gottfried, 2021; Bachman et al., 2020).

Measures

Moderate-to-Vigorous Physical Activity

Parents reported MVPA of their children in the spring of 3rd, 4th, and 5th grades using one question: "*In a typical week, on how many days does {CHILD} get exercise that causes rapid breathing, perspiration, and a rapid heartbeat for 20 continuous* *minutes or more?*" Responses ranged from 0 to 7. Following previous studies, this measure was used as a continuous variable, with higher scores indicating more MVPA (e.g., Jackson & Cunningham, 2017; Stevens et al., 2008).

Video Game Use

In the spring of 3rd, 4th, and 5th grades, parents reported the hours and minutes that the child played video games using the question: "*On any given weekday, how much time does {CHILD} spend playing video games? Please do not include time {CHILD} spends on the computer doing educational activities or homework.*" Videos games included those played on the computer, handheld devices (e.g., cellphone, iPad, Sony PSP), and systems (e.g., Playstation, Wii, Xbox). Minutes were converted into hours and then combined with the reported hours to create a measure of video game use on weekdays. This measure was top-coded at the 99th percentile to minimize the influence of outliers. As a result, 54 children in 3rd grade were top-coded at 4 hours, 86 children in 4th grade were top-coded at 4 hours, and 72 children in 5th grade were top-coded at 5 hours.

Sleep Duration

Parents also reported the hours and minutes that the child slept on school nights in the spring semester from 3rd to 5th grades using the question: "*On an average school night, how many hours of sleep does {CHILD} get?*" Minutes were converted into hours and then combined with the reported hours to create a measure of sleep duration on school nights.

Household SES

Household poverty status and parental educational attainment in the spring of 3rd grade were used as measures of household SES.

Household Poverty Status. Parents reported household monthly income via an 18-point scale ranging from 1 = *5,000 or less* to 18 = *200,001 or more*. Household income was used in conjunction with household size to determine the poverty status of the household. The weighted poverty thresholds one year prior to the data collection from the US Census Bureau were used. Households with an income lower than the threshold were classified as *poor*, at or above the threshold but below 200% of the threshold were classified as *near-poor*, and at or above 200% of the threshold were classified as *not-poor* (e.g., Newacheck et al., 2004).

Parental Educational Attainment. Data on the first parent's and second parent's educational attainment were collected. Educational attainment was classified as: 1 = *8th grade or less*, 2 = *9th to 12th grade*, 3 = *high school degree/equivalent*, 4 = *vocational/technical program*, 5 = *some college*, 6 = *bachelor's degree*, 7 = *graduate/professional school-no degree*, 8 = *master's degree (MA, MS)*, and 9 = *doctorate or professional degree*. The highest education attained by either parent was used as parental educational attainment (e.g., Carozza et al., 2010). Parental educational attainment was dummy coded such that 0 = *parental highest educational attainment was less than a bachelor's degree* and 1 = *parental highest educational attainment was a bachelor's degree or above*.

Child Gender

Child sex was reported by parents and coded as 0 = *female* and 1 = *male*.

Child Race/Ethnicity

Parents reported their children's race and ethnicity. Based on their responses, children were classified as non-Hispanic White, non-Hispanic Black, Hispanic, non-

Hispanic Asian, and non-Hispanic other.

Data Analytic Plan

Data analyses were conducted with Stata 16.1 and M*plus* 8.3 (Muthén & Muthén, 1998–2017). Descriptive statistics (e.g., valid *N*, mean, standard deviation, minimum, maximum, skewness, and kurtosis) in the full sample and subsamples by household poverty status, parental highest education, gender, and race/ethnicity were analyzed in Stata. Weighted descriptive statistics (e.g., mean, standard deviation) were computed with the Taylor series linearization method (Tourangeau et al., 2018). All cases in the ECLS-K:2011 were kept in analyses and the subpopulation option (e.g., the "subpop" command in Stata) was employed to select the analytic sample of this study. This approach is better than deleting cases that are not included in analyses and can properly calculate standard errors of estimates (Rao & Molina, 2015). Weighted means of study variables across subsamples were compared using the "lincom" or "pwcompare" command in Stata. The Bonferroni correction was used for multiple comparisons. Missing data were not handled in analyses in Stata.

Weighted zero-order correlations among study variables in the full sample and each subsample were analyzed using the "with" command in M*plus* (UCLA: Statistical Consulting Group, n.d.). Consistent with analyses in Stata, the Taylor series linearization method and subpopulation option were used for all analyses in M*plus*. Missing data were handled with the robust full information maximum likelihood (MLR) estimator in M*plus*.

Several steps were used to build the LCM-SR (Curran et al., 2014) in M*plus*. In the first step, a univariate linear latent growth curve model (LGCM) was examined for MVPA, video game use, and sleep duration. In the second step, a multivariate LGCM was examined, allowing the intercept and slope factors to covary. A significant covariance between two slope factors would indicate that the two lifestyle behaviors co-develop over time. In the third step, the time-specific residuals were modeled and allowed to covary within each grade. The equality of covariances over time was tested using chi-square difference tests and a more parsimonious model would be chosen when its model fit was not significantly worse than that of a more complicated model. In the fourth step, autoregressions among the time-specific residuals were then added and their equality over time was tested. Similar to the previous step, a more parsimonious model would be chosen when it did not result in a significantly worse model fit. In the final step, cross-lagged regressions were added. Like prior steps, the equality of cross-lagged regressions over time was tested and a more parsimonious model would be chosen if it fit the data equally well as the more complicated model.

When building the LCM-SR (see Figure 2) with the full sample, models successfully converged, and parameters were properly estimated in steps one to three. The model failed to converge in the fourth step after adding autoregressions among the time-specific residuals. When estimating a final LCM-SR with equality constraints on residuals, residual covariances, autoregressions, and cross-lagged regressions across time, the model successfully converged but had an error suggesting that the latent variable covariance matrix was not positive definite. This was due to a negative variance of the physical activity slope factor (estimate = -0.228, *SE* = .121, *p* = .060). Given the complexity of the LCM-SR and these error messages when building the model, I decided to employ the random intercept cross-lagged panel model (RI-CLPM; Hamaker et al., 2015) for the first research question testing the within-person associations among MVPA, video game use, and sleep duration across time. The RI-CLPM (see Figure 3) is very similar to the LCM-SR, with one key difference that the LCM-SR includes both intercept and slope factors but the RI-CLPM includes only the intercept factors (for a comparison see Orth et al., 2020). I then used the multivariate LGCM (see Figure 4) for the second research question to investigate how trajectories of these lifestyle behaviors were correlated. The analyses of the RI-CLPM and multivariate LGCM were conducted in the full sample and each subsample by household poverty status, parental highest education, gender, and race/ethnicity. Formal tests of differences in parameter estimates (e.g., autoregressive effects, cross-lagged effects, intercept factors, and slope factors) across subsamples were not conducted because the multiple group analysis is not compatible with the subpopulation option in M*plus*.

Model Fit Indices

Multiple model fit indices were used, including the Satorra-Bentler scaled χ^2 statistics, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the standardized root mean square residual (SRMR). Model fit is considered acceptable if RMSEA < .080, CFI > .900, TLI > .900, and SRMR < .080 and good if RMSEA < .050, CFI > .950, TLI > .950, and SRMR < .050 (Little, 2013).

Missing Data

Participants with complete data on MVPA, video game use, sleep duration, household poverty status, parental highest education, gender, and race/ethnicity were coded as 0 (N = 7,609) and those with missing data on any of these variables were coded as 1 (N = 3,639). Weighted proportions or means of lifestyle behaviors and social contexts variables across the two groups of children were compared in Stata.

As shown in Table 1.1, participants with and without missing data were significantly different in household poverty status, parental highest education, race/ethnicity, MVPA and sleep duration in 3rd, 4th, and 5th grades, and video game use in 3rd and 5th grades. Compared to children without missing data, those with missing data were less likely to come from not-poor families, have parents whose highest education was a bachelor's degree or above, and be non-Hispanic White. Additionally, those with missing data displayed lower levels of MVPA and sleep duration but higher levels of video game use than children without missing data. Children with and without missing data were not significantly different in gender. As mentioned earlier, the MLR estimator was used to handle missing data in all analyses with M*plus*.

Results

Preliminary Analyses

Descriptive Statistics

Table 1.2 shows descriptive statistics (i.e., valid *N*s, means, standard deviations, minimums, maximums, skewness, and kurtosis) of study variables in the full sample. The weighted sample consisted of 23% poor families, 22% near-poor families, and 55% not-poor families. Over half (58%) of children had parents whose highest education was lower than a bachelor's degree. Half (52%) of the sample were male children. Approximately 53% of children were non-Hispanic White, 11% were non-Hispanic Black, 27% were Hispanic, 4% were non-Hispanic Asian, and 5% were non-Hispanic other races. Study variables did not show problematic departures from normality:

skewness of study variables ranged between -0.55 and 1.78 and kurtosis ranged between -0.88 and 4.70 (Bryne, 2010).

Tables 1.3-1.6 present descriptive statistics of study variables and results of group comparisons across household poverty status, parental highest education, gender, and race/ethnicity subsamples, respectively. As shown in Table 1.3, study variables were significantly different across household poverty status: Children from poor families had the lowest levels of MVPA and sleep duration in 3rd, 4th, and 5th grades as compared to those from near-poor or not-poor families. Children from near-poor families had lower levels of MVPA and sleep duration from 3rd to 5th grades than children from not-poor families. Consistently, children from not-poor families had the lowest levels of video game use in 3rd, 4th, and 5th grades than those from poor or near-poor families. Children from poor or near-poor families were not significantly different in video game use from 3rd to 5th grades. As shown in Table 1.4, compared to children whose parents did not obtain a bachelor's degree, those whose parents had obtained a bachelor's degree or above were higher in MVPA and sleep duration and lower in video game use from 3rd to 5th grades. Based on Table 1.5, male children were higher in both MVPA and video game use across the three grades than female children. Sleep duration across grades did not significantly differ between male and female children.

Table 1.6 shows mean differences in study variables across racial/ethnic groups. Non-Hispanic White children had the highest levels of MVPA, followed by non-Hispanic Black children and Hispanic children, and non-Hispanic Asian children had the lowest MVPA across the three grades. Non-Hispanic Asian children also had lower video game use than non-Hispanic Black children and Hispanic children in 3rd and 5th grades. No racial/ethnic differences were found in 4^{th} grade video game use. Non-Hispanic Black children had the lowest sleep duration compared to other racial/ethnic groups, whereas non-Hispanic White children had the longest sleep duration across the three grades. There were differences between these racial/ethnic groups and non-Hispanic other children in MVPA, video game use, and sleep duration. However, due to the relatively small sample size of non-Hispanic other children and the fact that this group consisted of children with varied racial backgrounds, it was not considered further in analyses of racial/ethnic subsamples.

Correlations Among Lifestyle Behaviors

Table 1.7 presents weighted correlations among study variables in the full sample. Each study variable was positively correlated with itself from 3^{rd} grade through 5^{th} grade. As expected, video game use was negatively correlated with MVPA and sleep duration within each grade and across grades. MVPA was positively correlated with sleep duration within and across grades 3, 4, and 5.

Tables 1.8-1.11 show weighted correlations among study variables across household poverty status, parental highest education, gender, and race/ethnicity subsamples, respectively. Patterns of correlations across subsamples were generally consistent with those in the full sample, except that there were some non-significant correlations in subgroups. For example, all correlations (except for the positive correlation between MVPA and sleep duration in 3^{rd} grade) between MVPA with video game use and sleep duration were not significant among children from poor families (see Table 1.8). With two exceptions, MVPA was not correlated with video game use in children from near-poor families. Regarding the correlations in subsamples by parental highest education (see Table 1.9), all correlations except two were significant among children whose parents did not obtain a bachelor's degree. Similarly, all correlations except four were significant among children whose parents had obtained a bachelor's degree or above. All correlations except one were significant in female children, and all correlations were significant in male children (see Table 1.10). In terms of correlations in subsamples by race/ethnicity (see Table 1.11), all correlations except four were significant in non-Hispanic White children. MVPA was not correlated with sleep duration within and across grades in non-Hispanic Black children. With two exceptions, MVPA was not correlated with video game use in Hispanic children. Likewise, MVPA was not correlated with video game use in non-Hispanic Asian children. In this subsample, all correlations but three between video game use and sleep duration were non-significant. To summarize, the overall patterns of correlations were consistent across subsamples.

Main Analyses

Longitudinal Associations Among Lifestyle Behaviors

The first research question of this study concerns the longitudinal associations among MVPA, video game use, and sleep duration. A set of unconstrained RI-CLPMs was fit to the data for this research question. As shown in Table 1.12, the model fit of the unconstrained RI-CLPMs was excellent in the full sample and each subsample by household poverty status, parental highest education, gender, and race/ethnicity.

Within-person autoregressive and cross-lagged effects in the full sample are presented in Table 1.13. The autoregressive paths of MVPA and video game use from 4th to 5th grades were significant, suggesting that the deviation from a child's expected score on MVPA or video game use in 4th grade carried over to 5th grade. Additionally, the autoregressive path of sleep duration from 3^{rd} grade to 4^{th} grade was significant, implying that if a child scored higher than his/her expected score on sleep duration in 3^{rd} grade, this child was likely to score higher than his/her expected score on sleep duration in 4^{th} grade. Only one cross-lagged effect was significant. The positive prediction from 3^{rd} grade video game use to 4^{th} grade MVPA indicated that a child who scored higher than his/her expected score on 3^{rd} grade video game use was likely to score higher than his/her expected score on 4^{th} grade MVPA.

Regarding the between-person associations in the full sample (see Table 1.13), video game use was negatively correlated with MVPA and sleep duration, suggesting that children with higher levels of video game use had lower levels of MVPA and sleep duration across time. MVPA and sleep duration were positively correlated, indicating that children with higher MVPA also had longer sleep duration.

Patterns of autoregressive effects, cross-lagged effects, and between-person associations in the full sample were similar to patterns of findings in subsamples of children from not-poor families (see Table 1.14), whose parents had obtained a bachelor's degree or above (see Table 1.15), who were male (see Table 1.16), and who were non-Hispanic White (see Table 1.17). Patterns of results were somewhat different in other subsamples as compared to those in the full sample. For example, no cross-lagged effects were found in children from poor or near-poor families (see Table 1.14). Similarly, there were no significant cross-lagged effects in children whose parents did not obtain a bachelor's degree. One additional cross-lagged effect appeared in children whose parents had obtained a bachelor's degree or above: 4^{th} grade sleep duration negatively predicted 5^{th} grade video game use (see Table 1.15). There was a new cross-lagged effect among female children (see Table 1.16): 4th grade MVPA negatively predicted 5th grade video game use. In terms of cross-lagged effects in subsamples by race/ethnicity (see Table 1.17), 3rd grade MVPA positively predicted 4th grade video game use in Hispanic children. The cross-lagged path from 4th grade video game use to 5th grade MVPA was negative in non-Hispanic Black children but positive in non-Hispanic Asian children. Additionally, 3rd grade sleep duration negatively predicted 4th grade MVPA in non-Hispanic Asian children.

Correlations Among Trajectories of Lifestyle Behaviors

The second aim of this study is to investigate developmental trajectories of MVPA, video game use, and sleep duration from 3rd to 5th grades and to examine whether these trajectories are correlated. A set of multivariate LGCMs were fit to the data in the full sample and each subsample to address this research question. The multivariate LGCMs in non-Hispanic Black children and non-Hispanic Asian children were improperly estimated, which were caused by negative, non-significant variances of slope factors. To address this issue, variances of slope factors of MVPA and sleep duration were fixed at zero in non-Hispanic Black children and variance of the sleep duration slope factor was fixed at zero in non-Hispanic Asian children (Muthén, 2003). The model fit indices of the multivariate LGCMs in the full sample and subsamples are present in Table 1.18. All multivariate LGCMs fit the data well.

Table 1.19 shows means, variances, and covariances of the intercept and slope factors in the full sample. Levels of MVPA and sleep duration declined significantly from 3rd grade through 5th grade, whereas video game use increased significantly from 3rd to 5th grades. Variances of all intercept and slope factors but the sleep duration slope factor were statistically significant, suggesting individual differences in the trajectories of MVPA, video game use, and sleep duration. Intercept factors of the three lifestyle behaviors were correlated: The intercept factor of MVPA was negatively correlated with the video game use intercept factor and was positively correlated with the sleep duration intercept factor, and the video game use intercept factor was negatively correlated with the sleep duration intercept factor. There were some significant correlations between intercept factors and slope factors. Specifically, intercept factors of MVPA and sleep duration were negatively correlated with slope factors of video game use and sleep duration, indicating that higher levels of MVPA or sleep duration in 3^{rd} grade were associated with smaller increase in video game use but greater decrease in sleep duration from 3^{rd} through 5^{th} grades. The slope factors of the three lifestyle behaviors were not correlated, suggesting that changes in MVPA, video game use, and sleep duration from 3^{rd} to 5^{th} grades were not related. In summary, although there were significant correlations among intercept factors or between intercept factors and slope factors, slope factors were not correlated.

Tables 1.20-1.23 present means, variances, and covariances of intercept and slope factors in subsamples by household poverty status, parental highest education, gender, and race/ethnicity, respectively. One result in the subsample that was consistently different from that in the full sample was that the variance of the MVPA slope factor was not significant in all subsamples but one, implying that changes in MVPA from 3^{rd} to 5^{th} grades were not significantly different across children within each subsample (except non-Hispanic Asian children). Other results were generally consistent with those in the full sample, although there were fewer significant correlations among intercept factors or between intercept factors and slope factors in subsamples.

Discussion

This study sought to advance the literature by investigating the developmental relationships among MVPA, video game use, and sleep duration in a nationally representative sample of US children using two approaches. The first approach was to examine whether the three lifestyle behaviors were longitudinally, transactionally related over time, after disaggregating between- and within-person effects. The second approach was to investigate the developmental trajectories of the three lifestyle behaviors and to examine whether these trajectories were correlated. In addition, these analyses were conducted across household poverty status, parental highest education, gender, and race/ethnicity subsamples in order to systematically explore whether the developmental relationships among the three lifestyle behaviors varied across social contexts. Results showed that MVPA, video game use, and sleep duration were not transactionally related from 3^{rd} to 5^{th} grades at the within-person level. Regarding the trajectories of these lifestyle behaviors, MVPA and sleep duration significantly declined, whereas video game use significantly increased from 3^{rd} grade through 5^{th} grade. There were some significant correlations between intercepts and slopes of these trajectories. However, the slopes of trajectories were not correlated. With a few exceptions, patterns of results in subsamples of household poverty status, parental highest education, gender, and race/ethnicity were generally consistent with those in the full sample.

Longitudinal Associations Among Lifestyle Behaviors

Contrary to the hypothesis about transactional relationships, MVPA, video game use, and sleep duration were not longitudinally, transactionally related over time. This finding contrasts with those of previous studies suggesting small and negative transactional associations of screen time with sleep duration (Magee et al., 2014; Mazzer et al., 2018) and physical activity (Straatmann et al., 2019) in children and adolescents. One explanation for these discrepancies may be that prior studies utilized traditional CLPM, whereas this study employed RI-CLPM to examine transactional associations. As mentioned earlier, cross-lagged effects in the traditional CLPM conflate between- and within-person effects (Berry & Willoughby, 2017; Curran et al., 2014; Hamaker et al., 2015). By contrast, the RI-CLPM allows for the separation of between- and within-person effects and its cross-lagged effects represent within-person processes (Hamaker et al., 2015). Results in a traditional CLPM may not replicate at the level of within-person, as between- and within-person effects are conceptually different and may also be different in magnitude and direction (Curran & Bauer, 2011; Dietvorst et al., 2018; Hamaker et al., 2015). The absence of transactional within-person effects, coupled with the significant between-person associations in the present study, suggests that the transactional associations reported in previous studies (Magee et al., 2014; Mazzer et al., 2018; Straatmann et al., 2019) may be driven primarily by stable between-person differences. Such findings highlight the need to re-evaluate the longitudinal associations among physical activity, screen time, and sleep duration by disaggregating within-person and between-person effects.

Another possible explanation is that the present study is different from previous studies in terms of sample characteristics and measures of variables. For example, previous studies suggesting transactional associations were conducted in countries (e.g., Australia) other than the US and included participants of different developmental stages (e.g., 4-5 years, high school students) (Magee et al., 2014; Mazzer et al., 2018; Straatmann et al., 2019). Levels of MVPA, video game use, and sleep duration as well as their associations may be different across countries given that social, cultural, and environmental contexts, which are important determinants of lifestyle behaviors, vary across countries (Cockerham, 2005, 2013). Children in the present study aged 9 years on average in 3rd grade. These children might experience different biological and psychological processes than younger children or adolescents in other studies (Del Giudice, 2014), and these processes may shape the development of MVPA, video game use, and sleep duration as well as the associations among them (Sherar et al., 2010).

Additionally, unlike prior research that combined active (e.g., video game use) and passive (e.g., television viewing) screen time (e.g., Mazzer et al., 2018), this study focused on video game use as a form of active screen time. Research has shown that while passive screen time is often negatively associated with MVPA and sleep duration, active screen time is positively related to MVPA or not predictive of subsequent physical activity and sleep duration (Kikuchi et al., 2014; Magee et al., 2014; Straatmann et al., 2019). The lack of transactional associations of video game use with MVPA and sleep duration indicates that findings using total screen time or passive screen time may not be generalized to active screen time.

The only significant cross-lagged effect observed in the full sample—a small positive within-person effect of 3rd grade video game use on 4th grade MVPA—supports the notion that active and passive screen time should be examined separately. This positive prediction, though unexpected, was not surprising, as research has shown that playing video games, especially active or sports video games, may increase physical activity in children and adolescents (Adachi & Willoughby, 2015, 2016; Foley & Maddison, 2010). It is important to note that this positive prediction appeared only at the within-person or individual level and it is in the opposite direction from its between-person correlation at the group level. Such phenomenon is known as Simpson's paradox, which may occur when drawing inferences across between-person and within-person levels of observation (Dietvorst et al., 2018; Keijsers, 2016). The opposite patterns of results suggest that between-person and within-person associations between video game use and MVPA may be different. Thus, future research should use advanced statistical approaches such as RI-CLPM to isolate between-person and within-person processes.

Longitudinal Associations Across Subsamples

Consistent with findings in the full sample, the majority of cross-lagged effects in subsamples were non-significant. These findings suggest that with a few exceptions, MVPA, video game use, and sleep duration were not longitudinally related at the within-person level, regardless of social contexts of SES, gender, and race/ethnicity. Among the few significant cross-lagged effects, it is worth noting that the small positive prediction from 3rd grade video game use to 4th grade MVPA observed in the full sample also were present in some subsamples, including children who were from high SES families (i.e., not-poor families or parent(s) with a bachelor's degree or above), who were male, or who were non-Hispanic White. In addition, there were a few new significant cross-lagged effects in subsamples, but these effects were small in magnitude and did not show a systematic pattern. Overall, these different cross-lagged effects across subsamples provide some limited evidence that SES, gender, and race/ethnicity are important social contexts shaping the developmental associations among lifestyle behaviors. Below I discuss cross-lagged effects in subsamples by SES, gender, and race/ethnicity.

Longitudinal Associations by Household SES. The cross-lagged effect of 3rd grade video game use on 4th grade MVPA was present in high, but not low, SES families. Families of higher SES may have a greater awareness of the importance of practicing healthier lifestyles as well as easier access to places and facilities for physical activity (Estabrooks et al., 2003; Stenhammar et al., 2007). Thus, it is plausible that when children from high SES families increase the time spent on video games, they would subsequently increase the time spent on physical activity. Children from low SES families, on the other hand, have greater access to electronic media devices but lower access to physical activity facilities and spaces (Tandon et al., 2012), making it hard for them to increase physical activity with increasing video game use.

There was a small negative effect of 4th grade sleep duration on 5th grade video game use in children whose parents had obtained a bachelor's degree or above. This prediction was in the expected direction and consistent with findings in a prior study showing that sleep duration negatively predicted subsequent computer use (Magee et al., 2014). Tiredness and fatigue related to short sleep may reduce the likelihood of engaging in active activities and lead to more sedentary behavior such as video game use over time (Magee et al., 2014). Alternatively, shortened sleep may be a result of sleep problems (e.g., trouble falling asleep), such that engaging in video games or other screen-based activities may be used as a way to cope with sleep problems (Magee et al., 2014; Tavernier & Willoughby, 2014). It is unclear why the effect of 4th grade sleep duration on 5th grade video game use was not present in children whose parents did not obtain a bachelor's degree. One possible explanation is that less sleep may be related to increases in other types of screen time (e.g., television viewing) rather than video game use in these children given that they already spend a fair amount of time on video games.

