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EXPLORING SEDENTARY TIME OF RURAL CHILDREN
DURING STRUCTURED VS LESS-STRUCTURED DAYS

by

SERINA RAYAN

A thesis submitted in partial fulfilment of the requirements
for the Honors in the Major Program in Health Science
in the College of Sciences
and in the Burnett Honors College
at the University of Central Florida
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Thesis Chair: Keith Brazendale

Abstract

Childhood obesity research has focused predominantly on urban-dwelling children. However, existing literature indicates that rural children have higher rates of obesity than their urban counterparts. There is a current lack of evidence investigating the obesogenic behaviors (e.g., sedentary time, screen time) of rural children, and how these behaviors differ on school days. The purpose of this study is to examine rural children's sedentary time and screen time during school days versus non-school days. An observational within-subjects study design was conducted with children recruited from an afterschool program that serves rural-dwelling children in a Central Florida County. Upon parental consent, daily estimates of sedentary time and screen time were collected for 14-days using a wrist-worn accelerometer and a daily diary completed by the parent/child, respectively. Mixed effects models assessed differences between school versus non-school days. All models accounted for clustering at the child level, and controlled for age and sex. Data collection was conducted spring 2020. The final sample included 54 children (Girls 61%; Mean age 9.1 years; Overweight/Obese 20.3%). Boys and girls accumulated mean sedentary time of 615.4 min/day (\pm SD 155.8) and 614.1 min/day (\pm SD 153.9), respectively. Boys and girls accumulated a screen time of 186.2 min/day (\pm SD 157.4) and 153.1 min/day (\pm SD 139.6), respectively. Overall, children spent less time sedentary [-46.7 min/day (95% CI: -73.3, -20.0)] and accumulated decreased screen-time [-103.3 min/day (95% CI: -120, -86.5)] during school days vs non-school days. Initial evidence suggests that rural children engage in increased sedentary time and screen time during non-school days in comparison to school days. These findings provide evidence that can inform future research and interventions and underline the important role school, or more structured days, can have on positively shaping rural children's obesogenic behaviors

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Introduction

The prevalence of childhood obesity in the United States has been increasing over the past five decades. Existing research has shown that about 13.7 million children within the age group of 2-19 years are considered obese, thus, obesity in children is clearly a major public health concern (Roth, 2018). Childhood obesity is known to have detrimental effects in the overall health of the individual. For example, children who are considered overweight or obese have a higher probability of developing diseases such as type 2 diabetes, hypertension, early puberty and sleep apnea (Sahoo, 2015) (Lakshman,2012). Pediatric obesity is a health concern not only among children living in urban areas but among children living in rural areas as well (Harris,2018). **A recent meta-analysis reported that rural children have a 26% higher chance of being overweight or obese in comparison to their urban counterparts.**⁵ Understanding the causes of overweight and obesity, particularly in children who are more at risk is of paramount importance.

Several behavioral factors have been linked to children's weight status. Current literature provides evidence that a lack of physical activity, increased sedentary time, poor sleep, inadequate nutrition in the diet – hereon defined as '*obesogenic behaviors*' – can lead to weight gain in school children (Johnson, 2015). For example, the number of hours a child spends being sedentary increases the child's risk of developing obesity (Felső,2017). Recent evidence shows that sedentary time, independent of the child meeting his/her recommended daily physical activity requirement of 60 minutes, is associated with the development of childhood obesity. Hence among the several obesogenic behaviors that lead to weight gain in children, sedentary time is an important behavior to examine for this proposal.

Currently, there is limited evidence about rural children's obesogenic behaviors. As mentioned previously, rural children are at greater risk of being overweight or obese, yet little is known about specific obesogenic behaviors of rural children (Liu,2012). Due to the lack of observational research of children living in rural areas, it is necessary to further explore obesogenic behaviors of rural children, such as sedentary time and screen time, to gain a better understanding and to inform future research and interventions in this population (Tremblay, 2011).

Literature Review

Prevalence of obesity among rural children

Childhood obesity, defined as an excess of body fat, is a risk factor for poor health (R. Cain; Sahoo et al., 2015). The prevalence of obesity in US children is alarmingly high, affecting