Longitudinal Associations by Child Gender. Different patterns of longitudinal associations between MVPA and video game use emerged in male and female children. Third grade video game use positively predicted 4th grade MVPA in male children, whereas 4th grade MVPA negatively predicted 5th grade video game use in female children. These differential effects may be due to gender differences in video game use. Specifically, among different types of video games, boys play sports video games more frequently than girls (Gómez-Gonzalvo et al., 2020). Higher frequency of playing sports video games among boys may be associated with their increased involvement in physical activity (Adachi & Willoughby, 2015, 2016). However, involvement in physical activity was not predictive of subsequent video game use among boys. Video games, especially online video games, often serve as an important social tool for boys, allowing them to make new friends, connect with friends, and foster friendships (Lenhart, Amanda, 2015; Leonhardt & Overå, 2021). By contrast, social media rather than video games may be of greater social significance for female children (Leonhardt & Overå, 2021). To this end, decreasing time spent on video games may be an option for girls but not boys when they increase time spent on physical activity.

Longitudinal Associations by Child Race/Ethnicity. The associations between MVPA and video game use seemed to vary across race/ethnicity groups. Specifically, 3rd grade video game use positively predicted 4th grade MVPA among non-Hispanic White children, but the reverse was true in Hispanic children. The positive effect of video game use on MVPA also was found in non-Hispanic Asian children but it was from 4th grade to

5th grade. Among non-Hispanic Black children, 4th grade video game use, however, negatively predicted 5th grade MVPA. In addition, there was a negative prediction from 3rd grade sleep duration to 4th grade MVPA in non-Hispanic Asian children. It is unclear why different patterns of associations among lifestyle behaviors (primarily between MVPA and video game use) appeared across racial/ethnic groups. In general, levels of MVPA, video game use, and sleep duration differ by race/ethnicity (Anderson et al., 2008; Guglielmo et al., 2018; Yi et al., 2015). These racial/ethnic differences in lifestyle behaviors may be determined by varied biological, cultural, social, and environmental factors across racial/ethnic groups. These race/ethnicity-related factors may affect lifestyle behaviors as well as associations between lifestyle behaviors.

Trajectories of Lifestyle Behaviors

Consistent with the hypothesis about the developmental trajectories of lifestyle behaviors, MVPA and sleep duration decreased, while video game use increased over time. On average, video game use on a weekday increased by 10 minutes per year from 3rd to 5th grades, while sleep duration decreased by 8 minutes per year. These findings echo prior research suggesting that children are less physically active but more sedentary and sleep less as they age (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016). These developmental trajectories are worrisome, given numerous negative consequences associated with low physical activity, high sedentary behavior, and short sleep (Marciano & Camerini, 2021; Sampasa-Kanyinga et al., 2017, 2021; Tremblay et al., 2016; Urrila et al., 2017). Intervention and prevention programs that begin early in childhood may be necessary to prevent or attenuate these unfavorable trajectories.

Reasons for age-related changes in MVPA, video game use, and sleep duration were out of the scope of this study. One can only speculate that these age-related changes may arise as a result of complex combinations of biological, psychosocial, and environmental influences. For example, children in the present study were transitioning from middle childhood to adolescence, during which children experience the onset of puberty (Walvoord, 2010). Many biological changes as well as psychological factors related to puberty, including rapid weight gain, tiredness, emotional distress, the first onset of some mental disorders, and steep increases in symptoms for other mental disorders, may contribute to the decrease in physical activity and sleep duration and the increase in sedentary behavior (Crowley et al., 2007; Hochberg, 2008; Hoyt et al., 2018; Mendle, 2014; Oldehinkel et al., 2011; Sherar et al., 2010; Viner, 2015).

In addition, there may be unique factors related to the change in each of these lifestyle behaviors. A qualitative study suggests that reasons for becoming less physically active include the lack of support from significant others and loss the inspiration for sports (Kostamo et al., 2019). Indeed, adolescents perceive less parental encouragement and instructional support for being physically active and have fewer physically active friends as they are older, and all of these contribute to the decline in physical activity (Lau et al., 2016). Enjoyment of physical activity also declines in childhood through adolescence, along with a decline in MVPA (Haas et al., 2021).

Children may be motivated to play video games in order to fill time or avoid boredom, have fun, reduce stress, and have social interaction with others (Ferguson & Olson, 2013; Olson, 2010). The increase in video game use from 3rd to 5th grades may stem from parents having fewer rules around technology use as children age (Sanders et al., 2016). Also, as high-quality friendships become increasingly important and the feeling of loneliness is prevalent from middle childhood through adolescence (Qualter et al., 2015), children may increase the time spent on screen-based activities such as video gaming (Lawrence et al., 2021). Notably, children may play video games with a desire to build, maintain, or foster friendships. Playing video games, however, is positively associated with subsequent feelings of isolation (Lawrence et al., 2021).

Later bedtimes may be a direct and primary reason for age-related decline in sleep duration on weekday nights (Kuula et al., 2018; Nixon et al., 2008; Thorleifsdottir et al., 2002). In addition to puberty-related biological and psychological factors, many other factors also may lead to delays in bedtimes. For example, parents are less likely to set limits around their children's bedtimes as children get older, and this is related to later bedtimes (Short et al., 2011). Moreover, children have a higher homework load with higher grade levels, which may interfere with their sleep (Holland et al., 2021; Pressman et al., 2015). Although video game use was not related to sleep duration at the within-person level in the present study, other types of screen time such as television viewing may contribute to later bedtimes and short sleep duration (Nuutinen et al., 2013).

Trajectories of Lifestyle Behaviors Across Subsamples

Similar to findings in the full sample, declines in MVPA and sleep duration, and an increase in video game use, were observed across subsamples of SES, gender, and race/ethnicity. Because the analytic approach I employed did not allow for comparisons of trajectories across subsamples, below I discuss results from group comparisons (see Tables 1.3-1.6) which were based on observed scores. Overall, results based on observed scores, combined with the predicted trajectories, provide support for health lifestyle theory that social contexts affect lifestyle behaviors (Cockerham, 2005, 2013).

Lifestyle Behaviors by Household SES. In general, children from high SES families had more MVPA, lower video game use, and longer sleep duration in 3rd grade through 5th grade than children from lower SES families. These findings, which were echoed by the predicted trajectories across SES groups, replicate results of prior studies that children from high SES families practiced healthier lifestyle behaviors (Biggs et al., 2013; Drenowatz et al., 2010; Lampinen et al., 2017). Greater awareness of healthy lifestyle behaviors, more resources for physical activity, and lower access to electronic media devices in high SES families may contribute to higher physical activity and lower screen time in children (Estabrooks et al., 2003; Stenhammar et al., 2007; Tandon et al., 2012). Longer sleep duration in children from higher SES families may be explained by their earlier bedtimes than children from lower SES families (Biggs et al., 2013). Additionally, low family SES is associated with a host of risk factors, including high family chaos, low quality home environments, and pre-sleep worries, that contribute to low sleep quality and quantity (Bagley et al., 2015; Doane et al., 2019; Philbrook et al., 2020).

Lifestyle Behaviors by Child Gender. From 3rd to 5th grades, male children were higher in both MVPA and video game use than female children, but they had similar levels of sleep duration. Gender differences in physical activity have been consistently reported across countries and developmental stages (Bann et al., 2019). Girls are less physically active than boys and this may be due to lower levels of engagement in organized sports, enjoyment from being physically active, and confidence in sporting ability in girls than boys (Sport England, 2019; The Lancet Public Health, 2019; Vilhjalmsson & Kristjansdottir, 2003). Generally, compared to boys, girls are not less encouraged to be physically active, are provided less support and fewer opportunities, and encounter more barriers to participating in physical activity (Cowley et al., 2021; Lazarowicz et al., 2021). The finding that boys had more video game use is consistent with prior studies, and it may be because boys have more positive experiences playing video games, and video gaming is an important social tool for boys (Lenhart, Amanda, 2015; Leonhardt & Overå, 2021; Olson, 2010). The lack of gender differences in sleep duration contrasts with the finding that parent-reported sleep duration was longer in girls than boys in an Australian sample (Biggs et al., 2013) but replicates an actigraphy-based study of Australian children (Tremaine et al., 2010). Given these mixed findings, more research is needed to investigate whether there are gender differences in sleep duration and whether gender differences based on child- or parent-reports are biased compared to actigraphy-based assessments.

Lifestyle Behaviors by Child Race/Ethnicity. Across the four racial/ethnic groups, non-Hispanic White children had the highest level of MVPA, while non-Hispanic Asian children had the lowest MVPA and video game use. Such findings were in line with research suggesting that Asian American adults are less likely to meet physical activity guidelines (Yi et al., 2015). Investigations focused on Asian American children were rare, this study adds to the literature by including Asian American children and suggesting that they were less likely to be physically active but also played video games less than other racial/ethnic children. Findings in the present study also show that non-Hispanic White children have the longest sleep duration, followed by Hispanic children, and non-Hispanic Black children have the lowest sleep duration. Sleep duration in non-Hispanic Asian children was slightly lower than that of non-Hispanic White children but slightly higher than that of Hispanic children, but these differences were not significantly significant. Overall, these patterns of findings were consistent with prior research (Guglielmo et al., 2018). The mechanisms underlying racial/ethnic disparities in sleep duration remain unclear, emerging research suggests that discrimination may be a potential mechanism (Slopen et al., 2016).

Correlations Among Trajectories

Contrary to the expectation that the slope factors of trajectories of MVPA, video game use, and sleep duration were correlated, these slope factors were not correlated with each other. This suggests that changes in the three lifestyle behaviors do not covary, such that the decline in MVPA, increase in video game use, and decrease in sleep duration from 3rd grade through 5th grade were not related. The lack of correlation between changes in physical activity and sleep duration over time was reported in an actigraphy-based study (Antczak et al., 2021). Similarly, prior studies involving total screen time, television viewing, or sedentary behaviors suggest that changes in these measures were not correlated with changes in physical activity (Gunnell et al., 2016; Taveras et al., 2007). Given these consistent findings, one can speculate that changes in MVPA, video game use, and sleep duration over time may be related to other factors such as the increasing age and age-related variables. An alternative explanation is the variance of the sleep duration slope factor, which was marginally significant in the full sample, was relatively small. With the relatively small variance, covariances between the sleep duration slope factor and other slope factors were less likely to be observed.

Despite the non-significant correlations among the slope factors, all intercept factors were correlated and there were some significant correlations between the slope factors and intercept factors. Correlations among these intercept factors showed that 3rd grade MVPA was negatively correlated with 3rd grade video game use and positively correlated with 3rd grade sleep duration. In addition, 3rd grade video game use was negatively correlated with 3rd grade sleep duration. These results are in line with previous findings from cross-sectional studies (Antczak et al., 2020; Hale & Guan, 2015; Melkevik et al., 2010; Serrano-Sanchez et al., 2011).

Interestingly, higher 3rd grade MVPA or sleep duration was related to a smaller increase in video game use but a faster decline in sleep duration from 3rd to 5th grades. The correlations of 3rd grade MVPA and sleep duration with the change in video game use were in the expected direction and echo prior research that higher physical activity and longer sleep duration were associated with lower screen time (Chien et al., 2019; Straatmann et al., 2019). The correlation of 3rd grade MVPA with the change in sleep duration, however, was in an unexpected direction and seems to contrast previous findings that MVPA is beneficial to sleep (Antczak et al., 2020; Kredlow et al., 2015). The correlation involving the change in sleep duration should be interpreted in light of the fact that variance of the sleep duration slope factor was marginally significant. Given that children were likely homogeneous with regard to their declines in sleep duration over time, correlations involving the change in sleep duration may not be clinically significant.

Correlations Among Trajectories Across Subsamples

Patterns of correlations among intercepts and slopes of trajectories across SES, gender, and race/ethnicity were generally consistent with those in the full sample. Specifically, no correlations among slope factors were observed in subsamples and there were some correlations among intercept factors or between the intercept factors and slope factors. Regarding correlations among intercept factors, while the sleep duration intercept factor still was positively correlated with the MVPA intercept factor and negatively correlated with the video game use intercept factor across all subsamples (except non-Hispanic Black children), the MVPA intercept factor was not correlated with the video game use intercept factor in some subsamples. This is not surprising, given that the correlation between the intercept factors of MVPA and video game use observed in the full sample was very small.

There were some correlations between the sleep duration slope factor with some intercept factors in several subsamples. However, given that the variance of the sleep duration slope factor was not significant in all but two subsamples, correlations involving this factor may not be meaningful and will not be discussed further. The negative correlations between the video game use slope factor with the MVPA and sleep duration intercept factors, which were observed in the full sample, appeared in children from high SES families, non-Hispanic White children, and non-Hispanic Black children. In addition, the video game use slope factor was negatively correlated with the MVPA intercept factor in male children, whereas it was negatively correlated with the sleep duration intercept factor in female children. Collectively, these findings indicate that promoting MVPA and sleep duration may help attenuate the increase in video game use in subsequent years among some but not all populations.

Limitations and Future Directions

The present study has several strengths, including the large, nationally representative sample, the longitudinal design, and the analytic approach. Some limitations of this study must be noted. First, the three lifestyle behaviors examined were reported by parents. Although parent-reported measures and device-based measures are moderately or strongly correlated, parents may inaccurately estimate children's amount of MVPA, video game use, and sleep duration (Li, Sheehan, Valiente, et al., 2021; Sarker et al., 2015). Importantly, the biases in parent-reports as compared to device-based measures may vary across populations (e.g., Berglind & Tynelius, 2017; Li, Sheehan, Valiente, et al., 2021). This is worrisome as mean differences across groups based on reported measures may be inaccurate or artifact of measurement error. Future research should incorporate device-based measures to reduce potential biases in reported data, though these studies are unlikely to include large, nationally representative samples like the present study.

Second, the focus on video game use sheds light on the development of active screen time and its associations with other lifestyle behaviors. However, given the differences between active and passive screen time (Sweetser et al., 2012), it is unclear whether the findings of this study can be generalized to passive screen time and total screen time. The use of video game use as a measure of active screen time or mentally active sedentary behavior more broadly ignores the fact that certain forms of video game use (e.g., playing active video games) can generate a comparable amount of energy expenditure to moderate-tensity physical activity (Graf et al., 2009). Moreover, different types of video games may be differentially related to other lifestyle behaviors (Adachi & Willoughby, 2015, 2016; Foley & Maddison, 2010). More theoretical and empirical work is needed to better define and classify various types of screen time and video game use and to understand their precursors and outcomes.

Third, the measure of MVPA, which assessed the number of days per week participants had at least 20 minutes of MVPA, may not be comparable to measures of video game use and sleep duration which assessed the exact amount of time on weekdays. Specifically, physical activity, screen time, and sleep duration might be different between weekdays and weekends. In addition, the number of days children engaged in 20 minutes of MVPA or more per week might not reflect the average hours spent on MVPA per day. It is unclear how these differences across measures may impact findings. Future studies may benefit from a clear operationalization of the time frame and the assessment of the exact amount of time engaging in physical activity or different types of physical activity.

Fourth, the interval between assessment points was one year. This interval may be too long and thereby not allow for the detection of dynamic associations among MVPA, video game use, and sleep duration. Shorter intervals such as three or six months may be considered in future studies (Lawrence et al., 2021). Alternatively, the one-year interval may not be long enough for one lifestyle behavior to generate observable changes in another lifestyle behavior (Magee et al., 2014). More research is needed to identify the optimal time lags across developmental periods to best examine the longitudinal associations among lifestyle behaviors.

Conclusion

The present study provides a novel insight into the developmental associations among MVPA, video game use, and sleep duration during the transition from middle childhood to adolescence. Using a large, prospective sample of US children, I found that MVPA, video game use, and sleep duration were not transactionally related over time at the within-person level. From 3rd to 5th grades, levels of MVPA and sleep duration declined, and video game use increased over time. Changes in these lifestyle behaviors, however, were not correlated. Additionally, patterns of findings across social contexts of family SES, child sex, and child race/ethnicity were generally consistent with those in the full sample, with several exceptions. The lack of within-person transactional associations emphasizes the need to re-valuate the transactional associations in past work by disaggregating between-person and within-person effects. Further, the specific social contexts should be considered when evaluating the developmental associations among physical activity, sedentary behavior, and sleep duration.

CHAPTER 3

STUDY 2. DEVELOPMENTAL TRAJECTORIES OF PHYSICAL ACTIVITY, SEDENTARY BEHAVIOR, AND SLEEP DURATION IN US CHILDREN: PREDICTORS AND DEVELOPMENTAL OUTCOMES

Introduction

Healthy lifestyle behaviors play important roles in children's academic success, mental and physical health, and well-being (Marciano & Camerini, 2021; Sampasa-Kanyinga et al., 2017, 2021; Tremblay et al., 2016; Urrila et al., 2017). Among lifestyle behaviors, physical activity, sedentary behavior, and sleep, which are associated with time use within a daily 24-hour cycle, have received attention and been associated with a host of developmental outcomes (Pedišić et al., 2017; Tremblay et al., 2016). The 24-hour movement guidelines for children aged 5-13 years recommended at least 60 minutes of moderate-to-vigorous physical activity (MVPA), no more than 2 hours of recreational screen time, and 9-11 hours of sleep (Tremblay et al., 2016). Meeting these guidelines is associated with higher academic achievement (Marciano & Camerini, 2021), fewer internalizing and externalizing behaviors (Sampasa-Kanyinga et al., 2021), and better physical health (Carson et al., 2017). While the concurrent associations between three lifestyle behaviors and outcomes have been well-established, few studies have examined the longitudinal associations or how the trajectories of these lifestyle behaviors are related to developmental outcomes. Moreover, the predictors of trajectories of these lifestyle behaviors, beyond social structural factors, remain unclear. The first aim of this study is to examine whether early self-regulation is a predictor of the trajectories of physical activity, sedentary behavior, and sleep duration. The second aim is to test whether children's developmental outcomes (i.e., mental health, physical health, and academic performance) are predicted by trajectories of the three lifestyle behaviors. The third aim is to investigate whether these associations differ across social contexts of socioeconomic status (SES), gender, and race/ethnicity.

Healthy Lifestyle Behaviors and Developmental Outcomes

Healthy lifestyle behaviors in childhood may have long-term impacts on later academic success and health, given that they are likely to persist into adolescence and adulthood and support optimal brain development (Hanson et al., 2019; Telama, 2009; Telama et al., 2005; Urrila et al., 2017). A few studies have examined the longitudinal associations between lifestyle behaviors and developmental outcomes. For example, Buckhalt et al. (2009) found that sleep duration was positively related to intellectual ability and academic achievement about two years later, particularly among children with less-educated fathers. Faught et al. (2019) found that meeting the screen time recommendation (i.e., 2 hours per day or fewer) across time was related to subsequent higher math and English achievement in adolescence, while physical activity and sleep duration were not associated with academic achievement. Using a sample of Irish children, Neville et al. (2021) found that screen time at ages 3 and 5 was positively related to internalizing problems at ages 5 and 7, respectively, but screen time at age 7 was negatively related to internalizing problems at age 9. In the same study, they reported that screen time was not associated with later externalizing problems (Neville et al., 2021). Sleep duration at age 10 was negatively related to externalizing and internalizing problems at age 13 (Kelly & El-Sheikh, 2014). White girls who watched more TV at age 9 or 10 showed a steeper increase in body mass index (BMI) over the subsequent four years, but such association was absent in Black girls (Henderson, 2007).

Despite the emerging evidence for the predictions of earlier lifestyle behaviors to later developmental outcomes, it remains poorly understood whether or how trajectories (e.g., changes or growth) of lifestyle behaviors are related to later developmental outcomes. Research has suggested that on average, physical activity and sleep duration decrease throughout childhood and adolescence, while sedentary behavior increases over time (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016). Importantly, individual differences were observed in trajectories of these lifestyle behaviors. That is, children may be different in their initial levels of physical activity, sedentary behavior, and sleep duration as well as the changes in these lifestyle behaviors over time (Farooq et al., 2018; Iglowstein et al., 2003; Janssen et al., 2016; Yoo, 2020). As an example, Farooq et al. (2018) identified distinct trajectories of MVPA in children from ages 7 to 15, such that some children displayed relatively higher initial MVPA with steeper declines over time, some were low in initial MVPA with relatively small declines, and others gradually declined. Similarly, Yoo (2020) found that Korean children showed an average of 7.9 hours of sleep in 7^{th} grade, which declined by 0.4 hours each year from 7^{th} grade to 12^{th} grade, and there were significant individual heterogeneities around the average initial level and slope.

The differences in trajectories of lifestyle behaviors may predict later developmental outcomes. In support of this notion, a recent study reported that children with a steeper decrease in sleep duration from ages 2 to 4 had better reading and math performance in 1^{st} grade (Bernier et al., 2021). Children who persistently show high screen use from ages 2 to 5, compared to those with low to moderate screen use over time, are likely to have more externalizing problems (McArthur et al., 2020). Likewise, an increase in nighttime mobile phone use or poor sleep behavior from ages 8 to 10 was related to the subsequent increase in externalizing behavior (Vernon et al., 2018). However, Jiskrova et al. (2020) suggested that the trajectory of sleep duration (i.e., initial levels at age 1.5 and linear changes over time) from ages 1.5 to 7 was not related to externalizing or internalizing problems at age 11 or their changes from ages 11 to 18. With respect to BMI, low and stable sedentary behavior combined with high and stable MVPA across ages 7 to 15 were associated with low body fatness at age 15 (Farooq et al., 2021). Children with trajectories characterized as lower sleep duration at ages 10 to 13 are at greater risk of being overweight or obese at age 13 (Seegers et al., 2011).

There are two major limitations in previous studies examining the associations between lifestyle behaviors and developmental outcomes. First, the confounding effects of other lifestyle behaviors are often overlooked in research focusing on one lifestyle behavior. The 24-hour activity cycle model (Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay et al., 2016) suggests that physical activity, sedentary behavior, and sleep are interdependent, as the increase in time spent on one activity is related to the decrease of time spent on at least one other activity within a 24-hour cycle. Additionally, these lifestyle behaviors are all associated with developmental outcomes (Buckhalt et al., 2009; Carson et al., 2017; Marciano & Camerini, 2021; Neville et al., 2021; Sampasa-Kanyinga et al., 2021). Hence, without adjustments for other lifestyle behaviors, the associations concerning one lifestyle behavior and outcomes may be biased and misleading (Pedišić, 2014; Rosenberger et al., 2019). Second, research is scarce regarding whether the associations between lifestyle behaviors and developmental outcomes vary across social contexts. Social contexts, such as SES, gender, and race/ethnicity, are important social determinants of both lifestyle behaviors and developmental outcomes (Anderson et al., 2008; Biggs et al., 2013; Drenowatz et al., 2010; Mehta et al., 2013; Sirin, 2005). Additionally, a few existing studies suggested that social contexts moderated the relations between lifestyle behaviors and developmental outcomes (Buckhalt et al., 2009; Chang et al., 2018; Henderson, 2007). More research is needed to better understand whether a specific lifestyle behavior is more beneficial or harmful to certain populations.

Predictors of Trajectories of Healthy Lifestyle Behaviors

In addition to examining developmental outcomes associated with trajectories of lifestyle behaviors, investigating how factors in early childhood may shape these trajectories is also of great interest. Social contexts are the most studied predictors. For example, lower family SES is associated with faster linear declines in MVPA from childhood to adolescence (Nader et al., 2008). Lower family SES and racial/ethnic minority status are related to greater risk of having persistently high screen use than low to moderate screen use across early childhood years (McArthur et al., 2020). Lower levels of family SES or boys are associated with higher risk of developing a trajectory characterized as shorter sleep duration in early childhood (Plancoulaine et al., 2018; Touchette et al., 2009). Sleep duration trajectory is different among White, Black, Hispanic, and Asian girls; White girls had relatively higher duration but steeper declines than other girls (Hoyt et al., 2018).

The predictions of social contexts to trajectories of lifestyle behaviors are consistent with health lifestyle theory, suggesting that social structures, including class, gender, and race/ethnicity, are important in shaping lifestyle behaviors (Cockerham, 2005, 2013). In addition to social contexts, health lifestyle theory also emphasizes individual agency and the interplay of agency and structure in determining lifestyle behaviors (Cockerham, 2005, 2013). Middle childhood and early adolescence present critical periods to observe how agency and structure shape lifestyle behaviors, as children's lifestyle behaviors are increasingly less monitored by parents and more affected by their agency and social contexts during these periods (Mollborn & Lawrence, 2018). Among children, the agency may be present in their ability to monitor, control, and regulate their lifestyle behaviors based on rules and expectations in the household and children's goals. As such, children's self-regulatory capacity may be an important factor that interacts with social contexts to jointly shape their lifestyle behaviors.

Empirical studies have provided evidence for the effect of self-regulation on lifestyle behaviors (e.g., Bub et al., 2016; Cliff et al., 2018; Riggs et al., 2010). A recent meta-analysis showed that self-regulation was associated with a host of developmental outcomes, including unhealthy lifestyle behaviors (e.g., smoking and drinking), academic performance, behavioral problems, and obesity (Robson et al., 2020). In a sample of 4^{th} grade children, Riggs et al. (2010) found that better self-regulation predicted higher levels of physical activity four months later. Among Canadian children, kindergarten self-regulation positively predicted 4^{th} grade participation in physical activity and team sports (Piché et al., 2012, 2015). Poor self-regulation at 9 months was associated with higher media use at age 2, and this association was stronger in low SES families (Radesky et al., 2014). Likewise, Cliff et al. (2018) reported that self-regulation at age 4 was negatively related to electronic game use, television viewing, and media exposure at age 6. Additionally, lower self-regulation at age 4.5 predicts shorter sleep duration and more sleep problems at ages 8 and 11 (Bub et al., 2016). To date, no studies have examined how self-regulation is related to trajectories of lifestyle behaviors in childhood.

The Present Study

The goals of this study are to investigate predictors and associated outcomes of developmental trajectories of lifestyle behaviors in childhood. The three important lifestyle behaviors under investigation are physical activity, sedentary behavior, and sleep duration. In this study, MVPA is used as an index of physical activity and video game use is used as a measure of mentally active sedentary behavior or screen time. A measure of active screen time rather than the total amount of screen time combining both active (e.g., video game use) and passive (e.g., television viewing) screen time is employed, primarily because growing evidence suggests a need to distinguish between the two types of screen time (Hallgren et al., 2020; Kikuchi et al., 2014; S. Kim et al., 2020; Mazzer et al., 2018; Peracchia & Curcio, 2018; Sweetser et al., 2012). The focus on video game use allows for the investigation of the development of active screen time and its predictors and associated outcomes.

The first aim of this study is to test whether early self-regulation predicts trajectories of MVPA, video game use, and sleep duration from 3rd to 5th grades. Consistent with prior studies (e.g., Bub et al., 2016; Cliff et al., 2018; Riggs et al., 2010), better self-regulatory capacities are hypothesized to predict more optimal trajectories of the three lifestyle behaviors. The second aim is to examine whether trajectories of these lifestyle behaviors are related to subsequent externalizing and internalizing problems, BMI, and academic achievement in 5th grade. Based on previous empirical findings (e.g., Jiskrova et al., 2020; McArthur et al., 2020; Seegers et al., 2011; Vernon et al., 2018), trajectories characterized as higher MVPA, lower video game use, or longer sleep duration are hypothesized to be associated with better developmental outcomes. The third aim is to investigate whether these associations vary depending on social contexts of SES, gender, or race/ethnicity. Given the lack of empirical studies and based on health lifestyle theory (Cockerham, 2005, 2013), I tentatively predict that patterns of these associations differ across social contexts.

Method

Data

The sample analyzed in this study was the same as the sample in Study 1.

Measures

The measures of MVPA, video game use, and sleep duration from 3rd to 5th grade in Study 1 were used in this study. Social contexts of household SES (i.e., household poverty status and parental educational attainment), child gender, and race/ethnicity in Study 1 were also used in this study. Because this study included variables in kindergarten, household SES assessed in kindergarten rather than in 3rd grade (in Study 1) was used.

Externalizing and Internalizing Problems

Teachers reported children's externalizing and internalizing problems using the Social Skills Rating System (SSRS; Gresham & Elliott, 1990) in the spring semester of 5th grade. Externalizing problems were assessed with 6 items about behaviors such as acting impulsively, disturbing ongoing activities, getting angry, fighting, and arguing. Internalizing problems were assessed with 4 items about loneliness, anxiety, sadness, and low self-esteem. Each item was rated on a 4-point scale (1 = *never*, 4 = *very often*).

Scores were averaged across items, with higher scores indicating more externalizing or internalizing problems. The two subscales were moderately correlated, $r(8,541) = .30$, $p < .001$. The reliability coefficient in the current study was .88 for the externalizing problems subscale and .79 for the internalizing problems subscale (Tourangeau et al., 2018).

Body Mass Index

Children's weight and height assessed in the spring semester of 5th grade were used to create BMI scores. While converting BMI scores to age- and gender-specific percentiles or z-scores is popular and appropriate for cross-sectional studies, BMI z-score is less powerful than BMI itself to evaluate adiposity change of children and adolescents in longitudinal studies (Berkey & Colditz, 2007; Cole et al., 2005). Thus, the original BMI scores were used in this study.

Academic Achievement

Children's academic achievement was measured by reading, math, and science achievement in the spring semester of 5th grade (Tourangeau et al., 2018). Reading achievement included questions about basic skills (e.g., word recognition), vocabulary knowledge, and reading comprehension. Math achievement measured skills in conceptual knowledge, procedural knowledge, and problem solving. Science achievement included questions measuring life sciences, physical sciences, Earth and space sciences, and scientific inquiry. Two-stage assessments were used to measure reading, math, and science achievement. In the first stage, children were tested on a routing section that included items (i.e., 12, 18, and 15 items for reading, math, and science, respectively) with a broad range of difficulty for each subject. A child's performance on the routing section of a subject determined which one of three (i.e., low, middle, or high difficulty) second-stage tests the child received for that subject. Thus, item response theory (IRT) procedures were used to calculate scores for each subject to make scores comparable across students and grades. The IRT-based scores ranged from -4 to 4, with higher scores indicating greater academic achievement. Reading, math, and science achievement were highly correlated, rs(9,466 - 9,471) = .74 - .76, ps < .001. Thus, they were averaged to create a composite measure of academic achievement.

Self-Regulation

Teachers reported children's self-regulation using the Inhibitory Control and Attentional Focus subscales from the Children's Behavior Questionnaire-Short Form (CBQ-SF; Putnam & Rothbart, 2006) in the spring semester of kindergarten. Each subscale consisted of 6 items, and each item was rated on a 7-point scale (1= *extremely untrue* to 7 = *extremely true*). Item scores were averaged for each subscale, with higher scores indicating better ability in inhibitory control or attentional focus. The reliability coefficient in the current study was .87 for the Inhibitory Control subscale and .87 for the Attentional Focus subscale (Tourangeau et al., 2018). The two subscales were highly correlated, $r(10,119) = .79$, $p < .001$, and therefore, were averaged to create a composite measure of self-regulation.

Covariates

Covariates included externalizing (reliability coefficient was .89) and internalizing (reliability coefficient was .78) problems, BMI, and academic achievement in kindergarten.

Data Analytic Plan

Data analyses were conducted in Stata 16.1 and M*plus* 8.3 (Muthén & Muthén, 1998–2017). Descriptive statistics (e.g., valid *N*, mean, standard deviation, minimum, maximum, skewness, and kurtosis) of study variables and covariates in the full sample and each subsample by household poverty status, parental highest education, gender, and race/ethnicity were analyzed in Stata. A full sample weight (i.e., W1_2P0) was used to account for the complex sampling design (e.g., Ansari & Gottfried, 2021; Bachman et al., 2020). Taylor series linearization method was employed to compute weighted descriptive statistics (Tourangeau et al., 2018). All cases in the ECLS-K:2011 were kept in analyses and the analytic sample for each analysis was chosen using the subpopulation option to properly calculate standard errors of estimates (Rao & Molina, 2015). Weighted means of study variables and covariates across subsamples were compared in Stata. The Bonferroni correction was employed for multiple comparisons. Missing data were not handled in analyses in Stata.

Weighted zero-order correlations among study variables and covariates in the full sample and each subsample were calculated in M*plus* using the "with" command (UCLA: Statistical Consulting Group, n.d.). Taylor series linearization method and subpopulation option were used in all analyses with M*plus*. Additionally, the robust full information maximum likelihood (MLR) estimator was utilized to account for missing data.

Main analyses were conducted in M*plus*. First, an unconditional linear latent growth curve model (LGCM) was estimated separately for MVPA, video game use, and sleep duration. Next, a multivariate LGCM was estimated by combining the three LGCMs, allowing for covariances among the intercept and slope factors of trajectories. Then, early self-regulation was included as a predictor of the intercept and slope factors of trajectories. In a different set of analyses, distal outcome variables, including externalizing problems, internalizing problems, BMI, and academic achievement, instead of the predictor, were added to the multivariate LGCM. These distal outcome variables were predicted by the intercept and slope factors of trajectories. In addition, covariates in kindergarten were added as predictors to the corresponding distal outcome variables (e.g., kindergarten academic achievement was included as a predictor of 5^{th} grade academic achievement). All main analyses described above were conducted in the full sample as well as each subsample by household poverty status, parental highest education, gender, and race/ethnicity. Formal tests of differences in regression coefficients across subsamples were not conducted because the multiple group analysis is not compatible with the subpopulation option in M*plus*.

Model Fit Indices

The Satorra-Bentler scaled χ^2 statistics, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the standardized root mean square residual (SRMR) were used to evaluate model fit. Model fit is considered acceptable when RMSEA < .080, CFI > .900, TLI > .900, and SRMR < .080 and good when RMSEA < .050, CFI > .950, TLI > .950, and SRMR < .050 (Little, 2013).

Missing Data

Participants with complete data on all variables used in this study (i.e., lifestyle behaviors, social contexts variables, and covariates) were coded as 0 (N = 5,183) and those with missing data on any of these variables were coded as 1 (N = 6,065). The two groups of participants were significantly different in most variables involved in this study (see Table 2.1). Specifically, compared to children with complete data, those with missing data were less likely to be from not-poor families, have parents who had obtained a bachelor's degree or above, and be non-Hispanic White. In addition, children with missing data had lower levels of MVPA, sleep duration, academic achievement, and self-regulation but higher levels of video game use, externalizing problems, internalizing problems, and BMI than children with complete data. The MLR estimator was used to handle missing data in all analyses with M*plus*.

Results

Preliminary Analyses

Descriptive Statistics

Table 2.2 shows descriptive statistics of variables used in this study. The weighted sample consisted of 25% poor families, 22% near-poor families, and 54% not-poor families. Approximately 60% of children had parents whose highest education was lower than a bachelor's degree. Half (52%) of the weighted sample were male children. Approximately 53% of the weighted sample were non-Hispanic White children, 11% were non-Hispanic Black children, 27% were Hispanic children, 4% were non-Hispanic Asian children, and 5% were non-Hispanic other races. Skewness of study variables ranged between -0.94 and 2.30 and kurtosis ranged between -0.88 and 10.14. The slight deviation from normality was handled with the MLR estimator (Lai, 2018).

Tables 2.3-2.6 present descriptive statistics of study variables and covariates across household poverty status, parental highest education, gender, and race/ethnicity subsamples, respectively. Variables differed across household poverty status (see Table 2.3). Compared to children from poor or near-poor families, children from not-poor families on average had the highest levels of MVPA, sleep duration, academic achievement, and self-regulation as well as the lowest levels of video game use, externalizing and internalizing problems, and BMI across grades. Children from near-poor families had more optimal scores on some of these variables than children from poor families. Similarly, children whose parents had obtained a bachelor's degree or above exhibited more optimal scores on all study variables and covariates across grades than children whose parents did not obtain a bachelor's degree (see Table 2.4). Female and male children were different in some variables (see Table 2.5). For example, male children had higher levels of MVPA, video game use, and externalizing problems across grades than female children. Male children were also higher in kindergarten internalizing problems and BMI and lower in kindergarten self-regulation than female children. The average levels of study variables and covariates differed across racial/ethnic subsamples (see Table 2.6). With a few exceptions, non-Hispanic White children likely had more optimal scores on study variables and covariates across grades than racial/ethnic minority children. Non-Hispanic other children were different from children in other racial/ethnic groups in some study variables and covariates. This group, however, was not considered further in analyses of racial/ethnic subsamples because of its relatively small sample size and that this group consisted of children with varied racial backgrounds.

Correlations Among Study Variables

Table 2.7 shows weighted correlations between MVPA, video game use, and sleep duration with externalizing problems, internalizing problems, BMI, academic achievement, and self-regulation in the full sample. Weighted correlations among these variables were also computed in each subsample by household poverty status, parental highest education, gender, and race/ethnicity (see Tables 2.8-2.11). The weighted correlations among MVPA, video game use, and sleep duration in the full sample and subsamples are presented in Study 1.

As shown in Table 2.7, with a few exceptions, MVPA, video game use, and sleep duration were significantly correlated with externalizing problems, internalizing problems, BMI, academic achievement, and self-regulation within and across grades in the expected direction in the full sample. Specifically, MVPA across 3rd to 5th grades was generally negatively correlated with internalizing problems and BMI and positively correlated with academic achievement and self-regulation. Only one correlation between MVPA and externalizing problems was statistically significant: 4th grade MVPA was positively correlated with 5th grade externalizing problems. Video game use across 3rd to 5th grades was positively correlated with externalizing problems, internalizing problems, and BMI and negatively correlated with academic achievement and self-regulation. Additionally, sleep duration across 3rd to 5th grades was negatively correlated with externalizing problems, internalizing problems, and BMI and positively correlated with academic achievement and self-regulation.

Fewer significant correlations were observed in subsamples compared to the full sample. For example, as shown in Table 2.8, MVPA was not correlated with 5th grade internalizing problems or kindergarten self-regulation among children from poor families. In the same subsample, only three significant correlations were found between video game use and other variables, and sleep duration was not correlated with BMI (except a negative correlation between 3rd grade sleep duration and 5th grade BMI). In children from near-poor families, there were some significant correlations between MVPA with

BMI and academic achievement, only three significant correlations between video game use and other variables, and a few significant correlations between sleep duration and other variables (except academic achievement). Many significant correlations observed in the full sample remained significant in the subsample of children from not-poor families. However, self-regulation was not correlated with MVPA or sleep duration (except 3rd grade sleep duration) in this subsample.

Similarly, many significant correlations in the full sample remained significant in two subsamples by parental highest education (see Table 2.9). One important difference compared to the full sample is that self-regulation was not correlated with MVPA or sleep duration (except 3rd grade sleep duration) in both subsamples.

As shown in Table 2.10, many significant correlations in the full sample also remained significant in female and male subsamples. However, MVPA and video game use were not correlated with externalizing problems (except a positive correlation between 3rd grade video game use and kindergarten externalizing problems) in both subsamples. In addition, MVPA was not correlated with internalizing problems and video game use was not correlated with kindergarten internalizing problems in the female subsample.

Many significant correlations in the full sample were still significant in the non-Hispanic White subsample (see Table 2.11). Two major changes were that MVPV was not correlated with self-regulation and video game use was not correlated with kindergarten internalizing problems in non-Hispanic White children. Some significant correlations that appeared in the full sample were not significant in non-Hispanic Black, Hispanic, and non-Hispanic Asian subsamples. For instance, MVPA, video game use, and sleep duration were not correlated with externalizing problems or BMI (except a few exceptions), MVPA was not correlated with self-regulation, and sleep duration was not correlated with internalizing problems among non-Hispanic Black children. With three exceptions, MVPA, video game use, and sleep duration were not correlated with 5th grade externalizing and internalizing problems in Hispanic children. Additionally, MVPA was not correlated with self-regulation and video game use was not correlated with BMI and 5th grade academic achievement in Hispanic children. In the subsample of non-Hispanic Asian children, MVPA and sleep duration were not correlated with externalizing problems and self-regulation, and video game use was not correlated with externalizing and internalizing problems and BMI.

In summary, patterns of findings in each subsample were generally consistent with those in the full sample, except that there were fewer significant correlations in subsamples.

Main Analyses

Predicting Trajectories of Lifestyle Behaviors from Self-Regulation

The first research question in this study concerns whether self-regulation predicts trajectories of MVPA, video game use, and sleep duration. A set of multivariate LGCMs with self-regulation as a covariate was fit to the data in the full sample and each subsample to address this research question. When fitting the model in subsamples of children from poor families, male children, non-Hispanic Black children, and non-Hispanic Asian children, the model was not estimated properly, which was due to negative residual variances in slope factors. Therefore, the negative and non-significant residual variance of the sleep duration slope factor was fixed at zero in children from poor families, male children, and non-Hispanic Asian children, and the negative and non-significant residual variance of the MVPA slope factor was fixed at zero in non-Hispanic Black children (Muthén, 2005). Model fit indices with the full sample and subsamples are shown in Table 2.12. All models had a good or an acceptable fit to the data.

Table 2.13 shows the main findings in the full sample and each subsample. In the full sample, kindergarten self-regulation negatively predicted the intercept factor of video game use, positively predicted the intercept factor of sleep duration, and negatively predicted the slope factor of sleep duration. However, there were no predictions from kindergarten self-regulation to the intercept factor and slope factor of MVPA and the slope factor of video game use.

Regarding predictions in subsamples, kindergarten self-regulation negatively predicted the video game use intercept factor in all subsamples but non-Hispanic Asian children. A positive prediction from kindergarten self-regulation to the sleep duration intercept factor was found in most subsamples, except children from not-poor families, children whose parents had obtained a bachelor's degree or above, non-Hispanic Black children, and non-Hispanic Asian Children. Like in the full sample, a negative prediction from kindergarten self-regulation to the sleep duration slope factor was found in subsamples of children whose parents did not obtain a bachelor's degree and non-Hispanic White children. There were three new predictions in subsamples compared to the full sample: Kindergarten self-regulation negatively predicted the video game use slope factor in children from not-poor families but positively predicted this slope factor in children whose parents did not obtain a bachelor's degree, and it positively predicted the MVPA intercept factor in male children.

Associated Outcomes of Trajectories of Lifestyle Behaviors

The second aim of this study is to investigate whether trajectories of MVPA, video game use, and sleep duration are predictive of externalizing problems, internalizing problems, BMI, and academic achievement in 5th grade. A set of multivariate LGCMs with distal outcome variables was fit to the data in the full sample and each subsample for this research goal. The model failed to converge in six out of 11 subsamples. Kindergarten BMI was grand-mean centered in these subsamples to aid model convergence and in the full sample and other subsamples to be consistent. The models in subsamples of children from poor families, non-Hispanic Black children, Hispanic children, and non-Hispanic Asian children were not estimated properly, which was due to negative variances in slope factors. The negative and non-significant variance of the sleep duration slope factor was fixed at zero in children from poor families, Hispanic children, and non-Hispanic Asian children (Muthén, 2003). Among non-Hispanic Black children, the negative and non-significant variances of the MVPA and sleep duration slope factors were fixed at zero (Muthén, 2003). Model fit indices in the full sample and subsamples are shown in Table 2.14. All models had an acceptable or a good fit to the data.

Table 2.15 shows the main findings in the full sample. The sleep duration intercept factor negatively predicted 5th grade externalizing problems after controlling for kindergarten externalizing problems and other lifestyle behaviors. Likewise, the sleep duration intercept factor positively predicted 5th grade academic achievement after accounting for kindergarten academic achievement and other lifestyle behaviors. BMI in 5th grade was negatively predicted by the MVPA and sleep duration intercept factors and the MVPA slope factor, after controlling for kindergarten BMI and other lifestyle behaviors. All other predictions from the intercept or slope factors were not statistically significant.

Table 2.16 presents results in subsamples by household poverty status. No intercept or slope factors significantly predicted 5th grade outcome variables in children from poor families. Among children from near-poor families, there was only one significant prediction after controlling for covariates and other lifestyle behaviors: 5th grade academic achievement was positively predicted by the sleep duration intercept factor. More predictions appeared among children from not-poor families. Specifically, 5th grade externalizing problems and academic achievement were predicted by the sleep duration intercept factor, internalizing problems were negatively predicted by the MVPA intercept factor, and BMI was negatively predicted by the MVPA and sleep duration intercept factors, when adjusting for the stability and other lifestyle behaviors.

Table 2.17 shows results in subsamples by parental highest education. There were only two significant predictions when controlling for covariates and other lifestyle behaviors, and both were in children whose parents did not obtain a bachelor's degree. Specifically, in this subsample, the sleep duration intercept factor negatively predicted BMI and positively predicted academic achievement in 5th grade.

Table 2.18 presents results in female and male subsamples. Externalizing problems, internalizing problems, and BMI in 5th grade were negatively predicted by the sleep duration intercept factor when adjusting for covariates and other lifestyle behaviors in female children. No other predictions from intercept or slope factors were significant in female children, and there were no significant predictions in male children.

As shown in Table 2.19, after adjusting for kindergarten externalizing problems and other lifestyle behaviors, 5th grade externalizing problems were predicted by the sleep duration intercept factor in non-Hispanic White children and by the MVPA intercept factor in non-Hispanic Black children. Fifth grade internalizing problems were negatively predicted by the sleep duration intercept factor when adjusting for kindergarten internalizing problems and other lifestyle behaviors only among non-Hispanic White children. BMI in 5th grade was negatively predicted by the sleep duration intercept factor when adjusting for kindergarten BMI and other lifestyle behaviors among only non-Hispanic White children and Hispanic children. After controlling for kindergarten academic achievement and other lifestyle behaviors, 5th grade academic achievement was positively predicted by the sleep duration intercept factor in non-Hispanic White and Asian children and by the video game use intercept factor in Hispanic children.

In summary, patterns of findings in each subsample were consistent with those in the full sample, except that fewer significant predictions were observed in subsamples and there were a few new predictions in some subsamples.

Discussion

The main goals of this study were to investigate whether trajectories of MVPA, video game use, and sleep duration from 3rd to 5th grades were predicted by early self-regulation and were predictive of later externalizing and internalizing problems, BMI, and academic achievement. Further, these predictions were examined across SES, gender, or race/ethnicity groups to explore whether these associations varied depending on social contexts. Three sets of hypotheses were tested: 1) higher levels of self-regulation would predict more optimal trajectories of the three lifestyle behaviors, 2) more optimal trajectories would be associated with better developmental outcomes, and 3) patterns of these associations might vary by SES, gender, or race/ethnicity. Findings in the present study provided limited support for these hypotheses. Specifically, results showed that higher levels of kindergarten self-regulation predicted lower initial levels of the video game use trajectories, higher initial levels of the sleep duration trajectories, but steeper declines in sleep duration over time. Higher initial levels of the sleep duration trajectories predicted fewer externalizing problems, lower BMI, and higher academic achievement in 5th grade. In addition, higher initial levels and smaller declines of the MVPA trajectories predicted lower 5th grade BMI. The patterns of findings across subsamples were generally consistent with those in the full sample, but some different patterns of results emerged across subsamples.

Predicting Trajectories of Lifestyle Behaviors from Self-Regulation

The effects of kindergarten self-regulation on the intercept factors of video game use and sleep duration were in the expected direction. These findings suggest that children who have higher levels of self-regulation in kindergarten are likely to spend less time playing video games and sleep longer on weekdays in 3rd grade. Similar beneficial effects of self-regulation on screen time and sleep were also reported in prior studies (Bub et al., 2016; Cliff et al., 2018; Radesky et al., 2014). Children with better self-regulatory capacities, as indexed by better inhibitory control and attentional focusing in the present study, can better resist temptations as well as focus on their goals or household rules related to screen time and sleep, thereby decreasing the likelihood of engaging in undesired lifestyle behaviors such as video game use and delayed bedtime. As the importance of self-regulation in the development of healthy lifestyle behaviors has been increasingly recognized, early self-regulation may be considered as a potential target of interventions to promote health lifestyles (Baker et al., 2019).

In contrast to previous research that has suggested a positive association between self-regulation and physical activity (Piché et al., 2012, 2015; Riggs et al., 2010), kindergarten self-regulation was not predictive of the MVPA intercept factor. These discrepant findings may be because measures of self-regulation and physical activity were different between this study and prior studies. For example, Piché et al. (2012, 2015) utilized classroom engagement and dysregulation (e.g., emotional distress, impulsivity) as measures of self-regulation and assessed only the participation of structured physical activity (e.g., with a trainer) or team sports. The self-regulation measure of Riggs et al.'s (2010) study was the average of working memory, inhibitory control, emotional control, and organization materials, and it was linked with physical activity during non-structured time (e.g., evenings and weekends) but not during structured time (i.e., physical education class and lunch). Different components of self-regulation may serve different functions in affecting subsequent physical activity (Hall & Fong, 2015), such that a combination of these components, rather than a single or a few indexes, impacts later physical activity. The type of physical activity is also important to consider as self-regulatory capacities may be less influential to some types of physical activity (Riggs et al., 2010). Another explanation for the lack of prediction from early self-regulation to later MVPA in the full sample is that this effect may be moderated by other variables like child gender, as the positive prediction was present in male children but not female children.

With respect to the predictions of the slope factors, kindergarten self-regulation predicted only the sleep duration slope factor and it was in an unexpected direction. As mentioned earlier in Study 1, the variance of the sleep duration slope factor was marginally significant, suggesting that children were likely homogeneous in declines of sleep duration from 3rd to 5th grades. Additionally, the effect of self-regulation on the sleep duration slope factor was very small in magnitude. Therefore, the unexpected prediction, though statistically significant, may be of very limited clinical significance.

The lack of effects from early self-regulation to the changes of MVPA and video game use from 3rd through 5th grades suggests that differences in these age-related changes may be explained by other factors rather than individual differences in self-regulation. For example, the onset of puberty during the transition from middle childhood to adolescence and various factors related to puberty (e.g., tiredness and mental health problems) may drive changes in physical activity and screen time and explain differences in these changes (Hochberg, 2008; Mendle, 2014; Sherar et al., 2010; Viner, 2015; Walvoord, 2010). In addition, prior research has suggested that factors across multiple social contexts, including the family, school, and peer contexts, may influence the development of lifestyle behaviors in children (Mollborn & Lawrence, 2018). Given the importance of lifestyle behaviors in later development, more research is needed to investigate how biological, psychosocial, and contextual factors contribute uniquely and collectively to the development of lifestyle behaviors during childhood.

Predicting Trajectories from Self-Regulation Across Subsamples

The predictions of the video game use and sleep duration intercept factors from kindergarten self-regulation, which were observed in the full sample, were replicated in most subsamples. Across subsamples of SES, gender, and race/ethnicity, children who had higher levels of kindergarten self-regulation were likely to spend less time playing video games in 3rd grade, except for the subsample of non-Hispanic Asian children. Likewise, in all subsamples but children from high SES families (i.e., not-poor families or parents with a bachelor's degree or above), non-Hispanic Black children, and non-Hispanic Asian children, those with higher levels of kindergarten self-regulation tended to have more MVPA in 3rd grade. The effect of kindergarten self-regulation on the changes in sleep duration was observed in only two subsamples: Children whose parents did not obtain a bachelor's degree and non-Hispanic White children. Furthermore, three new predictions, which were not observed in the full sample, emerged in three subsamples. Specifically, higher levels of kindergarten self-regulation were related to more 3rd grade MVPA in male children, smaller increases in video game use among children from not-poor families, but steeper increases in video game use among children whose parents did not obtain a bachelor's degree. All of these significant effects were small in magnitude, but there are three patterns of results across subsamples that are worth noting.

The first pattern appears in subsamples by family SES. It seems that self-regulation is more important in predicting sleep duration among children from low than high SES families, given that kindergarten self-regulation predicted 3rd grade sleep duration in children from low but not high SES families. Low family SES is associated with numerous risk factors, such as low quality home environments, high levels of family chaos, and more pre-sleep worries, that are detrimental to children's sleep quality and quantity (Bagley et al., 2015; Doane et al., 2019; Philbrook et al., 2020). Children with better self-regulatory capacities may better cope with various environmental and psychological risk factors related to low SES, thereby having a higher quality of sleep and longer sleep duration.

The second pattern is observed in subsamples by gender and indicates that self-regulation may be more important for boys than girls in predicting later MVPA, given the findings that kindergarten self-regulation predicted 3rd grade MVPA in male but not female children. Most prior studies focused on the effect of physical activity on the development of self-regulation (Piché et al., 2015). This study adds to the literature that early self-regulation also predicts later MVPA in male children. It is unclear why this prediction is present only in male children. Perhaps other variables rather than self-regulation better explain individual differences in physical activity participation in girls. For instance, girls generally are less encouraged to be physically active and perceive more barriers but less support and fewer opportunities to engage in physical activity (Cowley et al., 2021; Lazarowicz et al., 2021). Self-regulatory capacities may not be helpful for girls to overcome these difficulties. More research is needed to better understand the association between self-regulation and physical activity by testing whether they are transactionally related over time (Piché et al., 2015) and whether there are moderators.

The third pattern occurs in racial/ethnic subsamples and is based on the finding that kindergarten self-regulation did not predict 3rd grade MVPA, video game use, or sleep duration or changes in these lifestyle behaviors from 3rd through 5th grades in non-Hispanic Asian children. Given this, self-regulation seems to be less important for non-Hispanic Asian children in predicting lifestyle behaviors compared to children of other racial/ethnic groups. However, there were only one or two significant predictions in some other racial/ethnic groups such as non-Hispanic Black children. In addition, all significant effects across race/ethnicity were relatively small in magnitude. Future research designed to replicate findings in the present study and to understand mechanisms explaining these potentially different associations across racial/ethnic groups is needed.

To summarize, with a few exceptions, findings across subsamples generally replicated those in the full sample. There were, however, slightly different patterns of findings across subsamples. These different patterns collectively indicate that early self-regulation may be more or less important in shaping later lifestyle behaviors for some populations. Therefore, the present study provides some evidence for health lifestyle theory (Cockerham, 2005, 2013), suggesting that individual agency may interact with social contexts to jointly shape lifestyle behaviors.

Associated Outcomes of Trajectories of Lifestyle Behaviors

The hypotheses that more optimal trajectories of MVPA, video game use, and sleep duration were associated with better developmental outcomes were partially supported. Specifically, children who had longer initial levels (i.e., 3^{rd} grade) of sleep duration were likely to have fewer externalizing problems, lower BMI, and higher academic achievement in 5^{th} grade, after controlling for the stability of these variables and trajectories of MVPA and video game use. Moreover, children who had higher initial levels of MVPA or smaller declines in MVPA in 3^{rd} through 5^{th} grades also tended to have lower BMI in 5^{th} grade, after controlling for kindergarten BMI and trajectories of video game use and sleep duration. These findings were in line with the larger body of literature on healthy lifestyle behaviors (Buckhalt et al., 2009; Farooq et al., 2021; Kelly & El-Sheikh, 2014; Seegers et al., 2011). Extending prior work, trajectories of MVPA, video game use, and sleep duration were simultaneously included in the model to predict outcome variables. As such, the confounding effects of the initial levels of and changes in the other two lifestyle behaviors were adjusted when evaluating the effects of one lifestyle behavior on outcome variables.

The effects of 3rd grade sleep duration on later externalizing problems, BMI, and academic achievement were consistent with prior cross-sectional and longitudinal studies suggesting that insufficient sleep is associated with physical and mental health problems and poor school performance (Buckhalt et al., 2009; Cappuccio et al., 2011; Kelly & El-Sheikh, 2014). Various variables may explain the associations between short sleep duration and negative developmental outcomes. For example, increased levels of daytime sleepiness, attention problems, irritability, emotional instability, and aggression, which are associated with insufficient nighttime sleep, may contribute to more externalizing problems and lower academic performance (Kamphuis et al., 2012; Paavonen et al., 2009; Perez-Lloret et al., 2013). Additionally, insufficient sleep is associated with increased energy and fat intake which would further be related to higher BMI and obesity (St-Onge et al., 2011).

Physical activity seems to be particularly important for BMI, given that both initial levels of and changes in MVPA were associated with later BMI in the full sample. These findings are not surprising, as energy expenditure induced by physical activity can directly affect body composition and weight (Westerterp, 2013). This study offers new insight into the association between physical activity and BMI by suggesting that children who show steeper declines in MVPA over time are likely to have higher BMI. Given the fact that levels of physical activity begin to decline early in life (Farooq et al., 2018), interventions aiming to promote physical activity in childhood as well as maintain persistent physical activity participation over time may be particularly beneficial in preventing obesity.

Except for these aforementioned effects, all other effects of the intercept or slope factors on outcome variables were non-significant in the full sample. This may be due to the controls of the stability of outcome variables as well as trajectories of other lifestyle behaviors. Alternatively, the variance of the sleep duration slope factor was marginally significant, and this relatively small variance may limit the ability to detect associations between this slope factor and subsequent outcomes.

Associated Outcomes of Trajectories Across Subsamples

In addition to the controls for confounding effects from other lifestyle behaviors, the present study also advances the literature by systematically investigating the associations between lifestyle behaviors trajectories and outcome variables across social contexts of SES, gender, and race/ethnicity. Initial levels of sleep duration seemed to be the most important factor predicting 5th grade outcome variables across subsamples of SES, gender, and race/ethnicity, with 15 out of 19 significant predictions across subsamples from the sleep duration intercept factor. This finding suggests that longer sleep duration in 3rd grade is beneficial to 5th grade mental health, physical health, and/or academic achievement among most subgroups of children.

In particular, longer sleep duration in 3rd grade was related to more optimal 5th outcomes, including higher academic achievement among children from not-poor families, but not among those from poor families. However, results across subsamples by parental highest education showed that longer 3rd grade sleep duration predicted higher 5th grade academic achievement only in children whose parents did not obtain a bachelor's degree. The latter result echoes the finding of a prior study suggesting that father education moderated the association between sleep duration and later academic achievement, such that longer sleep duration was related to higher academic achievement only among children with less educated fathers (Buckhalt et al., 2009). While the two indexes of family SES—family poverty status and parental highest education—are highly correlated, each may capture some unique aspects of family SES which may account for the inconsistent findings. Given that these effects were small in magnitude, more studies are needed to replicate these findings and to investigate the underlying mechanisms.

The beneficial effects of 3rd grade sleep duration on 5th grade outcome variables were observed in female but not male children. As girls are likely starting puberty at earlier ages than boys and puberty is associated with increased risk of physical and mental health problems (Hochberg, 2008; Mendle, 2014; Walvoord, 2010), longer sleep duration may be an important protective factor for girls' physical and mental health during the transitioning from middle childhood to adolescence.

Across racial/ethnic subsamples, the beneficial effects of 3rd grade sleep duration on 5th grade outcome variables primarily appeared in non-Hispanic White children, suggesting that longer sleep duration may be more important for non-Hispanic White children than children of racial/ethnic minority groups. There were two new predictions in children of racial/ethnic minority groups: The MVPA intercept factor positively predicted 5th grade externalizing problems in non-Hispanic Black children and the video game use intercept factor positively predicted 5th grade academic achievement in Hispanic children. These different patterns of results should be interpreted in light of the racial/ethnic differences in biological, cultural, social, and environmental factors as well as their complex combinations.

Limitations and Future Directions

Using a prospective cohort of US children, the present study sheds light on early predictors and associated outcomes of trajectories of MVPA, video game use, and sleep duration from 3rd through 5th grades. Strengths of this study include the large, nationally representative sample, the longitudinal design, the control of other lifestyle behaviors in predicting outcome variables, and the systematic investigation of associations across social contexts. Some limitations are worth noting.

First, the associations of lifestyle behaviors with predictors and outcomes may not be unidirectional. Healthy lifestyle behaviors, such as higher physical activity, lower screen time, and longer sleep duration in early childhood may have influences on brain development, which in turn may affect the development of self-regulation. Higher self-regulatory capacities may further help children initiate and maintain healthy lifestyle behaviors. Such transactional associations have been suggested in prior studies (Cliff et al., 2018; Piché et al., 2015). In addition, research also suggests that there may be transactional associations between lifestyle behaviors and children's adjustment (Kelly & El-Sheikh, 2014; Neville et al., 2021). These potentially transactional associations should be considered in future research.

Second, the measure of self-regulation included inhibitory control and attentional focus, other components of self-regulation such as emotion regulation are not considered in the present study. Varied components of self-regulation may be differentially associated with the development of lifestyle behaviors (Hall & Fong, 2015). More research is needed to investigate how different self-regulation components are related to subsequent lifestyle behaviors across developmental periods.

Third, the measure of physical activity was too broad, which did not distinguish between different types of physical activity or assess the exact amount of time spent engaging in physical activity. Different forms of physical activity such as structured and non-structured physical activity, may require different levels of self-regulatory capacities to participate in and maintain participation. Different forms of physical activity (e.g., solo versus team) may be associated with varied benefits to developmental outcomes. Additionally, the amount of time spent engaging in physical activity may also matter for later outcomes. Future studies should develop better and more comprehensive specifications of physical activity to advance understanding of early precursors and later developmental outcomes associated with physical activity.

Fourth, lifestyle behaviors of MVPA, video game use, and sleep duration were reported by parents. Prior studies reported strong correlations between parent-reported and device-based measures of sleep duration but only moderate correlations between parent-reported and device-based measures of physical activity (Li, Sheehan, Valiente, et al., 2021; Sarker et al., 2015). Additionally, the biases in parent-reports may be different across populations. For instance, a study of Swedish children aged 4 showed that parents reported that boys were more physically active and sedentary than girls, while accelerometer data revealed that boys are more active and less sedentary than girls (Berglind & Tynelius, 2017). Given these important limitations related to parent-reports, future studies should use more objective measures to provide more accurate assessments of children's lifestyle behaviors.

Finally, the intersectionality of multiple social contexts was not considered in this study. The intersection of several disadvantaged identities may place certain groups of children at greater risk for developing adverse outcomes, including unhealthy lifestyle behaviors (Buckhalt et al., 2009; El-Sheikh et al., 2010). Future studies can investigate how intersecting social contexts affect the development of lifestyle behaviors.

Conclusion

To conclude, this study provides clear evidence that early self-regulation is related to later healthy lifestyle behaviors, and the importance of early self-regulation in shaping later lifestyle behaviors may vary across social contexts of SES, gender, and race/ethnicity. These findings support health lifestyle theory (Cockerham, 2005, 2013) and highlight the need for further study of the interactions between early self-regulation and social contexts on the development of healthy lifestyle behaviors. Additionally, the present study contributes to a better understanding of the associations of MVPA, video game use, and sleep duration with later developmental outcomes. Earlier sleep duration seemed to be more important than the other two lifestyle behaviors in predicting later physical and mental health and academic achievement across social contexts, after controlling for the stability of the outcome variables and the effects of the other two lifestyle behaviors. Together, promoting self-regulatory capacities early in the life course may be particularly beneficial as it may be related to subsequent lifestyle behaviors, which may further have implications for later physical and mental health and academic achievement.

CHAPTER 4

GENERAL DISCUSSION

The main goals of this dissertation were to examine the developmental associations among physical activity, sedentary behavior, and sleep duration, the trajectories of the three lifestyle behaviors, and early predictors and associated outcomes of these trajectories in US children during the transition from middle childhood to adolescence. Based on the 24-hour activity cycle model (Pedišić et al., 2017; Rosenberger et al., 2019; Tremblay, 2020; Tremblay et al., 2016) and health lifestyle theory (Cockerham, 2005, 2013), I proposed a theoretical framework (see Figure 1) motivating two studies in my dissertation.

Study 1 was designed to examine a central part of the theoretical framework, concerning the developmental associations among physical activity, sedentary behavior, and sleep duration. A large longitudinal sample of US children from the ECLS-K:2011 was analyzed. Children's physical activity, sedentary behavior, and sleep duration from 3^{rd} to 5^{th} grades were reported each year by parents. Physical activity was measured as MVPA. Sedentary behavior was focused on video game use as a measure of active screen time (Hallgren et al., 2020; Kikuchi et al., 2014; Sweetser et al., 2012). As found in Study 1, although MVPA, video game use, and sleep duration were correlated within and across grades at the between-person level, the three lifestyle behaviors were not transactionally related over time at the within-person level. Another approach to unpack the developmental associations among the three lifestyle behaviors showed that the changes (i.e., declines in MVPA and sleep duration and increase in video game use) in these lifestyle behaviors over time were not correlated either. These main findings in the full sample were replicated in subsamples across social contexts of SES, gender, and race/ethnicity.

Study 2 focused on investigating predictors and associated outcomes of the development of physical activity, sedentary behavior, and sleep duration. Study 2 used the same sample and measures of lifestyle behaviors as Study 1. Kindergarten self-regulation was examined as an early predictor of trajectories of the MVPA, video game use, and sleep duration, given the importance of early self-regulatory capacities (Robson et al., 2020) and that children have increased control over their lifestyles with age (Mollborn & Lawrence, 2018). Fifth grade externalizing and internalizing problems, BMI, and academic achievement were tested as mental health, physical health, and academic outcomes, respectively. As found in Study 2, higher levels of kindergarten self-regulation predicted lower initial levels of video game use and higher initial levels but steeper declines in sleep duration. Higher initial levels of sleep duration predicted fewer externalizing problems, lower BMI, and higher academic achievement, after controlling for the stability of outcome variables and other lifestyle behaviors. Additionally, lower BMI was also predicted by higher initial levels and smaller declines in MVPA. Some of these findings in the full sample were replicated across social contexts.

Taken together, the two studies in my dissertation contribute to a better understanding of the development of three important lifestyle behaviors in US children transitioning from middle childhood to adolescence. Below I discuss five major findings across studies.

First, as an answer to the first research question (RQ1) outlined in Chapter 1, the three measures of lifestyle behaviors were not transactionally related over time. The lack of transactional associations was unexpected and contrasts with findings of previous studies (Magee et al., 2014; Mazzer et al., 2018; Straatmann et al., 2019). Despite differences in samples and measures between this and prior work, a possible reason is that the analytical strategy (i.e., RI-CLPM) employed in this work overcomes some limitations of the analytic strategy (i.e., CLPM) in past work (Curran & Bauer, 2011; Dietvorst et al., 2018; Hamaker et al., 2015). As such, the significant transactional associations in past work may be driven primarily by stable between-person differences rather than within-person processes. These findings highlight the need to re-evaluate the longitudinal associations among lifestyle behaviors by disaggregating within-person and between-person effects.

Second, declines in MVPA and sleep duration and increases in video game use were observed from 3rd through 5th grades. These changes, however, were not correlated. This answers the second research question (RQ2). This finding suggests that the three lifestyle behaviors may develop in an isolated but not collective way over time, at least at the between-person level. Examining whether age-related changes in lifestyle behaviors are correlated is a unique approach to shed light on the complex developmental associations among lifestyle behaviors and their co-development. In the present dissertation, lifestyle behaviors were assessed at three time points spanning three years during the transition from middle childhood to adolescence. Future research may benefit by including more time points spanning a longer period in order to better understand whether and how various lifestyle behaviors co-develop over time.

Third, to answer the fourth research question (RQ4), kindergarten self-regulation was predictive of initial levels of video game use as well as initial levels and declines in sleep duration. However, self-regulation did not predict initial levels of MVPA and changes in MVPA and video game use. Thus, early self-regulation may be relevant to some lifestyle behaviors. It is worth noting that the effects of self-regulation on subsequent lifestyle behaviors were small in magnitude. Additionally, children were likely homogeneous regarding their declines in sleep duration over time, as variance of the sleep duration slope factor was marginally significant. However, these effects may be still worth consideration and further investigation because the negative consequences of low self-regulatory capacities on lifestyle behaviors may accumulate over time. In addition to considering the long-term effects of early self-regulation on lifestyle behaviors and their changes over time, future studies may consider evaluating the potential transactional associations between self-regulation and lifestyle behaviors (Cliff et al., 2018; Piché et al., 2015), particularly during childhood in which self-regulatory capacities undergo rapid changes.

Fourth, as an answer to the fifth research question (RQ5), initial levels of the sleep duration trajectories predicted subsequent externalizing problems, BMI, and academic achievement, after controlling for the stability of outcome variables and other lifestyle behaviors. Additionally, BMI was also predicted by initial levels of and changes in MVPA, controlling for its stability and other lifestyle behaviors. Longer or sufficient sleep duration is very important for children's mental health, physical health, and academic achievement. Insufficient sleep has been linked with various risk factors, including daytime sleepiness, more energy and fat intake, attention problems, emotional instability, and aggression (Kamphuis et al., 2012; Paavonen et al., 2009; Perez-Lloret et al., 2013; St-Onge et al., 2011), which may collectively contribute to negative mental, physical, and academic outcomes.

Finally, although most of the aforementioned findings were generally replicated across social contexts of SES, gender, and race/ethnicity, there were exceptions. Specifically, some associations observed in the full sample were present in some subsamples but were absent in other subsamples. Several new predictions that did not appear in the full sample emerged in some subsamples. These slightly different patterns of findings across subsamples in both studies provide some answers to the third and sixth research questions (RQ3 & RQ6) and indicate that social contexts may play a role in the development of lifestyle behaviors and how lifestyle behaviors are related to early predictors and later outcomes. The two studies provided some evidence for health lifestyle theory (Cockerham, 2005, 2013), highlighting the need to consider specific social contexts in the research of lifestyle behaviors. Future research should benefit by considering the intersectionality of multiple social contexts. For example, children with intersecting disadvantaged identities (e.g., low SES and racial/ethnic minorities) may be at increased risk for adverse outcomes, including unhealthy lifestyle behaviors (Buckhalt et al., 2009; El-Sheikh et al., 2010).

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APPENDIX A

TABLES

Table 1.1

Comparisons Between Participants With and Without Missing Data

	No Missing Data on Variables (N = 7,609)		Missing on One Variable or More (N = 3,639)			
	Weighted M/%	Weighted SD	Weighted M/%	Weighted SD	t / χ^2	p
G3 Household Poverty Status					520.92	< .001
Poor	19.0%	-	33.5%	-		
Near-poor	20.8%	-	26.1%	-		
Not-poor	60.2%	-	40.4%	-		
G3 Parental Highest Education					434.90	< .001
Less than bachelor's degree	53.1%	-	72.0%	-		
Bachelor's degree or above	47.0%	-	28.0%	-		
Child Gender					0.08	.814
Female	48.4%	-	48.2%	-		
Male	51.6%	-	51.8%	-		
Child Race/Ethnicity					540.68	< .001
Non-Hispanic White	58.7%	-	40.5%	-		
Non-Hispanic Black	8.4%	-	16.2%	-		
Hispanic	23.4%	-	33.1%	-		
Non-Hispanic Asian	4.2%	-	4.9%	-		
Non-Hispanic Other	5.3%	-	5.3%	-		
G3 MVPA (days/week)	4.47	2.10	4.28	2.33	2.97	.003
G4 MVPA (days/week)	4.31	2.12	3.96	2.40	5.65	< .001
G5 MVPA (days/week)	4.30	2.13	3.77	2.42	5.65	< .001
G3 Video Game Use (hours/day)	0.70	0.69	0.77	0.82	3.86	< .001
G4 Video Game Use (hours/day)	0.89	0.81	0.93	0.90	1.74	.083
G5 Video Game Use (hours/day)	1.01	0.92	1.09	1.03	2.50	.013
G3 Sleep Duration (hours/day)	9.19	0.96	9.01	1.05	5.53	< .001
G4 Sleep Duration (hours/day)	9.04	0.92	8.85	0.98	7.51	< .001
G5 Sleep Duration (hours/day)	8.93	0.92	8.74	1.06	5.06	< .001

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.2
Descriptive Statistics of Study Variables in the Full Sample

	Unweighted						Weighted	
	Valid *N*	*M*/%	*SD*	Range	Skewness	Kurtosis	*M*/%	*SD*
G3 Household Poverty Status								
Poor	2,311	22.2%					22.8%	
Near-poor	2,330	22.4%					22.2%	
Not-poor	5,775	55.4%					55.0%	
G3 Parental Highest Education								
Less than bachelor's degree	5,896	56.6%					58.0%	
Bachelor's degree or above	4,520	43.4%					42.0%	
Child Gender								
Female	5,485	48.8%					48.3%	
Male	5,763	51.2%					51.7%	
Child Race/Ethnicity								
Non-Hispanic White	5,633	50.1%					52.9%	
Non-Hispanic Black	1,151	10.2%					10.9%	
Hispanic	2,934	26.1%					26.5%	
Non-Hispanic Asian	885	7.9%					4.4%	
Non-Hispanic Other	645	5.7%					5.3%	
G3 MVPA (days/week)	9,947	4.40	2.18	0 - 7	-0.42	-0.78	4.43	2.16
G4 MVPA (days/week)	9,588	4.20	2.21	0 - 7	-0.31	-0.88	4.24	2.18
G5 MVPA (days/week)	8,913	4.18	2.20	0 - 7	-0.32	-0.87	4.23	2.18
G3 Video Game Use (hours/day)	10,009	0.71	0.72	0 - 4	1.78	4.45	0.72	0.72
G4 Video Game Use (hours/day)	9,649	0.89	0.83	0 - 4	1.43	2.38	0.90	0.83
G5 Video Game Use (hours/day)	8,959	1.02	0.95	0 - 5	1.61	3.57	1.02	0.94
G3 Sleep Duration (hours/day)	10,188	9.15	0.98	0 - 14	-0.24	2.02	9.15	0.99
G4 Sleep Duration (hours/day)	9,824	9.00	0.94	2 - 13	-0.07	0.56	9.00	0.94
G5 Sleep Duration (hours/day)	9,151	8.90	0.95	0 - 13	-0.55	4.70	8.90	0.95

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.3
Descriptive Statistics of Study Variables in Children From Poor, Near-Poor, and Not-Poor Families

	Poor Families[a] (*N* = 2,311)	Near-Poor Families[b] (*N* = 2,330)	Not-Poor Families[c] (*N* = 5,775)	Pairwise Comparisons
	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	
Moderate-to-Vigorous Physical Activity				
G3	4.00 (2.51)	4.33 (2.24)	4.64 (1.93)	c > b > a
G4	3.81 (2.44)	4.12 (2.28)	4.47 (1.97)	c > b > a
G5	3.75 (2.51)	4.09 (2.21)	4.49 (1.96)	c > b > a
Video Game Use				
G3	0.83 (0.85)	0.78 (0.77)	0.65 (0.63)	a, b > c
G4	0.99 (0.89)	0.97 (0.87)	0.84 (0.77)	a, b > c
G5	1.12 (1.01)	1.10 (0.98)	0.95 (0.87)	a, b > c
Sleep Duration				
G3	8.83 (1.04)	9.05 (0.99)	9.32 (0.92)	c > b > a
G4	8.76 (0.99)	8.90 (0.97)	9.16 (0.87)	c > b > a
G5	8.69 (1.08)	8.84 (0.94)	9.02 (0.87)	c > b > a

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Bonferroni corrections were used for pairwise comparisons. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.4

Descriptive Statistics of Study Variables in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

	Below Bachelor's Degree (N = 5,896)	Bachelor's Degree or Above (N = 4,520)	t	p
	Weighted M (SD)	Weighted M (SD)		
Moderate-to-Vigorous Physical Activity				
G3	4.26 (2.31)	4.65 (1.91)	6.65	<. 001
G4	4.09 (2.29)	4.46 (1.97)	6.00	<. 001
G5	4.06 (2.28)	4.50 (1.96)	7.14	<. 001
Video Game Use				
G3	0.79 (0.77)	0.63 (0.63)	10.67	<. 001
G4	0.97 (0.86)	0.81 (0.76)	9.38	<. 001
G5	1.10 (0.96)	0.91 (0.87)	7.85	<. 001
Sleep Duration				
G3	9.00 (1.01)	9.36 (0.90)	15.01	<. 001
G4	8.88 (0.96)	9.19 (0.86)	11.77	<. 001
G5	8.81 (0.98)	9.04 (0.88)	8.48	<. 001

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.5

Descriptive Statistics of Study Variables in Female and Male Children

	Female (N = 5,485)	Male (N = 5,763)	t	p
	Weighted M (SD)	Weighted M (SD)		
Moderate-to-Vigorous Physical Activity				
G3	4.21 (2.14)	4.63 (2.16)	7.22	< .001
G4	4.00 (2.16)	4.47 (2.18)	9.30	< .001
G5	4.01 (2.13)	4.43 (2.21)	7.30	< .001
Video Game Use				
G3	0.58 (0.62)	0.85 (0.78)	16.45	< .001
G4	0.75 (0.76)	1.04 (0.86)	14.22	< .001
G5	0.87 (0.87)	1.17 (0.97)	13.16	< .001
Sleep Duration				
G3	9.16 (0.99)	9.14 (0.98)	1.05	.296
G4	9.01 (0.93)	8.99 (0.94)	0.84	.404
G5	8.88 (0.93)	8.92 (0.96)	1.72	.087

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.6
Descriptive Statistics of Study Variables in Non-Hispanic White, Non-Hispanic Black, Hispanic, Non-Hispanic Asian, and Non-Hispanic Other Children

	Non-Hispanic White[a] (*N* = 5,633)	Non-Hispanic Black[b] (*N* = 1,151)	Hispanic[c] (*N* = 2,934)	Non-Hispanic Asian[d] (*N* = 885)	Non-Hispanic Other[e] (*N* = 645)	Pairwise Comparisons
	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	
Moderate-to-Vigorous Physical Activity						
G3	4.74 (1.87)	4.05 (2.32)	4.01 (2.36)	3.47 (3.20)	4.65 (2.22)	a > b, c > d; e > b, c, d
G4	4.57 (1.92)	3.94 (2.33)	3.74 (2.32)	3.29 (3.24)	4.59 (2.27)	a > b, c > d; e > b, c, d
G5	4.56 (1.90)	3.85 (2.32)	3.74 (2.35)	3.27 (3.15)	4.47 (2.26)	a > b, c > d; e > b, c, d
Video Game Use						
G3	0.70 (0.63)	0.83 (0.92)	0.74 (0.75)	0.58 (0.94)	0.79 (0.77)	a, b, c, e > d; b > a
G4	0.88 (0.75)	0.94 (0.94)	0.93 (0.86)	0.89 (1.25)	0.93 (0.89)	na
G5	0.98 (0.83)	1.08 (1.07)	1.10 (0.99)	0.87 (1.31)	1.09 (1.09)	b, c, e > d; c > a
Sleep Duration						
G3	9.30 (0.92)	8.71 (0.99)	9.00 (1.00)	9.14 (1.14)	9.15 (1.00)	a > c, d > b; e > b
G4	9.13 (0.87)	8.58 (0.97)	8.89 (0.94)	9.03 (1.15)	9.00 (0.93)	a > c > b; d, e > b
G5	9.00 (0.86)	8.53 (1.19)	8.83 (0.92)	8.91 (1.26)	8.90 (0.98)	a > c > b; d, e > b

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Bonferroni corrections were used for pairwise comparisons. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.7

Weighted Correlations Among Study Variables in the Full Sample

	1	2	3	4	5	6	7	8
1. G3 MVPA	-							
2. G4 MVPA	.46	-						
3. G5 MVPA	.46	.50	-					
4. G3 Video Game Use	-.04	-.03[a]	-.05[b]	-				
5. G4 Video Game Use	-.05	-.03[a]	-.05	.41	-			
6. G5 Video Game Use	-.07	-.06	-.08	.35	.43	-		
7. G3 Sleep Duration	.09	.08	.08	-.12	-.11	-.13	-	
8. G4 Sleep Duration	.08	.07	.08	-.11	-.11	-.12	.53	-
9. G5 Sleep Duration	.07	.06	.07	-.11	-.10	-.11	.48	.51

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum. All correlations were significant at $p < .001$, except that [a] was significant at $p < .05$ and [b] was significant at $p < .01$.

Table 1.8

Weighted Correlations Among Study Variables in Children From Poor, Near-Poor, and Not-Poor Families

	1	2	3	4	5	6	7	8
Children from Poor Families								
1. G3 MVPA	-							
2. G4 MVPA	.40***	-						
3. G5 MVPA	.37***	.40***	-					
4. G3 Video Game Use	-.02	-.01	-.02	-				
5. G4 Video Game Use	-.03	-.03	-.05	.43***	-			
6. G5 Video Game Use	-.01	-.01	-.04	.33***	.42***	-		
7. G3 Sleep Duration	.08**	.04	.04	-.09***	-.12***	-.10***	-	
8. G4 Sleep Duration	.04	.01	.02	-.06	-.11***	-.10***	.43***	-
9. G5 Sleep Duration	.03	.04	.01	-.10*	-.11**	-.15***	.40***	.46***
Children from Near-Poor Families								
1. G3 MVPA	-							
2. G4 MVPA	.43***	-						
3. G5 MVPA	.43***	.49***	-					
4. G3 Video Game Use	-.05	-.03	-.04	-				
5. G4 Video Game Use	-.02	-.02	-.06*	.38***	-			
6. G5 Video Game Use	-.04	-.04	-.09**	.27***	.40***	-		
7. G3 Sleep Duration	.10***	.07*	.07**	-.12***	-.08**	-.09***	-	
8. G4 Sleep Duration	.10***	.08**	.08**	-.11***	-.12***	-.10***	.50***	-
9. G5 Sleep Duration	.07*	.05*	.07*	-.07*	-.07*	-.09**	.49***	.51***
Children from Not-Poor Families								
1. G3 MVPA	-							
2. G4 MVPA	.49***	-						
3. G5 MVPA	.50***	.53***	-					
4. G3 Video Game Use	-.03	-.01	-.04*	-				
5. G4 Video Game Use	-.05**	-.03	-.03	.39***	-			
6. G5 Video Game Use	-.09***	-.07***	-.07***	.38***	.43***	-		
7. G3 Sleep Duration	.05**	.06**	.05**	-.10***	-.09***	-.12***	-	
8. G4 Sleep Duration	.06**	.05**	.06***	-.11***	-.08***	-.11***	.55***	-
9. G5 Sleep Duration	.06***	.05**	.06***	-.10***	-.09***	-.09***	.49***	.52***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.9

Weighted Correlations Among Study Variables in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

	1	2	3	4	5	6	7	8
Children with Parental Highest Education Lower Than Bachelor's Degree								
1. G3 MVPA	-							
2. G4 MVPA	.43***	-						
3. G5 MVPA	.42***	.46***	-					
4. G3 Video Game Use	-.04**	-.03	-.04*	-				
5. G4 Video Game Use	-.03*	-.02	-.05**	.40***	-			
6. G5 Video Game Use	-.05**	-.04*	-.07***	.31***	.41***	-		
7. G3 Sleep Duration	.08***	.05**	.05***	-.10***	-.09***	-.10***	-	
8. G4 Sleep Duration	.06**	.04*	.05**	-.07***	-.10***	-.08***	.48***	-
9. G5 Sleep Duration	.04*	.05**	.05**	-.08***	-.08***	-.11***	.45***	.49***
Children with Parental Highest Education of Bachelor's Degree or Above								
1. G3 MVPA	-							
2. G4 MVPA	.50***	-						
3. G5 MVPA	.50***	.54***	-					
4. G3 Video Game Use	-.02	-.01	-.03	-				
5. G4 Video Game Use	-.05**	-.04*	-.03	.39***	-			
6. G5 Video Game Use	-.08***	-.07***	-.06**	.38***	.43***	-		
7. G3 Sleep Duration	.08***	.09***	.08***	-.11***	-.10***	-.13***	-	
8. G4 Sleep Duration	.09***	.09***	.09***	-.14***	-.10***	-.15***	.56***	-
9. G5 Sleep Duration	.09***	.06***	.07***	-.12***	-.10***	-.10***	.50***	.53***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.10

Weighted Correlations Among Study Variables in Female and Male Children

	1	2	3	4	5	6	7	8
Female Children								
1. G3 MVPA	-							
2. G4 MVPA	.45***	-						
3. G5 MVPA	.45***	.48***	-					
4. G3 Video Game Use	-.06***	-.04	-.04*	-				
5. G4 Video Game Use	-.04*	-.05**	-.05**	.35***	-			
6. G5 Video Game Use	-.08***	-.10***	-.08***	.29***	.35***	-		
7. G3 Sleep Duration	.10***	.09***	.08***	-.11***	-.10***	-.13***	-	
8. G4 Sleep Duration	.07***	.06**	.08***	-.08***	-.11***	-.12***	.52***	-
9. G5 Sleep Duration	.07***	.07***	.07***	-.09***	-.08***	-.10***	.46***	.50***
Male Children								
1. G3 MVPA	-							
2. G4 MVPA	.46***	-						
3. G5 MVPA	.46***	.50***	-					
4. G3 Video Game Use	-.06***	-.06***	-.09***	-				
5. G4 Video Game Use	-.08***	-.05**	-.09***	.41***	-			
6. G5 Video Game Use	-.10***	-.07***	-.12***	.35***	.45***	-		
7. G3 Sleep Duration	.09***	.07***	.08***	-.13***	-.12***	-.13***	-	
8. G4 Sleep Duration	.09***	.08***	.09***	-.14***	-.12***	-.13***	.54***	-
9. G5 Sleep Duration	.06**	.04*	.06**	-.12***	-.12***	-.13***	.51***	.52***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.11

Weighted Correlations Among Study Variables in Non-Hispanic White, Non-Hispanic Black, Hispanic, and Non-Hispanic Asian Children

	1	2	3	4	5	6	7	8
Non-Hispanic White Children								
1. G3 MVPA	-							
2. G4 MVPA	.48***	-						
3. G5 MVPA	.50***	.52***	-					
4. G3 Video Game Use	-.04**	-.02	-.05***	-				
5. G4 Video Game Use	-.06**	-.02	-.05**	.41***	-			
6. G5 Video Game Use	-.07***	-.07***	-.09***	.36***	.44***	-		
7. G3 Sleep Duration	.04**	.03	.05**	-.12***	-.11***	-.14***	-	
8. G4 Sleep Duration	.06***	.03	.07***	-.12***	-.12***	-.13***	.54***	-
9. G5 Sleep Duration	.05**	.04*	.05**	-.12***	-.11***	-.10***	.48***	.51***
Non-Hispanic Black Children								
1. G3 MVPA	-							
2. G4 MVPA	.38***	-						
3. G5 MVPA	.40***	.39***	-					
4. G3 Video Game Use	.02	-.05	.00	-				
5. G4 Video Game Use	-.11**	-.10**	-.13**	.37***	-			
6. G5 Video Game Use	-.09	-.11*	-.04	.33***	.49***	-		
7. G3 Sleep Duration	-.01	.05	.03	-.08*	-.10**	-.12**	-	
8. G4 Sleep Duration	-.01	.01	-.03	-.03	-.09*	-.13**	.49***	-
9. G5 Sleep Duration	-.04	.04	-.02	-.05	-.10*	-.15**	.42***	.44***
Hispanic Children								
1. G3 MVPA	-							
2. G4 MVPA	.40***	-						
3. G5 MVPA	.37***	.44***	-					
4. G3 Video Game Use	-.07**	-.03	-.06	-				
5. G4 Video Game Use	.00	.00	-.03	.41***	-			
6. G5 Video Game Use	-.04	-.03	-.07**	.31***	.41***	-		
7. G3 Sleep Duration	.12***	.07***	.03	-.10***	-.10***	-.09***	-	
8. G4 Sleep Duration	.09***	.06**	.06*	-.11***	-.10***	-.08***	.45***	-
9. G5 Sleep Duration	.08***	.03	.06**	-.08**	-.07**	-.08**	.45***	.49***
Non-Hispanic Asian Children								
1. G3 MVPA	-							
2. G4 MVPA	.47***	-						
3. G5 MVPA	.37***	.46***	-					
4. G3 Video Game Use	-.07	-.05	-.02	-				

5. G4 Video Game Use	.01	-.08	.04	.31***	-			
6. G5 Video Game Use	-.07	-.05	-.05	.26***	.27***	-		
7. G3 Sleep Duration	.14***	.04	.15***	-.06	-.03	-.08*	-	
8. G4 Sleep Duration	.13**	.10*	.21***	-.09	-.05	-.11**	.50***	-
9. G5 Sleep Duration	.19***	.11*	.11	-.07*	.03	-.02	.55***	.49***

Note. G3 = 3^{rd} grade, G4 = 4^{th} grade, G5 = 5^{th} grade, MVPA = moderate-to-vigorous physical activity. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.12
Model Fit Indices From the Random Intercept Cross-Lagged Panel Models in the Full Sample and Subsamples

	SB χ^2	*df*	*p*	RMSEA [90% CI]	CFI	TLI	SRMR
Full Sample	15.577	3	.001	0.019 [0.011 ,0.029]	0.999	0.984	0.008
Household Poverty Status							
Poor	0.157	3	.984	0.000 [0.000, 0.000]	1.000	1.024	0.002
Near-Poor	1.577	3	.665	0.000 [0.000, 0.027]	1.000	1.008	0.005
Not-Poor	19.977	3	<.001	0.031 [0.019, 0.045]	0.997	0.964	0.011
Parental Highest Education							
Lower Than Bachelor's Degree	4.042	3	.257	0.008 [0.000, 0.024]	1.000	0.997	0.005
Bachelor's Degree or Above	9.658	3	.022	0.022 [0.007, 0.038]	0.999	0.983	0.009
Gender							
Female	14.317	3	.003	0.026 [0.014, 0.041]	0.997	0.967	0.011
Male	4.366	3	.225	0.009 [0.000, 0.025]	1.000	0.997	0.006
Race/ethnicity							
Non-Hispanic White	8.256	3	.041	0.018 [0.003, 0.033]	0.999	0.988	0.008
Non-Hispanic Black	4.345	3	.227	0.020 [0.000, 0.057]	0.998	0.979	0.013
Hispanic	2.918	3	.405	0.000 [0.000, 0.031]	1.000	1.000	0.006
Non-Hispanic Asian	3.006	3	.391	0.002 [0.000, 0.057]	1.000	1.000	0.011

Note. SB χ^2 = Satorra-Bentler scaled χ^2, RMSEA = root mean square error of approximation, CFI = comparative fit index, TLI = Tucker-Lewis index, SRMR = standardized root mean square residual.

Table 1.13

Longitudinal Associations Among Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in the Full Sample

	Standardized Estimate	*SE*	*p*
Within-Person Effects			
Autoregressive Effects			
G3 MVPA → G4 MVPA	.01	.03	.698
G4 MVPA → G5 MVPA	.08	.02	<.001
G3 VGU → G4 VGU	.03	.04	.400
G4 VGU → G5 VGU	.18	.02	<.001
G3 SD → G4 SD	.08	.03	.004
G4 SD → G5 SD	.01	.03	.719
Cross-Lagged Effects			
G3 MVPA → G4 VGU	.02	.02	.265
G4 MVPA → G5 VGU	-.01	.02	.409
G3 VGU → G4 MVPA	.06	.02	.007
G4 VGU → G5 MVPA	-.00	.02	.924
G3 MVPA → G4 SD	.01	.02	.520
G4 MVPA → G5 SD	-.03	.03	.350
G3 SD → G4 MVPA	.00	.02	.879
G4 SD → G5 MVPA	.02	.02	.454
G3 VGU → G4 SD	.01	.03	.668
G4 VGU → G5 SD	.01	.02	.648
G3 SD → G4 VGU	.00	.02	.973
G4 SD → G5 VGU	-.02	.02	.241
Between-Person Associations			
Intercept_MVPA with Intercept_VGU	-.15	.03	<.001
Intercept_MVPA with Intercept_SD	.16	.02	<.001
Intercept_VGU with Intercept_SD	-.26	.03	<.001

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.14

Longitudinal Associations Among Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children From Poor, Near-Poor, and Not-Poor Families

	Children from Poor Families	Children from Near-Poor Families	Children from Not-Poor Families
	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)
Within-Person Effects			
Autoregressive Effects			
G3 MVPA → G4 MVPA	.04 (.06)	.04 (.06)	-.02 (.04)
G4 MVPA → G5 MVPA	.04 (.05)	.12 (.06)*	.09 (.03)**
G3 VGU → G4 VGU	.12 (.07)	.15 (.06)*	-.08 (.05)
G4 VGU → G5 VGU	.18 (.05)***	.23 (.04)***	.16 (.04)***
G3 SD → G4 SD	-.00 (.07)	.05 (.05)	.10 (.04)**
G4 SD → G5 SD	.08 (.07)	.02 (.07)	.00 (.04)
Cross-Lagged Effects			
G3 MVPA → G4 VGU	-.02 (.05)	.03 (.04)	.04 (.03)
G4 MVPA → G5 VGU	-.00 (.04)	-.01 (.04)	-.01 (.02)
G3 VGU → G4 MVPA	-.01 (.05)	.02 (.04)	.10 (.03)**
G4 VGU → G5 MVPA	-.06 (.05)	-.04 (.04)	.03 (.03)
G3 MVPA → G4 SD	.01 (.04)	.06 (.04)	-.01 (.04)
G4 MVPA → G5 SD	.02 (.05)	-.03 (.05)	-.02 (.03)
G3 SD → G4 MVPA	.01 (.04)	-.00 (.04)	.00 (.03)
G4 SD → G5 MVPA	-.02 (.04)	.01 (.04)	.02 (.03)
G3 VGU → G4 SD	.09 (.08)	-.05 (.05)	.02 (.03)
G4 VGU → G5 SD	-.01 (.04)	.01 (.05)	.01 (.03)
G3 SD → G4 VGU	-.03 (.05)	-.01 (.04)	.03 (.03)
G4 SD → G5 VGU	.00 (.03)	-.02 (.04)	-.01 (.03)
Between-Person Associations			
Intercept_MVPA with Intercept_VGU	-.03 (.06)	-.13 (.08)	-.14 (.03)***
Intercept_MVPA with Intercept_SD	.08 (.05)	.15 (.05)**	.11 (.03)***
Intercept_VGU with Intercept_SD	-.27 (.08)**	-.22 (.06)***	-.23 (.03)***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.15

Longitudinal Associations Among Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

	Lower Than Bachelor's Degree	Bachelor's Degree or Above
	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)
Within-Person Effects		
Autoregressive Effects		
G3 MVPA → G4 MVPA	.02 (.04)	.01 (.04)
G4 MVPA → G5 MVPA	.06 (.03)*	.12 (.04)**
G3 VGU → G4 VGU	.10 (.05)*	-.10 (.06)
G4 VGU → G5 VGU	.19 (.03)***	.16 (.04)***
G3 SD → G4 SD	.04 (.03)	.12 (.04)**
G4 SD → G5 SD	.03 (.04)	.02 (.04)
Cross-Lagged Effects		
G3 MVPA → G4 VGU	.02 (.03)	.02 (.04)
G4 MVPA → G5 VGU	-.01 (.02)	-.01 (.02)
G3 VGU → G4 MVPA	.03 (.03)	.08 (.04)*
G4 VGU → G5 MVPA	-.02 (.03)	.02 (.03)
G3 MVPA → G4 SD	.02 (.03)	.01 (.03)
G4 MVPA → G5 SD	-.00 (.04)	-.03 (.03)
G3 SD → G4 MVPA	.00 (.03)	.02 (.03)
G4 SD → G5 MVPA	.00 (.03)	.02 (.03)
G3 VGU → G4 SD	.04 (.04)	-.03 (.04)
G4 VGU → G5 SD	.00 (.03)	.01 (.04)
G3 SD → G4 VGU	-.00 (.03)	.02 (.03)
G4 SD → G5 VGU	.02 (.02)	-.07 (.03)*
Between-Person Associations		
Intercept_MVPA with Intercept_VGU	-.12 (.04)**	-.11 (.03)***
Intercept_MVPA with Intercept_SD	.11 (.03)***	.16 (.03)***
Intercept_VGU with Intercept_SD	-.23 (.05)***	-.25 (.03)***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.16

Longitudinal Associations Among Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Female and Male Children

	Female Children	Male Children
	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)
Within-Person Effects		
Autoregressive Effects		
G3 MVPA → G4 MVPA	.02 (.04)	-.00 (.04)
G4 MVPA → G5 MVPA	.07 (.04)	.09 (.03)**
G3 VGU → G4 VGU	.03 (.06)	.04 (.05)
G4 VGU → G5 VGU	.15 (.03)***	.20 (.04)***
G3 SD → G4 SD	.11 (.04)**	.04 (.04)
G4 SD → G5 SD	.02 (.04)	.00 (.04)
Cross-Lagged Effects		
G3 MVPA → G4 VGU	.02 (.03)	.03 (.03)
G4 MVPA → G5 VGU	-.06 (.02)**	.02 (.03)
G3 VGU → G4 MVPA	.04 (.03)	.07 (.03)*
G4 VGU → G5 MVPA	-.01 (.04)	.00 (.03)
G3 MVPA → G4 SD	-.01 (.03)	.05 (.03)
G4 MVPA → G5 SD	-.02 (.04)	-.05 (.04)
G3 SD → G4 MVPA	.02 (.03)	-.01 (.04)
G4 SD → G5 MVPA	-.00 (.03)	.04 (.03)
G3 VGU → G4 SD	.06 (.04)	-.01 (.04)
G4 VGU → G5 SD	.02 (.03)	-.01 (.03)
G3 SD → G4 VGU	-.01 (.03)	.01 (.03)
G4 SD → G5 VGU	-.03 (.03)	-.02 (.02)
Between-Person Associations		
Intercept_MVPA with Intercept_VGU	-.15 (.04)***	-.24 (.04)***
Intercept_MVPA with Intercept_SD	.16 (.04)***	.15 (.03)***
Intercept_VGU with Intercept_SD	-.26 (.04)***	-.29 (.04)***

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.17

Longitudinal Associations Among Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Non-Hispanic White, Non-Hispanic Black, Hispanic, and Non-Hispanic Asian Children

	Non-Hispanic White Children	Non-Hispanic Black Children	Hispanic Children	Non-Hispanic Asian Children
	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)	Standardized Estimate (*SE*)
Within-Person Effects				
Autoregressive Effects				
G3 MVPA → G4 MVPA	-.03 (.04)	-.02 (.07)	.04 (.06)	.16 (.10)
G4 MVPA → G5 MVPA	.07 (.03)*	-.01 (.09)	.10 (.05)*	.20 (.08)*
G3 VGU → G4 VGU	.02 (.05)	-.02 (.10)	.13 (.06)*	.06 (.06)
G4 VGU → G5 VGU	.18 (.03)***	.22 (.08)**	.21 (.04)***	.10 (.06)
G3 SD → G4 SD	.14 (.03)***	-.04 (.13)	.02 (.05)	-.20 (.15)
G4 SD → G5 SD	.03 (.04)	.03 (.08)	.02 (.04)	-.10 (.16)
Cross-Lagged Effects				
G3 MVPA → G4 VGU	.00 (.03)	-.11 (.07)	.09 (.04)*	.09 (.07)
G4 MVPA → G5 VGU	-.02 (.02)	-.08 (.07)	.02 (.04)	-.01 (.08)
G3 VGU → G4 MVPA	.09 (.03)**	-.04 (.08)	.06 (.04)	.02 (.06)
G4 VGU → G5 MVPA	.00 (.03)	-.17 (.08)*	.04 (.04)	.11 (.05)*
G3 MVPA → G4 SD	.01 (.03)	.00 (.08)	.05 (.04)	-.17 (.12)
G4 MVPA → G5 SD	-.03 (.04)	.09 (.07)	-.06 (.04)	-.11 (.08)
G3 SD → G4 MVPA	-.05 (.03)	.09 (.06)	.03 (.04)	-.27 (.09)**
G4 SD → G5 MVPA	.03 (.03)	-.05 (.07)	.01 (.04)	.07 (.07)
G3 VGU → G4 SD	.02 (.03)	.10 (.12)	-.05 (.05)	.01 (.09)
G4 VGU → G5 SD	.01 (.03)	-.05 (.06)	.02 (.04)	.15 (.09)
G3 SD → G4 VGU	.01 (.03)	-.02 (.08)	-.04 (.03)	.09 (.09)
G4 SD → G5 VGU	-.02 (.03)	-.07 (.07)	-.00 (.03)	-.05 (.06)
Between-Person Associations				
Intercept_MVPA with Intercept_VGU	-.14 (.03)***	-.09 (.09)	-.18 (.08)*	-.15 (.13)
Intercept_MVPA with Intercept_SD	.10 (.03)***	-.02 (.07)	.14 (.04)**	.43 (.08)***
Intercept_VGU with Intercept_SD	-.29 (.03)***	-.21 (.12)	-.20 (.06)***	-.23 (.08)**

Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.18

Model Fit Indices From the Multivariate Latent Growth Curve Models in the Full Sample and Subsamples

	SB χ^2	*df*	*p*	RMSEA [90% CI]	CFI	TLI	SRMR
Full Sample	32.372	18	.020	0.008 [0.003, 0.013]	0.998	0.997	0.008
Household Poverty Status							
Poor	11.385	18	.877	0.000 [0.000, 0.009]	1.000	1.009	0.010
Near-Poor	15.376	18	.636	0.000 [0.000, 0.016]	1.000	1.003	0.014
Not-Poor	32.363	18	.020	0.012 [0.005, 0.018]	0.997	0.995	0.010
Parental Highest Education							
Lower Than Bachelor's Degree	23.416	18	.175	0.007 [0.000, 0.014]	0.999	0.998	0.008
Bachelor's Degree or Above	39.253	18	.003	0.016 [0.009, 0.023]	0.996	0.991	0.013
Gender							
Female	29.791	18	.040	0.011 [0.002, 0.018]	0.997	0.994	0.010
Male	25.397	18	.114	0.008 [0.000, 0.015]	0.999	0.997	0.011
Race/ethnicity							
Non-Hispanic White	32.652	18	.018	0.012 [0.005, 0.018]	0.997	0.995	0.011
Non-Hispanic Black[a]	23.865	29	.736	0.000 [0.000, 0.017]	1.000	1.008	0.025
Hispanic	25.635	18	.108	0.012 [0.000, 0.022]	0.997	0.993	0.014
Non-Hispanic Asian[b]	46.345	24	.004	0.032 [0.018, 0.046]	0.956	0.934	0.058

Note. SB χ^2 = Satorra-Bentler scaled χ^2, RMSEA = root mean square error of approximation, CFI = comparative fit index, TLI = Tucker-Lewis index, SRMR = standardized root mean square residual.

[a] Variances of slope factors of moderate-to-vigorous physical activity and sleep duration were fixed at zero because they were negative and non-significant.

[b] Variance of the sleep duration slope factor was fixed at zero because it was negative and non-significant.

Table 1.19

Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in the Full Sample

		Unstandardized			Standardized		
		Estimate	*SE*	*p*	Estimate	*SE*	*p*
Means and Variances of Intercept and Slope Factors							
Means of	Intercept_MVPA	4.38	.04	< .001			
	Intercept_VGU	0.73	.01	< .001			
	Intercept_SD	9.13	.02	< .001			
	Slope_MVPA	-0.10	.02	< .001			
	Slope_VGU	0.16	.01	< .001			
	Slope_SD	-0.13	.01	< .001			
Variances of	Intercept_MVPA	2.24	.11	< .001			
	Intercept_VGU	0.25	.02	< .001			
	Intercept_SD	0.53	.02	< .001			
	Slope_MVPA	0.12	.05	.014			
	Slope_VGU	0.05	.01	< .001			
	Slope_SD	0.02	.01	.059			
Covariances Among Intercept and Slope Factors							
Intercept_MVPA with	Intercept_VGU	-0.05	.02	.001	-.07	.02	.001
	Intercept_SD	0.19	.03	< .001	.18	.02	< .001
	Slope_MVPA	-0.03	.06	.647	-.06	.11	.618
	Slope_VGU	-0.04	.01	.008	-.10	.04	.011
	Slope_SD	-0.03	.01	.014	-.14	.06	.027
Intercept_VGU with	Intercept_SD	-0.08	.01	< .001	-.22	.02	< .001
	Slope_MVPA	-0.01	.01	.615	-.03	.06	.625
	Slope_VGU	-0.01	.01	.408	-.07	.08	.367
	Slope_SD	0.01	.01	.259	.08	.08	.276
Intercept_SD with	Slope_MVPA	-0.01	.02	.527	-.04	.06	.519
	Slope_VGU	-0.02	.01	.007	-.10	.04	.006
	Slope_SD	-0.04	.01	.004	-.36	.07	< .001
Slope_MVPA with	Slope_VGU	-0.00	.01	.556	-.05	.09	.560
	Slope_SD	0.01	.01	.534	.12	.18	.523
Slope_VGU with	Slope_SD	0.00	.00	.666	.05	.11	.667

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 1.20

Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children From Poor, Near-Poor, and Not-Poor Families

		Children from Poor Families	Children from Near-Poor Families	Children from Not-Poor Families
		Estimate (*SE*)	Estimate (*SE*)	Estimate (*SE*)
Means and Variances of Intercept and Slope Factors				
Means of	Intercept_MVPA	3.96 (.07)***	4.29 (.07)***	4.60 (.04)***
	Intercept_VGU	0.83 (.02)***	0.79 (.02)***	0.66 (.01)***
	Intercept_SD	8.82 (.03)***	9.04 (.04)***	9.31 (.02)***
	Slope_MVPA	-0.12 (.04)**	-0.12 (.03)***	-0.08 (.02)***
	Slope_VGU	0.16 (.01)***	0.16 (.02)***	0.15 (.01)***
	Slope_SD	-0.07 (.01)***	-0.11 (.01)***	-0.15 (.01)***
Variances of	Intercept_MVPA	2.70 (.35)***	2.33 (.25)***	1.82 (.12)***
	Intercept_VGU	0.38 (.05)***	0.31 (.04)***	0.17 (.02)***
	Intercept_SD	0.47 (.06)***	0.49 (.05)***	0.48 (.03)***
	Slope_MVPA	0.15 (.17)	0.24 (.13)	0.07 (.05)
	Slope_VGU	0.08 (.02)**	0.09 (.02)***	0.03 (.01)**
	Slope_SD	0.03 (.03)	0.01 (.03)	0.02 (.01)
Covariances/Correlations Among Intercept and Slope Factors				
Intercept_MVPA with	Intercept_VGU	-.05 (.04)	-.08 (.05)	-.04 (.03)
	Intercept_SD	.16 (.06)**	.21 (.05)***	.10 (.03)***
	Slope_MVPA	-.25 (.21)	-.15 (.17)	.08 (.22)
	Slope_VGU	.03 (.07)	.02 (.07)	-.25 (.06)***
	Slope_SD	-.20 (.16)	-.21 (.28)	.01 (.07)
Intercept_VGU with	Intercept_SD	-.18 (.05)***	-.24 (.04)***	-.18 (.03)***
	Slope_MVPA	-.01 (.13)	.01 (.10)	-.05 (.08)
	Slope_VGU	-.26 (.13)*	-.31 (.09)**	.23 (.20)
	Slope_SD	.01 (.16)	.33 (.36)	-.04 (.08)
Intercept_SD with	Slope_MVPA	-.20 (.19)	-.11 (.09)	.03 (.08)
	Slope_VGU	-.09 (.08)	.01 (.07)	-.16 (.06)**
	Slope_SD	-.05 (.27)	-.28 (.17)	-.42 (.06)***
Slope_MVPA with	Slope_VGU	-.21 (.26)	-.20 (.14)	.26 (.18)
	Slope_SD	.27 (.50)	.30 (.43)	-.03 (.21)
Slope_VGU with	Slope_SD	-.22 (.24)	-.26 (.31)	.31 (.16)

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Unstandardized estimates were reported for means and variances, and standardized estimates were reported for covariances. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.21

Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

		Lower Than Bachelor's Degree	Bachelor's Degree or Above
		Estimate (*SE*)	Estimate (*SE*)
Means and Variances of Intercept and Slope Factors			
Means of	Intercept_MVPA	4.23 (.06)***	4.61 (.04)***
	Intercept_VGU	0.79 (.01)***	0.64 (.01)***
	Intercept_SD	8.99 (.03)***	9.35 (.03)***
	Slope_MVPA	-0.10 (.02)***	-0.09 (.02)***
	Slope_VGU	0.16 (.01)***	0.15 (.01)***
	Slope_SD	-0.10 (.01)***	-0.16 (.01)***
Variances of	Intercept_MVPA	2.40 (.18)***	1.84 (.11)***
	Intercept_VGU	0.31 (.03)***	0.16 (.02)***
	Intercept_SD	0.51 (.03)***	0.46 (.03)***
	Slope_MVPA	0.13 (.08)	0.11 (.06)
	Slope_VGU	0.07 (.02)**	0.03 (.01)*
	Slope_SD	0.02 (.02)	0.02 (.01)
Covariances/Correlations Among Intercept and Slope Factors			
Intercept_MVPA with	Intercept_VGU	-.07 (.03)*	-.03 (.03)
	Intercept_SD	.16 (.03)***	.15 (.03)***
	Slope_MVPA	-.10 (.16)	-.03 (.14)
	Slope_VGU	-.02 (.05)	-.24 (.07)**
	Slope_SD	-.18 (.11)	.01 (.07)
Intercept_VGU with	Intercept_SD	-.19 (.03)***	-.22 (.03)***
	Slope_MVPA	-.00 (.09)	-.05 (.07)
	Slope_VGU	-.23 (.08)**	.28 (.23)
	Slope_SD	.11 (.10)	-.07 (.10)
Intercept_SD with	Slope_MVPA	-.12 (.09)	.02 (.06)
	Slope_VGU	-.04 (.05)	-.17 (.06)**
	Slope_SD	-.23 (.11)*	-.40 (.08)***
Slope_MVPA with	Slope_VGU	-.18 (.14)	.22 (.16)
	Slope_SD	.35 (.30)	-.16 (.15)
Slope_VGU with	Slope_SD	-.13 (.14)	.29 (.18)

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Unstandardized estimates were reported for means and variances, and standardized estimates were reported for covariances. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.22
Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Female and Male Children

		Female Children	Male Children
		Estimate (*SE*)	Estimate (*SE*)
Means and Variances of Intercept and Slope Factors			
Means of	Intercept_MVPA	4.15 (.05)***	4.59 (.05)***
	Intercept_VGU	0.59 (.01)***	0.87 (.01)***
	Intercept_SD	9.15 (.03)***	9.11 (.03)***
	Slope_MVPA	-0.10 (.02)***	-0.10 (.02)***
	Slope_VGU	0.15 (.01)***	0.16 (.01)***
	Slope_SD	-0.14 (.01)***	-0.11 (.01)***
Variances of	Intercept_MVPA	2.14 (.16)***	2.24 (.17)***
	Intercept_VGU	0.17 (.03)***	0.30 (.02)***
	Intercept_SD	0.53 (.04)***	0.52 (.03)***
	Slope_MVPA	0.10 (.08)	0.13 (.08)
	Slope_VGU	0.04 (.01)***	0.07 (.02)***
	Slope_SD	0.03 (.02)*	0.01 (.02)
Covariances/Correlations Among Intercept and Slope Factors			
Intercept_MVPA with	Intercept_VGU	-.12 (.03)***	-.12 (.03)***
	Intercept_SD	.18 (.03)***	.18 (.04)***
	Slope_MVPA	-.09 (.16)	-.02 (.18)
	Slope_VGU	-.12 (.06)	-.10 (.05)*
	Slope_SD	-.13 (.07)	-.25 (.33)
Intercept_VGU with	Intercept_SD	-.20 (.04)***	-.25 (.03)***
	Slope_MVPA	.08 (.09)	-.11 (.08)
	Slope_VGU	-.08 (.15)	-.10 (.10)
	Slope_SD	.08 (.09)	.02 (.16)
Intercept_SD with	Slope_MVPA	-.07 (.09)	-.02 (.07)
	Slope_VGU	-.16 (.06)**	-.05 (.04)
	Slope_SD	-.44 (.07)***	-.27 (.17)
Slope_MVPA with	Slope_VGU	-.14 (.15)	.01 (.11)
	Slope_SD	.18 (.21)	.06 (.36)
Slope_VGU with	Slope_SD	.14 (.12)	-.09 (.26)

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Unstandardized estimates were reported for means and variances, and standardized estimates were reported for covariances. All estimates and *SE*s were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 1.23
Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Non-Hispanic White, Non-Hispanic Black, Hispanic, and Non-Hispanic Asian Children

		Non-Hispanic White Children	Non-Hispanic Black Children[a]	Hispanic Children	Non-Hispanic Asian Children[b]
		Estimate (*SE*)	Estimate (*SE*)	Estimate (*SE*)	Estimate (*SE*)
Means and Variances of Intercept and Slope Factors					
Means of	Intercept_MVPA	4.70 (.04)***	4.06 (.1)***	3.94 (.07)***	3.42 (.12)***
	Intercept_VGU	0.71 (.01)***	0.84 (.04)***	0.74 (.02)***	0.60 (.04)***
	Intercept_SD	9.29 (.03)***	8.67 (.04)***	8.99 (.03)***	9.14 (.05)***
	Slope_MVPA	-0.08 (.02)***	-0.13 (.05)*	-0.13 (.03)***	-0.09 (.07)
	Slope_VGU	0.15 (.01)***	0.13 (.02)***	0.19 (.01)***	0.17 (.02)***
	Slope_SD	-0.15 (.01)***	-0.08 (.02)**	-0.09 (.01)***	-0.12 (.02)***
Variances of	Intercept_MVPA	1.81 (.14)***	2.28 (.19)***	2.35 (.28)***	3.42 (.53)***
	Intercept_VGU	0.21 (.02)***	0.35 (.07)***	0.32 (.03)***	0.23 (.05)***
	Intercept_SD	0.52 (.03)***	0.52 (.04)***	0.44 (.04)***	0.40 (.03)***
	Slope_MVPA	0.05 (.06)	-	0.23 (.15)	0.61 (.23)**
	Slope_VGU	0.04 (.01)***	0.09 (.05)	0.08 (.02)***	0.04 (.03)
	Slope_SD	0.03 (.01)**	-	0.01 (.02)	-
Covariances/Correlations Among Intercept and Slope Factors					
Intercept_MVPA with	Intercept_VGU	-.06 (.03)*	-.08 (.07)	-.10 (.04)*	-.13 (.08)
	Intercept_SD	.07 (.03)**	.00 (.05)	.28 (.05)***	.24 (.06)***
	Slope_MVPA	.11 (.30)	-	-.18 (.20)	-.46 (.13)***
	Slope_VGU	-.12 (.05)*	-.22 (.11)*	.07 (.06)	-.01 (.14)
	Slope_SD	.04 (.05)	-	-.51 (.45)	-
Intercept_VGU with	Intercept_SD	-.22 (.03)***	-.14 (.07)*	-.22 (.04)***	-.13 (.07)*
	Slope_MVPA	-.06 (.12)	-	.03 (.09)	.13 (.07)
	Slope_VGU	-.03 (.12)	.02 (.26)	-.26 (.10)**	-.22 (.21)
	Slope_SD	.02 (.06)	-	.22 (.27)	-
Intercept_SD with	Slope_MVPA	.08 (.11)	-	-.31 (.12)*	.00 (.09)
	Slope_VGU	-.12 (.05)*	-.23 (.11)*	-.02 (.07)	-.03 (.12)
	Slope_SD	-.45 (.06)***	-	-.17 (.25)	-
Slope_MVPA with	Slope_VGU	-.05 (.14)	-	-.21 (.17)	-.09 (.17)
	Slope_SD	-.18 (.29)	-	1.00 (.90)	-
Slope_VGU with	Slope_SD	.17 (.11)	-	-.06 (.25)	-

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Unstandardized estimates were reported for means and variances, and standardized estimates were reported for covariances. All estimates and *SE*s were

weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
[a] Variances of slope factors of moderate-to-vigorous physical activity and sleep duration were fixed at zero because they were negative and non-significant.
[b] Variance of the sleep duration slope factor was fixed at zero because it was negative and non-significant.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.1
Comparisons Between Participants With and Without Missing Data

	No Missing Data on Variables (N = 5,183)		Missing on One Variable or More (N = 6,065)		t / χ^2	p
	Weighted M/%	Weighted SD	Weighted M/%	Weighted SD		
K Household Poverty Status					597.56	< .001
Poor	17.5%	-	32.2%	-		
Near-poor	19.9%	-	24.1%	-		
Not-poor	62.6%	-	43.8%	-		
K Parental Highest Education					589.29	< .001
Less than bachelor's degree	49.6%	-	68.5%	-		
Bachelor's degree or above	50.4%	-	31.5%	-		
Child Gender					1.59	.388
Female	48.9%	-	47.9%	-		
Male	51.1%	-	52.1%	-		
Child Race/Ethnicity					732.35	< .001
Non-Hispanic White	63.9%	-	43.4%	-		
Non-Hispanic Black	7.2%	-	14.1%	-		
Hispanic	20.0%	-	32.1%	-		
Non-Hispanic Asian	3.7%	-	5.1%	-		
Non-Hispanic Other	5.2%	-	5.4%	-		
G3 MVPA (days/week)	4.56	2.01	4.28	2.31	4.99	< .001
G4 MVPA (days/week)	4.39	2.05	4.06	2.32	5.74	< .001
G5 MVPA (days/week)	4.38	2.09	4.01	2.29	7.56	< .001
G3 Video Game Use (hours/day)	0.70	0.67	0.74	0.77	1.98	.049
G4 Video Game Use (hours/day)	0.89	0.79	0.91	0.87	1.35	.178
G5 Video Game Use (hours/day)	1.00	0.90	1.05	0.98	2.62	.009
G3 Sleep Duration (hours/day)	9.23	0.94	9.06	1.03	5.73	< .001
G4 Sleep Duration (hours/day)	9.08	0.90	8.91	0.97	7.23	< .001
G5 Sleep Duration (hours/day)	8.95	0.91	8.84	1.00	4.18	< .001
K Externalizing Problems	1.57	0.59	1.66	0.64	6.49	< .001
G5 Externalizing Problems	1.57	0.55	1.68	0.61	7.78	< .001
K Internalizing Problems	1.48	0.47	1.53	0.50	4.18	< .001
G5 Internalizing Problems	1.54	0.49	1.62	0.56	7.76	< .001
K Body Mass Index	16.52	2.33	16.71	2.62	3.21	.002
G5 Body Mass Index	20.16	4.79	20.79	5.08	4.62	< .001
K Academic Achievement	-0.26	0.53	-0.47	0.59	13.84	< .001
G5 Academic Achievement	1.82	0.42	1.63	0.48	15.42	< .001
K Self-Regulation	5.19	1.18	4.91	1.25	10.15	< .001

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.2

Descriptive Statistics of Study Variables and Covariates in the Full Sample

	Unweighted						Weighted	
	Valid *N*	*M*/%	*SD*	Range	Skewness	Kurtosis	*M*/%	*SD*
K Household Poverty Status								
Poor	2,386	23.9%					24.5%	
Near-poor	2,168	21.7%					21.9%	
Not-poor	5,438	54.4%					53.6%	
K Parental Highest Education								
Less than bachelor's degree	6,541	58.4%					59.7%	
Bachelor's degree or above	4,666	41.6%					40.3%	
Child Gender								
Female	5,485	48.8%					48.3%	
Male	5,763	51.2%					51.7%	
Child Race/Ethnicity								
Non-Hispanic White	5,633	50.1%					52.9%	
Non-Hispanic Black	1,151	10.2%					10.9%	
Hispanic	2,934	26.1%					26.5%	
Non-Hispanic Asian	885	7.9%					4.4%	
Non-Hispanic Other	645	5.7%					5.3%	
G3 MVPA (days/week)	9,947	4.40	2.18	0 - 7	-0.42	-0.78	4.43	2.16
G4 MVPA (days/week)	9,588	4.20	2.21	0 - 7	-0.31	-0.88	4.24	2.18
G5 MVPA (days/week)	8,913	4.18	2.20	0 - 7	-0.32	-0.87	4.23	2.18
G3 Video Game Use (hours/day)	10,009	0.71	0.72	0 - 4	1.78	4.45	0.72	0.72
G4 Video Game Use (hours/day)	9,649	0.89	0.83	0 - 4	1.43	2.38	0.90	0.83
G5 Video Game Use (hours/day)	8,959	1.02	0.95	0 - 5	1.61	3.57	1.02	0.94
G3 Sleep Duration (hours/day)	10,188	9.15	0.98	0 - 14	-0.24	2.02	9.15	0.99
G4 Sleep Duration (hours/day)	9,824	9.00	0.94	2 - 13	-0.07	0.56	9.00	0.94
G5 Sleep Duration (hours/day)	9,151	8.90	0.95	0 - 13	-0.55	4.70	8.90	0.95
K Externalizing Problems	10,127	1.60	0.61	1 - 4	1.26	1.57	1.61	0.62
G5 Externalizing Problems	8,622	1.60	0.58	1 - 4	1.27	1.60	1.61	0.58
K Internalizing Problems	10,113	1.49	0.48	1 - 4	1.34	2.31	1.50	0.48
G5 Internalizing Problems	8,566	1.57	0.52	1 - 4	1.43	2.65	1.57	0.52
K Body Mass Index	10,879	16.60	2.51	7.60 - 49.14	2.30	10.14	16.62	2.49
G5 Body Mass Index	9,120	20.34	4.87	6.05 - 78.49	1.53	5.06	20.43	4.92
K Academic Achievement	10,705	-0.36	0.57	-3.03 - 1.19	-0.65	0.77	-0.37	0.57
G5 Academic Achievement	9,467	1.74	0.45	-0.79 - 2.55	-0.94	1.37	1.73	0.45
K Self-Regulation	10,121	5.08	1.22	1 - 7	-0.62	-0.24	5.05	1.22

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.3
Descriptive Statistics of Study Variables and Covariates in Children From Poor, Near-Poor, and Not-Poor Families

	Poor Families[a] (*N* = 2,386)	Near-Poor Families[b] (*N* = 2,168)	Not-Poor Families[c] (*N* = 5,438)	Pairwise Comparisons
	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	
Moderate-to-Vigorous Physical Activity				
G3	4.05 (2.47)	4.37 (2.24)	4.64 (1.91)	c > b > a
G4	3.85 (2.42)	4.20 (2.22)	4.47 (1.98)	c > b > a
G5	3.70 (2.41)	4.19 (2.24)	4.48 (1.96)	c > b > a
Video Game Use				
G3	0.81 (0.82)	0.75 (0.76)	0.66 (0.64)	a > b > c
G4	1.00 (0.89)	0.94 (0.86)	0.83 (0.77)	a, b > c
G5	1.13 (1.01)	1.09 (0.97)	0.95 (0.87)	a, b > c
Sleep Duration				
G3	8.87 (1.05)	9.06 (0.97)	9.34 (0.91)	c > b > a
G4	8.76 (1.01)	8.94 (0.92)	9.16 (0.87)	c > b > a
G5	8.72 (1.08)	8.86 (0.92)	9.02 (0.88)	c > b > a
Externalizing Problems				
K	1.72 (0.67)	1.63 (0.62)	1.55 (0.57)	a > b > c
G5	1.69 (0.61)	1.65 (0.61)	1.56 (0.54)	a, b > c
Internalizing Problems				
K	1.55 (0.51)	1.53 (0.50)	1.46 (0.46)	a, b > c
G5	1.62 (0.55)	1.62 (0.55)	1.52 (0.49)	a, b > c
Body Mass Index				
K	17.00 (2.75)	16.81 (2.56)	16.29 (2.19)	a > b > c
G5	21.37 (5.11)	20.91 (4.96)	19.69 (4.62)	a > b > c
Academic Achievement				
K	-0.72 (0.57)	-0.44 (0.54)	-0.15 (0.48)	c > b > a
G5	1.46 (0.47)	1.68 (0.45)	1.90 (0.37)	c > b > a
Self-Regulation				
K	4.76 (1.26)	4.99 (1.24)	5.23 (1.16)	c > b > a

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Bonferroni corrections were used for pairwise comparisons. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.4
Descriptive Statistics of Study Variables and Covariates in Children With Parental Highest Education Lower than a Bachelor's Degree and of a Bachelor's Degree or Above

	Below Bachelor's Degree (N = 6,541)	Bachelor's Degree or Above (N = 4,666)	t / $\chi 2$	p
	Weighted M (SD)	Weighted M (SD)		
Moderate-to-Vigorous Physical Activity				
G3	4.25 (2.32)	4.66 (1.89)	6.76	<. 001
G4	4.06 (2.31)	4.48 (1.96)	7.08	<. 001
G5	4.00 (2.31)	4.51 (1.95)	8.94	<. 001
Video Game Use				
G3	0.79 (0.77)	0.63 (0.63)	9.68	<. 001
G4	0.97 (0.87)	0.80 (0.75)	9.66	<. 001
G5	1.10 (0.97)	0.91 (0.87)	7.68	<. 001
Sleep Duration				
G3	9.00 (1.01)	9.36 (0.90)	15.20	<. 001
G4	8.87 (0.96)	9.18 (0.86)	12.74	<. 001
G5	8.81 (0.98)	9.03 (0.88)	8.46	<. 001
Externalizing Problems				
K	1.66 (0.63)	1.54 (0.58)	7.91	<. 001
G5	1.66 (0.60)	1.54 (0.53)	7.97	<. 001
Internalizing Problems				
K	1.53 (0.50)	1.45 (0.46)	7.45	<. 001
G5	1.61 (0.54)	1.51 (0.48)	8.57	<. 001
Body Mass Index				
K	16.93 (2.67)	16.17 (2.08)	15.03	< .001
G5	21.25 (5.24)	19.25 (4.09)	18.69	< .001
Academic Achievement				
K	-0.55 (0.56)	-0.10 (0.48)	29.41	<. 001
G5	1.58 (0.45)	1.95 (0.36)	33.24	<. 001
Self-Regulation				
K	4.88 (1.24)	5.30 (1.16)	14.55	<. 001

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.5
Descriptive Statistics of Study Variables and Covariates in Female and Male Children

	Female (N = 5,485)	Male (N = 5,763)	t / $\chi 2$	p
	Weighted M (SD)	Weighted M (SD)		
Moderate-to-Vigorous Physical Activity				
G3	4.21 (2.14)	4.63 (2.16)	7.22	< .001
G4	4.00 (2.16)	4.47 (2.18)	9.30	< .001
G5	4.01 (2.13)	4.43 (2.21)	7.30	< .001
Video Game Use				
G3	0.58 (0.62)	0.85 (0.78)	16.45	< .001
G4	0.75 (0.76)	1.04 (0.86)	14.22	< .001
G5	0.87 (0.87)	1.17 (0.97)	13.16	< .001
Sleep Duration				
G3	9.16 (0.99)	9.14 (0.98)	1.05	.296
G4	9.01 (0.93)	8.99 (0.94)	0.84	.404
G5	8.88 (0.93)	8.92 (0.96)	1.72	.087
Externalizing Problems				
K	1.49 (0.54)	1.73 (0.65)	18.47	< .001
G5	1.46 (0.49)	1.76 (0.61)	20.68	< .001
Internalizing Problems				
K	1.49 (0.47)	1.51 (0.49)	2.44	.016
G5	1.56 (0.51)	1.58 (0.53)	1.16	.248
Body Mass Index				
K	16.54 (2.51)	16.69 (2.46)	2.92	.004
G5	20.41 (4.88)	20.45 (4.96)	0.37	.714
Academic Achievement				
K	-0.36 (0.55)	-0.38 (0.59)	1.57	.117
G5	1.72 (0.44)	1.74 (0.47)	1.78	.077
Self-Regulation				
K	5.34 (1.13)	4.78 (1.25)	22.43	< .001

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Percentages or means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.6

Descriptive Statistics of Study Variables and Covariates in Non-Hispanic White, Non-Hispanic Black, Hispanic, Non-Hispanic Asian, and Non-Hispanic Other Children

	Non-Hispanic White[a] (*N* = 5,633)	Non-Hispanic Black[b] (*N* = 1,151)	Hispanic[c] (*N* = 2,934)	Non-Hispanic Asian[d] (*N* = 885)	Non-Hispanic Other[e] (*N* = 645)	Pairwise Comparisons
	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	Weighted *M* (*SD*)	
Moderate-to-Vigorous Physical Activity						
G3	4.74 (1.87)	4.05 (2.32)	4.01 (2.36)	3.47 (3.20)	4.65 (2.22)	a > b, c > d; e > b, c, d
G4	4.57 (1.92)	3.94 (2.33)	3.74 (2.32)	3.29 (3.24)	4.59 (2.27)	a > b, c > d; e > b, c, d
G5	4.56 (1.90)	3.85 (2.32)	3.74 (2.35)	3.27 (3.15)	4.47 (2.26)	a > b, c > d; e > b, c, d
Video Game Use						
G3	0.70 (0.63)	0.83 (0.92)	0.74 (0.75)	0.58 (0.94)	0.79 (0.77)	a, b, c, e > d; b > a
G4	0.88 (0.75)	0.94 (0.94)	0.93 (0.86)	0.89 (1.25)	0.93 (0.89)	na
G5	0.98 (0.83)	1.08 (1.07)	1.10 (0.99)	0.87 (1.31)	1.09 (1.09)	b, c, e > d; c > a
Sleep Duration						
G3	9.30 (0.92)	8.71 (0.99)	9.00 (1.00)	9.14 (1.14)	9.15 (1.00)	a > c, d > b; e > b
G4	9.13 (0.87)	8.58 (0.97)	8.89 (0.94)	9.03 (1.15)	9.00 (0.93)	a > c > b; d, e > b
G5	9.00 (0.86)	8.53 (1.19)	8.83 (0.92)	8.91 (1.26)	8.90 (0.98)	a > c > b; d, e > b
Externalizing Problems						
K	1.59 (0.58)	1.83 (0.70)	1.59 (0.59)	1.49 (0.66)	1.62 (0.65)	b > a, c, e > d
G5	1.59 (0.55)	1.90 (0.66)	1.57 (0.55)	1.48 (0.66)	1.60 (0.55)	b > a, c, e > d
Internalizing Problems						
K	1.49 (0.46)	1.54 (0.49)	1.51 (0.50)	1.41 (0.57)	1.54 (0.56)	a, b, c, e > d
G5	1.57 (0.51)	1.60 (0.51)	1.56 (0.52)	1.51 (0.64)	1.62 (0.58)	na
Body Mass Index						
K	16.33 (2.14)	16.92 (2.70)	17.12 (2.72)	16.01 (2.95)	16.86 (2.96)	b, c, e > a > d
G5	19.84 (4.52)	21.63 (5.42)	21.28 (4.94)	19.05 (5.29)	21.07 (5.74)	b, c, e > a > d
Academic Achievement						
K	-0.19 (0.48)	-0.62 (0.56)	-0.66 (0.58)	-0.30 (0.75)	-0.30 (0.58)	a > d, e > b, c
G5	1.86 (0.38)	1.44 (0.45)	1.55 (0.46)	1.90 (0.55)	1.76 (0.48)	a, d > c, e > b
Self-Regulation						
K	5.14 (1.18)	4.72 (1.23)	4.97 (1.21)	5.29 (1.48)	5.07 (1.30)	d > c, e > b; a > c > b

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade. Bonferroni corrections were used for pairwise comparisons. Means and standard deviations were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

Table 2.7

Weighted Correlations Among Study Variables and Covariates in the Full Sample

	G3 MVPA	G4 MVPA	G5 MVPA	G3 VGU	G4 VGU	G5 VGU	G3 SD	G4 SD	G5 SD
K Externalizing Problems	.00	.02	.01	.07***	.06***	.05***	-.06***	-.03*	-.03*
G5 Externalizing Problems	.01	.03*	.02	.05***	.05**	.06***	-.05***	-.06***	-.04**
K Internalizing Problems	-.02	-.04**	-.05***	.03**	.03**	.04**	-.04***	-.04**	-.04**
G5 Internalizing Problems	-.03*	-.05***	-.07***	.05**	.05**	.06***	-.07***	-.05***	-.04***
K Body Mass Index	-.07***	-.06***	-.09***	.03*	.03*	.04**	-.08***	-.08***	-.06***
G5 Body Mass Index	-.09***	-.09***	-.12***	.06***	.05***	.06***	-.12***	-.12***	-.10***
K Academic Achievement	.13***	.13***	.14***	-.07***	-.06***	-.07***	.17***	.14***	.11***
G5 Academic Achievement	.11***	.10***	.12***	-.06***	-.04***	-.06***	.19***	.15***	.11***
K Self-Regulation	.02	.03*	.04**	-.09***	-.08***	-.06***	.09***	.04***	.04**

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.8

Weighted Correlations Among Study Variables and Covariates in Children From Poor, Near-Poor, and Not-Poor Families

	G3 MVPA	G4 MVPA	G5 MVPA	G3 VGU	G4 VGU	G5 VGU	G3 SD	G4 SD	G5 SD
Children from Poor Families									
K Externalizing Problems	.00	.03	.04	.09***	.03	.03	-.07**	-.03	-.03
G5 Externalizing Problems	.00	.07*	.03	.06	.04	.03	-.05	-.07**	-.05
K Internalizing Problems	-.06*	-.01	-.06*	.01	.02	.02	-.07**	-.05*	-.03
G5 Internalizing Problems	.04	.00	-.01	.04	.05	.05	-.05	-.03	-.07**
K Body Mass Index	-.06*	-.06*	-.08***	.01	-.01	.02	-.04	.00	-.03
G5 Body Mass Index	-.07*	-.07**	-.13***	-.01	-.02	-.01	-.05*	-.02	-.03
K Academic Achievement	.12***	.09***	.10***	-.01	.01	-.01	.08**	.06*	.08*
G5 Academic Achievement	.09**	.05*	.05	-.03	.01	-.02	.11***	.05*	.07*
K Self-Regulation	-.00	-.01	-.01	-.10***	-.06*	-.05	.12***	.04	.07**
Children from Near-Poor Families									
K Externalizing Problems	.01	.04	.02	.08***	.06*	.02	-.05*	-.03	-.04
G5 Externalizing Problems	.02	.04	.05	.02	.06*	.03	-.01	-.06	-.00
K Internalizing Problems	.06*	.01	.02	.01	-.01	-.03	-.03	.01	-.01
G5 Internalizing Problems	-.01	.00	-.04	.03	.03	.05	-.04	-.03	-.02
K Body Mass Index	-.09***	-.05	-.07**	.01	.03	-.00	-.03	-.07*	-.04
G5 Body Mass Index	-.07**	-.05	-.07**	.02	.03	-.00	-.05	-.07*	-.06*
K Academic Achievement	.09***	.09***	.11***	-.01	.00	.02	.11***	.06*	.05
G5 Academic Achievement	.07**	.04	.04	-.00	.02	.03	.15***	.10***	.08*
K Self-Regulation	-.01	.00	.03	-.05	-.03	.01	.06*	.02	.01
Children from Not-Poor Families									
K Externalizing Problems	.03	.01	.02	.05**	.06***	.07***	-.01	.01	.00
G5 Externalizing Problems	.03	.03	.02	.05*	.05**	.07***	-.04**	-.04*	-.03
K Internalizing Problems	-.01	-.03	-.04*	.03	.04	.04*	.00	.00	-.02
G5 Internalizing Problems	-.07***	-.09***	-.09***	.05*	.04*	.06**	-.07**	-.05**	-.04*
K Body Mass Index	-.05**	-.06***	-.05*	.03	.05**	.06**	-.08***	-.10***	-.08***
G5 Body Mass Index	-.09***	-.09***	-.11***	.09*	.08***	.10***	-.13***	-.15***	-.14***
K Academic Achievement	.06**	.08**	.07***	-.05*	-.07***	-.08***	.09***	.09***	.05**
G5 Academic Achievement	.05*	.06**	.08***	-.03	-.04*	-.05**	.13***	.11***	.07***
K Self-Regulation	.01	.03	.02	-.08***	-.11***	-.09***	.03*	.00	.01

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.9

Weighted Correlations Among Study Variables and Covariates in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

	G3 MVPA	G4 MVPA	G5 MVPA	G3 VGU	G4 VGU	G5 VGU	G3 SD	G4 SD	G5 SD
Children with Parental Highest Education Lower Than Bachelor's Degree									
K Externalizing Problems	.00	.03	.01	.07***	.04**	.03	-.06***	-.01	-.00
G5 Externalizing Problems	.02	.05**	.03	.05*	.03	.04*	-.03	-.04**	-.01
K Internalizing Problems	-.01	-.03*	-.05**	.04*	.03	.02	-.03*	-.02	-.03
G5 Internalizing Problems	-.01	-.03	-.05*	.06**	.05**	.06**	-.04*	-.01	-.03
K Body Mass Index	-.05**	-.04*	-.07***	.01	-.00	.01	-.03*	-.03*	-.03
G5 Body Mass Index	-.06***	-.06***	-.10***	.03	.01	.02	-.06***	-.06***	-.05**
K Academic Achievement	.12***	.12***	.13***	-.05**	-.01	-.02	.12***	.08***	.08***
G5 Academic Achievement	.09***	.08***	.09***	-.04*	.02	-.00	.14***	.09***	.09***
K Self-Regulation	.01	.00	.03	-.08***	-.05**	-.03*	.08***	.01	.03
Children with Parental Highest Education of Bachelor's Degree or Above									
K Externalizing Problems	.03	.02	.05**	.05**	.06**	.05**	-.02	-.02	-.04*
G5 Externalizing Problems	.03	.02	.04*	.03	.06**	.06**	-.04*	-.05**	-.05**
K Internalizing Problems	-.02	-.02	-.01	.01	.02	.04	-.02	-.03	-.03
G5 Internalizing Problems	-.04*	-.07***	-.08***	.01	.01	.05**	-.08***	-.08***	-.05**
K Body Mass Index	-.07***	-.08***	-.05**	.03	.05**	.05**	-.09***	-.12***	-.09***
G5 Body Mass Index	-.10***	-.11***	-.11***	.06**	.07***	.07***	-.13***	-.15***	-.14***
K Academic Achievement	.05**	.05*	.06**	-.01	-.06**	-.05**	.10***	.09***	.05*
G5 Academic Achievement	.04	.04	.06**	-.00	-.04*	-.05**	.11***	.11***	.05*
K Self-Regulation	-.00	.02	-.00	-.07***	-.10***	-.06***	.04*	.02	.02

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.10
Weighted Correlations Among Study Variables and Covariates in Female and Male Children

	G3 MVPA	G4 MVPA	G5 MVPA	G3 VGU	G4 VGU	G5 VGU	G3 SD	G4 SD	G5 SD
Female Children									
K Externalizing Problems	.00	.01	.01	.04*	.02	.01	-.04*	-.01	-.02
G5 Externalizing Problems	-.01	.01	-.01	.00	.02	-.00	-.04*	-.05**	-.04
K Internalizing Problems	.02	-.01	-.02	.02	.02	.01	-.03*	-.03*	-.03
G5 Internalizing Problems	-.01	-.03	-.03	.04*	.05*	.06**	-.08***	-.06**	-.05**
K Body Mass Index	-.09***	-.06**	-.12***	.04*	.03	.04**	-.08***	-.11***	-.09***
G5 Body Mass Index	-.09***	-.07***	-.14***	.07***	.03	.05**	-.13***	-.15***	-.13***
K Academic Achievement	.13***	.12***	.13***	-.09***	-.07***	-.08***	.16***	.11***	.08***
G5 Academic Achievement	.10***	.09***	.11***	-.11***	-.08***	-.09***	.18***	.11***	.09***
K Self-Regulation	.03	.04*	.04*	-.06***	-.04*	-.02	.08***	.02	.04
Male Children									
K Externalizing Problems	-.03	-.02	-.03	.04*	.03	.02	-.07***	-.05*	-.04*
G5 Externalizing Problems	-.03	.00	-.00	-.00	.00	.02	-.06**	-.07***	-.05*
K Internalizing Problems	-.06***	-.07***	-.08***	.04*	.04*	.05**	-.06**	-.04	-.04**
G5 Internalizing Problems	-.06**	-.08***	-.11***	.05*	.04*	.06**	-.06***	-.04*	-.04*
K Body Mass Index	-.06***	-.08***	-.06***	.01	.02	.02	-.07***	-.06***	-.04*
G5 Body Mass Index	-.09***	-.11***	-.11***	.05*	.05**	.07***	-.10***	-.09***	-.07***
K Academic Achievement	.13***	.14***	.16***	-.05**	-.05**	-.05**	.18***	.17***	.13***
G5 Academic Achievement	.12***	.11***	.12***	-.05*	-.03	-.04*	.21***	.19***	.13***
K Self-Regulation	.06***	.07***	.08***	-.04*	-.04**	-.02	.10***	.06**	.06**

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.11
Weighted Correlations Among Study Variables and Covariates in Non-Hispanic White, Non-Hispanic Black, Hispanic, and Non-Hispanic Asian Children

	G3 MVPA	G4 MVPA	G5 MVPA	G3 VGU	G4 VGU	G5 VGU	G3 SD	G4 SD	G5 SD
Non-Hispanic White Children									
K Externalizing Problems	.01	.03	.01	.07***	.06***	.06***	-.04*	-.03	-.02
G5 Externalizing Problems	.01	.03	-.00	.07**	.06**	.09***	-.06***	-.07***	-.04*
K Internalizing Problems	.00	-.02	-.05**	.02	.01	.03	-.03	-.04*	-.04**
G5 Internalizing Problems	-.06**	-.06***	-.10***	.06*	.06**	.06**	-.09***	-.08***	-.06***
K Body Mass Index	-.08***	-.07***	-.08***	.04*	.03	.04*	-.09***	-.10***	-.07***
G5 Body Mass Index	-.10***	-.10***	-.14***	.09***	.06**	.06***	-.12***	-.14***	-.11***
K Academic Achievement	.04*	.03	.06**	-.04*	-.06**	-.04*	.13***	.11***	.07**
G5 Academic Achievement	.05**	.03	.07**	-.04*	-.03	-.05*	.15***	.13***	.08***
K Self-Regulation	.01	-.00	.03	-.09***	-.08***	-.07***	.07***	.03*	.03*
Non-Hispanic Black Children									
K Externalizing Problems	.02	.02	-.01	.12**	.10**	-.01	-.04	-.02	.04
G5 Externalizing Problems	.05	.08	.04	.02	.05	.02	.05	.00	.04
K Internalizing Problems	-.05	-.10**	-.01	.08*	.08**	.05	-.02	.01	.01
G5 Internalizing Problems	-.04	-.10*	-.06	.08*	.08	.13**	.04	.05	.04
K Body Mass Index	-.09*	-.03	-.06	-.04	-.00	.03	-.02	-.01	-.00
G5 Body Mass Index	-.12***	-.02	-.02	-.02	-.02	.01	.01	.02	-.00
K Academic Achievement	.06	.06	.03	-.08*	-.12***	-.06	.11**	.06*	.07
G5 Academic Achievement	.08*	.05	.04	-.11**	-.10**	-.08*	.12***	.05	.08*
K Self-Regulation	-.01	-.01	.01	-.13**	-.11**	-.03	.05*	-.01	-.00
Hispanic Children									
K Externalizing Problems	-.02	.02	.04	.06*	.04	.04	-.06*	-.01	-.04
G5 Externalizing Problems	-.01	.01	.05*	.02	.02	.01	-.02	-.04	-.01
K Internalizing Problems	-.06**	-.02	-.06*	.05*	.04	.05	-.04	-.04	-.03
G5 Internalizing Problems	-.00	-.04	-.05*	.02	.01	.03	-.06*	-.03	-.01
K Body Mass Index	-.01	-.02	-.06**	.01	.00	.01	-.03	-.03	-.05*
G5 Body Mass Index	-.03	-.04*	-.11***	.02	.02	.03	-.08***	-.07**	-.10***
K Academic Achievement	.13***	.13***	.13***	-.07**	-.01	-.05	.09***	.07**	.06**
G5 Academic Achievement	.11***	.11***	.09***	-.01	.04	-.00	.11***	.06*	.04
K Self-Regulation	.02	.03	.00	-.08**	-.05	-.06**	.07**	.02	.02
Non-Hispanic Asian Children									
K Externalizing Problems	.07	-.01	.04	-.02	.05	.02	.07	.08	.03
G5 Externalizing Problems	.06	.04	.09	-.01	.06	.05	.04	.05	.00
K Internalizing Problems	-.01	-.10*	-.08	.01	.04	-.01	-.11**	-.11*	-.12**
G5 Internalizing Problems	-.06	-.06	-.14***	-.01	.06	.07	-.08	-.14*	-.10

K Body Mass Index	-.06	-.07	-.05	.04	.04	.00	-.01	-.07	-.05
G5 Body Mass Index	-.03	-.10**	-.10**	.01	.05	.04	-.06	-.08*	-.03
K Academic Achievement	.17***	.15**	.13**	-.09*	-.14***	-.11**	.09*	.03	.03
G5 Academic Achievement	.10*	.10*	.04	-.09*	-.17***	-.07	.17***	.07	.10
K Self-Regulation	-.00	.09	.06	-.04	-.11**	-.01	.04	.01	.01

Note. K = kindergarten, G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.12

Model Fit Indices From the Multivariate Latent Growth Curve Models With Self-Regulation as a Covariate in the Full Sample and Subsamples

	SB χ^2	*df*	*p*	RMSEA [90% CI]	CFI	TLI	SRMR
Full Sample	38.974	21	.010	0.009 [0.004, 0.014]	0.998	0.996	0.008
Household Poverty Status							
Poor[a]	21.649	27	.755	0.000 [0.000, 0.012]	1.000	1.007	0.014
Near-Poor	23.163	21	.335	0.007 [0.000, 0.021]	0.999	0.997	0.014
Not-Poor	50.668	21	< .001	0.017 [0.011, 0.023]	0.995	0.989	0.011
Parental Highest Education							
Lower Than Bachelor's Degree	27.418	21	.157	0.007 [0.000, 0.014]	0.999	0.997	0.008
Bachelor's Degree or Above	52.058	21	< .001	0.019 [0.012, 0.025]	0.993	0.986	0.013
Gender							
Female	32.315	21	.054	0.010 [0.000, 0.017]	0.997	0.994	0.010
Male[a]	36.911	27	.097	0.008 [0.000, 0.015]	0.998	0.997	0.017
Race/ethnicity							
Non-Hispanic White	37.424	21	.015	0.012 [0.005, 0.019]	0.997	0.993	0.011
Non-Hispanic Black[b]	19.979	27	.832	0.000 [0.000, 0.015]	1.000	1.015	0.019
Hispanic	28.878	21	.117	0.012 [0.000, 0.022]	0.996	0.992	0.014
Non-Hispanic Asian[a]	52.522	27	.002	0.036 [0.021, 0.051]	0.943	0.905	0.060

Note. SB χ^2 = Satorra-Bentler scaled χ^2, RMSEA = root mean square error of approximation, CFI = comparative fit index, TLI = Tucker-Lewis index, SRMR = standardized root mean square residual.

[a] Residual variance of the sleep duration slope factor was fixed at 0 because it was negative and non-significant.

[b] Residual variance of the moderate-to-vigorous physical activity slope factor was fixed at 0 because it was negative and non-significant.

Table 2.13

Predicting Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration From Kindergarten Self-Regulation in the Full Sample and Subsamples

	Intercept_MVPA	Intercept_VGU	Intercept_SD	Slope_MVPA	Slope_VGU	Slope_SD
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Full Sample	0.02 (.02)	-0.06 (.01)***	0.06 (.01)***	0.02 (.01)	0.00 (.00)	-0.02 (.01)**
Household Poverty Status						
Poor[a]	-0.02 (.04)	-0.07 (.02)***	0.07 (.02)***	-0.01 (.03)	0.01 (.01)	-0.01 (.01)
Near-Poor	-0.02 (.05)	-0.03 (.02)*	0.04 (.02)*	0.03 (.03)	0.02 (.01)	-0.02 (.01)
Not-Poor	0.01 (.02)	-0.05 (.01)***	0.02 (.01)	0.02 (.02)	-0.01 (.01)*	-0.01 (.01)
Parental Highest Education						
Lower Than Bachelor's Degree	-0.01 (.03)	-0.05 (.01)***	0.05 (.01)***	0.02 (.02)	0.01 (.01)*	-0.02 (.01)*
Bachelor's Degree or Above	-0.00 (.03)	-0.04 (.01)***	0.02 (.01)	0.00 (.01)	-0.01 (.01)	-0.00 (.01)
Gender						
Female	0.04 (.03)	-0.04 (.01)***	0.06 (.02)***	0.01 (.02)	0.01 (.01)	-0.02 (.01)
Male[a]	0.09 (.03)**	-0.03 (.01)**	0.07 (.01)***	0.02 (.02)	0.00 (.01)	-0.01 (.01)
Race/ethnicity						
Non-Hispanic White	-0.00 (.03)	-0.05 (.01)***	0.05 (.01)***	0.02 (.02)	-0.00 (.01)	-0.02 (.01)*
Non-Hispanic Black[b]	-0.02 (.06)	-0.10 (.03)**	0.03 (.02)	0.01 (.04)	0.03 (.02)	-0.03 (.02)
Hispanic	0.04 (.04)	-0.05 (.02)**	0.04 (.02)*	-0.02 (.03)	0.00 (.01)	-0.02 (.01)
Non-Hispanic Asian[a]	0.02 (.10)	-0.04 (.03)	0.02 (.03)	0.06 (.06)	0.00 (.02)	-0.00 (.02)

Note. MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

[a] Residual variance of the sleep duration slope factor was fixed at 0 because it was negative and non-significant.

[b] Residual variance of the moderate-to-vigorous physical activity slope factor was fixed at 0 because it was negative and non-significant.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.14
Model Fit Indices From the Multivariate Latent Growth Curve Models With Distal Outcome Variables in the Full Sample and Subsamples

	SB χ^2	*df*	*p*	RMSEA [90% CI]	CFI	TLI	SRMR
Full Sample	848.625	78	< .001	0.030 [0.028, 0.031]	0.968	0.947	0.046
Household Poverty Status							
Poor[a]	183.086	88	< .001	0.021 [0.017, 0.026]	0.979	0.968	0.033
Near-Poor	176.273	78	< .001	0.024 [0.019, 0.029]	0.980	0.966	0.034
Not-Poor	370.477	78	< .001	0.026 [0.024, 0.029]	0.974	0.957	0.038
Parental Highest Education							
Lower Than Bachelor's Degree	385.389	78	< .001	0.025 [0.022, 0.027]	0.975	0.959	0.034
At Bachelor's Degree or Above	323.539	78	< .001	0.026 [0.023, 0.029]	0.977	0.962	0.037
Gender							
Female	495.220	78	< .001	0.031 [0.029, 0.034]	0.965	0.941	0.046
Male	443.146	78	< .001	0.029 [0.026, 0.031]	0.970	0.949	0.048
Race/ethnicity							
Non-Hispanic White	381.882	78	< .001	0.026 [0.024, 0.029]	0.974	0.956	0.040
Non-Hispanic Black[b]	147.339	97	< .001	0.021 [0.014, 0.028]	0.979	0.972	0.040
Hispanic[a]	262.762	88	< .001	0.026 [0.022, 0.030]	0.973	0.960	0.037
Non-Hispanic Asian[a]	172.520	88	< .001	0.033 [0.026, 0.040]	0.941	0.913	0.057

Note. SB χ^2 = Satorra-Bentler scaled χ^2, RMSEA = root mean square error of approximation, CFI = comparative fit index, TLI = Tucker-Lewis index, SRMR = standardized root mean square residual.
[a] Variance of the sleep duration slope factor was fixed at zero because it was negative and non-significant.
[b] Variances of slope factors of moderate-to-vigorous physical activity and sleep duration were fixed at zero because they were negative and non-significant.

Table 2.15
Predicting Outcome Variables From Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in the Full Sample

	G5 Externalizing Problems	G5 Internalizing Problems	G5 Body Mass Index	G5 Academic Achievement
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Intercept_MVPA	0.01 (.01)	-0.01 (.01)	-0.13 (.06)*	-0.00 (.00)
Intercept_VGU	0.03 (.02)	0.04 (.02)	0.28 (.18)	0.01 (.01)
Intercept_SD	-0.04 (.01)**	-0.03 (.02)	-0.45 (.09)***	0.03 (.01)**
Slope_MVPA	0.06 (.08)	-0.19 (.11)	-1.37 (.65)*	0.02 (.05)
Slope_VGU	0.11 (.07)	0.06 (.07)	-0.34 (.41)	0.04 (.04)
Slope_SD	-0.07 (.18)	0.29 (.25)	0.42 (1.38)	-0.35 (.25)
K Covariate	0.40 (.01)***	0.24 (.02)***	1.50 (.02)***	0.61 (.01)***

Note. K = kindergarten, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. For each outcome variable, K covariate is the outcome variable measured in kindergarten (e.g., K covariate for G5 externalizing problems is K externalizing problems). Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** *p* < .001, ** *p* < .01, * *p* < .05.

Table 2.16

Predicting Outcome Variables From Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children From Poor, Near-Poor, and Not-Poor Families

	G5 Externalizing Problems	G5 Internalizing Problems	G5 Body Mass Index	G5 Academic Achievement
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Children from Poor Families[a]				
Intercept_MVPA	0.03 (.03)	-0.00 (.06)	-0.32 (.54)	-0.01 (.02)
Intercept_VGU	0.08 (.18)	-0.04 (.39)	-1.11 (3.35)	-0.05 (.14)
Intercept_SD	-0.06 (.04)	-0.04 (.07)	-0.35 (.64)	0.02 (.03)
Slope_MVPA	0.39 (1.60)	-0.87 (3.32)	-7.90 (28.81)	-0.32 (1.23)
Slope_VGU	0.04 (.28)	-0.05 (.55)	-1.52 (4.77)	-0.02 (.19)
Slope_SD	-	-	-	-
K Covariate	0.34 (.03)***	0.24 (.03)***	1.43 (.04)***	0.59 (.01)***
Children from Near-Poor Families				
Intercept_MVPA	0.02 (.02)	-0.00 (.01)	-0.01 (.07)	-0.01 (.01)
Intercept_VGU	0.01 (.06)	0.02 (.06)	0.01 (.28)	0.04 (.02)
Intercept_SD	-0.01 (.03)	-0.03 (.04)	-0.28 (.18)	0.05 (.02)*
Slope_MVPA	0.10 (.11)	-0.11 (.13)	-0.51 (.65)	-0.08 (.07)
Slope_VGU	0.17 (.09)	0.10 (.11)	-0.32 (.56)	0.02 (.05)
Slope_SD	-0.05 (.35)	0.26 (.40)	-0.02 (1.92)	-0.18 (.29)
K Covariate	0.39 (.03)***	0.24 (.03)***	1.51 (.04)***	0.61 (.02)***
Children from Not-Poor Families				
Intercept_MVPA	0.02 (.01)	-0.03 (.01)**	-0.20 (.08)**	0.00 (.01)
Intercept_VGU	0.01 (.06)	0.05 (.07)	0.81 (.78)	0.01 (.03)
Intercept_SD	-0.04 (.02)*	-0.02 (.02)	-0.58 (.13)***	0.03 (.01)**
Slope_MVPA	-0.04 (.09)	-0.07 (.09)	-0.92 (.73)	0.06 (.06)
Slope_VGU	0.21 (.25)	-0.06 (.24)	-0.53 (2.48)	0.10 (.11)
Slope_SD	-0.02 (.24)	0.47 (.45)	-1.16 (1.85)	-0.28 (.27)
K Covariate	0.40 (.02)***	0.23 (.02)***	1.53 (.04)***	0.57 (.01)***

Note. K = kindergarten, G5 = 5[th] grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. For each outcome variable, K covariate is the outcome variable measured in kindergarten (e.g., K covariate for G5 externalizing problems is K externalizing problems). Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

[a] Variance of the sleep duration slope factor was fixed at zero because it was negative and non-significant.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.17

Predicting Outcome Variables From Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Children With Parental Highest Education Lower Than a Bachelor's Degree and of a Bachelor's Degree or Above

	G5 Externalizing Problems	G5 Internalizing Problems	G5 Body Mass Index	G5 Academic Achievement
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Children with Parental Highest Education Lower Than Bachelor's Degree				
Intercept_MVPA	0.02 (.01)	-0.00 (.01)	-0.07 (.10)	-0.01 (.01)
Intercept_VGU	0.04 (.03)	0.06 (.03)	0.06 (.26)	0.03 (.02)
Intercept_SD	-0.02 (.02)	-0.02 (.02)	-0.36 (.13)**	0.04 (.01)***
Slope_MVPA	0.09 (.13)	-0.18 (.16)	-1.73 (1.41)	0.03 (.10)
Slope_VGU	0.07 (.09)	0.05 (.08)	-0.54 (.51)	0.05 (.05)
Slope_SD	-0.21 (.43)	0.22 (.42)	2.37 (4.06)	-0.40 (.51)
K Covariate	0.39 (.01)***	0.23 (.02)***	1.49 (.03)***	0.61 (.01)***
Children with Parental Highest Education of Bachelor's Degree or Above				
Intercept_MVPA	0.02 (.02)	-0.01 (.02)	-0.10 (.14)	-0.00 (.01)
Intercept_VGU	-0.04 (.12)	-0.07 (.10)	-0.03 (.89)	0.02 (.05)
Intercept_SD	-0.05 (.05)	-0.05 (.04)	-0.74 (.41)	0.02 (.03)
Slope_MVPA	-0.02 (.15)	-0.21 (.18)	-1.43 (1.48)	0.04 (.09)
Slope_VGU	0.38 (.47)	0.32 (.40)	1.78 (3.71)	-0.06 (.21)
Slope_SD	-0.37 (.69)	0.01 (.52)	-4.64 (6.90)	-0.20 (.43)
K Covariate	0.40 (.02)***	0.24 (.02)***	1.46 (.03)***	0.54 (.01)***

Note. K = kindergarten, G5 = 5^{th} grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. For each outcome variable, K covariate is the outcome variable measured in kindergarten (e.g., K covariate for G5 externalizing problems is K externalizing problems). Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.

*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.18
Predicting Outcome Variables From Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Female and Male Children

	G5 Externalizing Problems	G5 Internalizing Problems	G5 Body Mass Index	G5 Academic Achievement
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Female Children				
Intercept_MVPA	-0.00 (.01)	0.00 (.01)	-0.07 (.08)	-0.00 (.01)
Intercept_VGU	-0.02 (.03)	0.06 (.04)	0.41 (.25)	-0.05 (.03)
Intercept_SD	-0.04 (.02)*	-0.04 (.02)*	-0.58 (.12)***	0.02 (.01)
Slope_MVPA	-0.04 (.12)	-0.14 (.16)	-1.65 (1.36)	0.08 (.09)
Slope_VGU	0.01 (.10)	0.09 (.13)	-1.40 (.73)	0.03 (.06)
Slope_SD	-0.13 (.17)	0.18 (.20)	0.37 (1.39)	-0.17 (.15)
K Covariate	0.38 (.02)***	0.21 (.02)***	1.50 (.04)***	0.61 (.01)***
Male Children				
Intercept_MVPA	-0.00 (.02)	-0.01 (.04)	-0.12 (.16)	-0.02 (.07)
Intercept_VGU	-0.03 (.03)	0.03 (.04)	0.36 (.26)	0.00 (.06)
Intercept_SD	-0.05 (.03)	-0.01 (.05)	-0.31 (.20)	0.03 (.10)
Slope_MVPA	0.11 (.11)	-0.24 (.18)	-1.26 (.93)	-0.03 (.15)
Slope_VGU	0.09 (.12)	0.08 (.16)	0.48 (.71)	-0.03 (.27)
Slope_SD	-0.16 (1.08)	0.75 (2.44)	2.50 (10.02)	-1.65 (5.34)
K Covariate	0.35 (.01)***	0.27 (.02)***	1.49 (.03)***	0.60 (.01)***

Note. K = kindergarten, G5 = 5^{th} grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. For each outcome variable, K covariate is the outcome variable measured in kindergarten (e.g., K covariate for G5 externalizing problems is K externalizing problems). Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
*** $p < .001$, ** $p < .01$, * $p < .05$.

Table 2.19

Predicting Outcome Variables From Trajectories of Moderate-to-Vigorous Physical Activity, Video Game Use, and Sleep Duration in Non-Hispanic White, Non-Hispanic Black, Hispanic, and Non-Hispanic Asian Children

	G5 Externalizing Problems	G5 Internalizing Problems	G5 Body Mass Index	G5 Academic Achievement
	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)	Unstandardized Estimate (*SE*)
Non-Hispanic White Children				
Intercept_MVPA	0.01 (.02)	-0.03 (.02)	-0.13 (.19)	0.01 (.01)
Intercept_VGU	0.05 (.04)	0.07 (.04)	0.57 (.39)	0.01 (.01)
Intercept_SD	-0.04 (.02)*	-0.05 (.02)*	-0.51 (.18)**	0.03 (.01)**
Slope_MVPA	-0.09 (.20)	-0.20 (.26)	-2.69 (3.10)	0.00 (.13)
Slope_VGU	0.18 (.11)	0.01 (.11)	-0.69 (.94)	0.03 (.04)
Slope_SD	-0.08 (.15)	0.07 (.21)	-1.31 (1.82)	-0.14 (.13)
K Covariate	0.40 (.02)***	0.26 (.02)***	1.55 (.03)***	0.61 (.01)***
Non-Hispanic Black Children[a]				
Intercept_MVPA	0.05 (.03)*	-0.01 (.02)	-0.09 (.13)	0.01 (.01)
Intercept_VGU	-0.03 (.09)	0.08 (.06)	0.07 (.29)	-0.05 (.03)
Intercept_SD	0.07 (.05)	0.08 (.04)	0.20 (.21)	0.02 (.02)
Slope_MVPA	-	-	-	-
Slope_VGU	0.31 (.24)	0.23 (.19)	-0.66 (.99)	0.05 (.10)
Slope_SD	-	-	-	-
K Covariate	0.38 (.03)***	0.28 (.04)***	1.55 (.09)***	0.59 (.02)***
Hispanic Children[b]				
Intercept_MVPA	0.00 (.01)	-0.00 (.01)	-0.08 (.10)	0.01 (.01)
Intercept_VGU	0.00 (.03)	0.00 (.03)	-0.04 (.19)	0.05 (.02)**
Intercept_SD	0.00 (.03)	-0.04 (.03)	-0.75 (.23)**	0.02 (.01)
Slope_MVPA	0.13 (.11)	-0.14 (.10)	-1.50 (.96)	-0.03 (.05)
Slope_VGU	0.06 (.09)	-0.03 (.11)	-0.33 (.70)	0.04 (.05)
Slope_SD	-	-	-	-
K Covariate	0.35 (.02)***	0.19 (.03)***	1.39 (.03)***	0.59 (.01)***
Non-Hispanic Asian Children[b]				
Intercept_MVPA	0.03 (.02)	-0.02 (.02)	-0.10 (.10)	-0.02 (.01)
Intercept_VGU	0.04 (.06)	0.03 (.09)	0.09 (.57)	-0.04 (.05)
Intercept_SD	0.01 (.05)	-0.06 (.05)	-0.08 (.29)	0.08 (.04)*
Slope_MVPA	0.07 (.06)	-0.08 (.05)	-0.56 (.37)	-0.04 (.04)
Slope_VGU	0.34 (.32)	0.54 (.42)	2.70 (2.91)	0.06 (.14)
Slope_SD	-	-	-	-
K Covariate	0.38 (.05)***	0.15 (.06)**	1.30 (.12)***	0.48 (.03)***

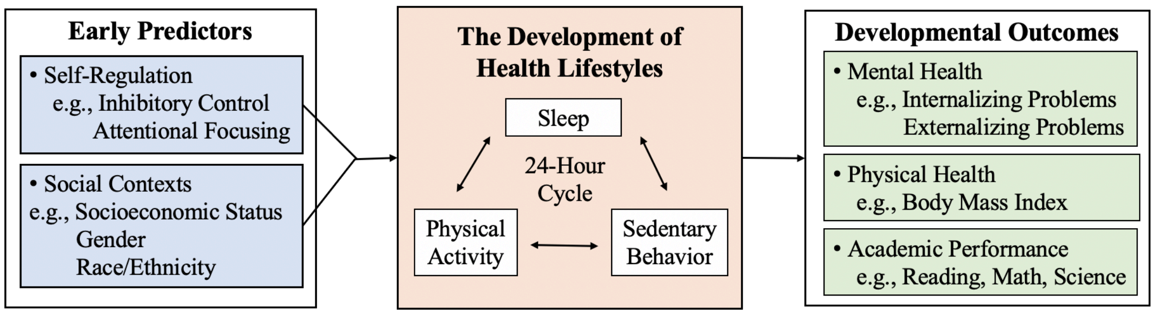
Note. K = kindergarten, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. For each outcome variable, K covariate is the outcome variable measured in kindergarten (e.g., K covariate for G5 externalizing problems is K externalizing problems). Estimates were weighted by W1_2P0 using the Taylor series linearization method with W1_2P0PSU being specified as the primary sampling units and W1_2P0STR as the stratum.
[a] Variances of slope factors of moderate-to-vigorous physical activity and sleep duration were fixed at zero because they were negative and non-significant.
[b] Variance of the sleep duration slope factor was fixed at zero because it was negative and non-significant.
*** $p < .001$, ** $p < .01$, * $p < .05$.

APPENDIX B

FIGURES

Figure 1

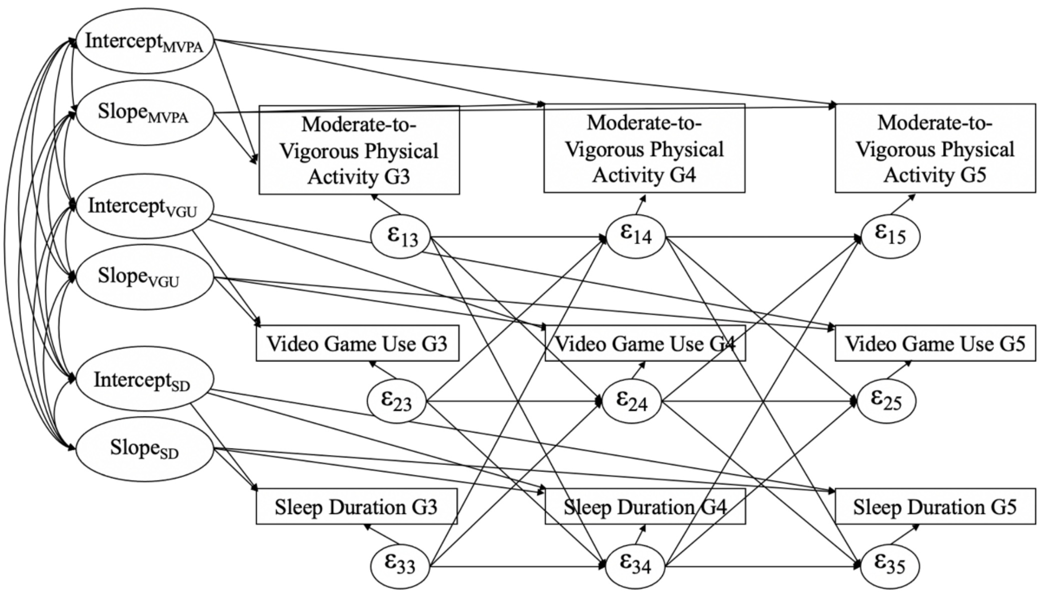
Conceptual Model Understanding the Development of Health Lifestyles in Childhood and its Early Predictors and Associated Outcomes



Note. Study 1 is focused on the developmental associations (i.e., longitudinal, transactional associations and correlations of developmental trajectories) among physical activity, sedentary behavior, and sleep duration in children. Study 2 is focused on early predictors and associated outcomes of developmental trajectories of these lifestyle behaviors.

Figure 2

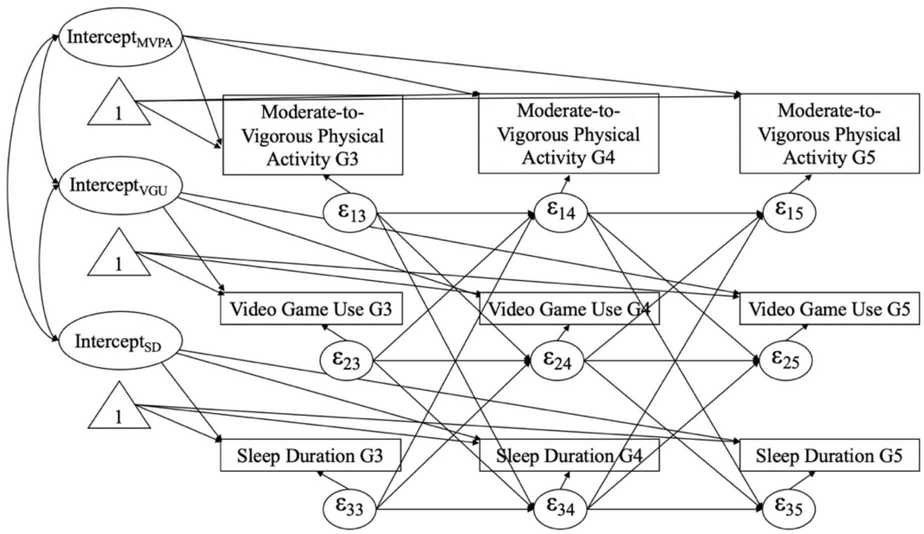
Hypothesized Latent Curve Model With Structured Residuals



Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. The time-specific residuals are allowed to covary (not shown) within each grade.

Figure 3

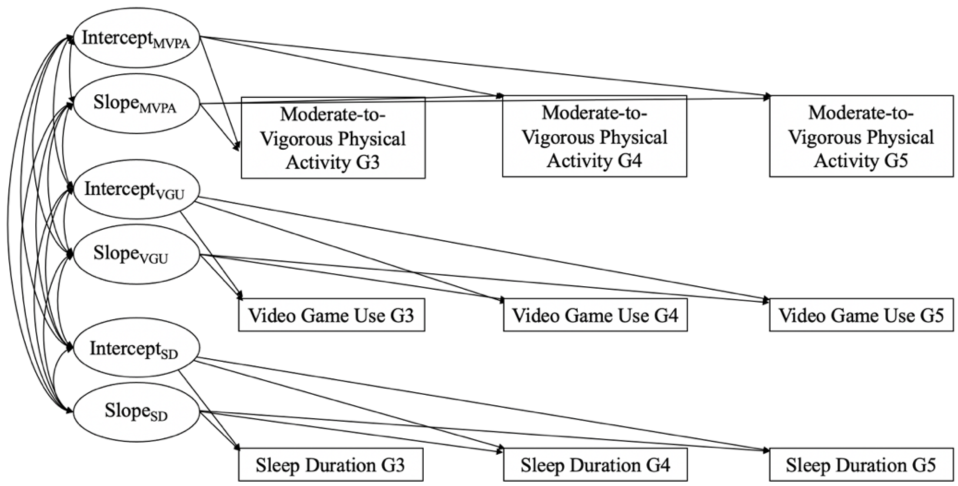
Hypothesized Random Intercept Cross-Lagged Panel Model



Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration. The time-specific residuals are allowed to covary (not shown) within each grade.

Figure 4

Hypothesized Multivariate Latent Growth Curve Model



Note. G3 = 3rd grade, G4 = 4th grade, G5 = 5th grade, MVPA = moderate-to-vigorous physical activity, VGU = video game use, SD = sleep duration.

APPENDIX C

HUMAN SUBJECT IRB EXEMPTION FORMS

EXEMPTION GRANTED

Carlos Valiente
CLAS-SS: Social and Family Dynamics, T. Denny Sanford School of (SSFD) 480/727-7569
valiente@asu.edu

Dear Carlos Valiente:

On 10/15/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Healthy Lifestyle Behaviors Among US Children: Early Predictors and Associated Outcomes
Investigator:	Carlos Valiente
IRB ID:	STUDY00014786
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• 2021.10.14 IRB Social Behavioral Longfeng Dissertation.docx, Category: IRB Protocol; • ECLS Email Approval.pdf, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (4) Data, documents, or specimens on 10/15/2021.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

REMINDER - All in-person interactions with human subjects require the completion of the ASU Daily Health Check by the ASU members prior to the interaction and the use of face coverings by researchers, research teams and research participants during the interaction. These requirements will minimize risk, protect health and support a safe research environment. These requirements apply both on- and off-campus.

The above change is effective as of July 29th 2021 until further notice and replaces all previously published guidance. Thank you for your continued commitment to ensuring a healthy and productive ASU community.

Sincerely,

IRB Administrator

cc:
Longfeng Li
Marilyn Thompson
Connor Sheehan

EXEMPTION GRANTED

On 5/11/2022 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	Healthy Lifestyle Behaviors Among US Children: Early Predictors and Associated Outcomes
Investigator:	Connor Sheehan
IRB ID:	STUDY00014786
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	None

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (4) Data, documents, or specimens on 5/11/2022.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

REMINDER - - Effective January 12, 2022, in-person interactions with human subjects require adherence to all current policies for ASU faculty, staff, students and visitors. Up-to-date information regarding ASU's COVID-19 Management Strategy can be found here. IRB approval is related to the research activity involving human subjects, all other protocols related to COVID-19 management including face coverings, health checks, facility access, etc. are governed by current ASU policy.

Sincerely,

IRB Administrator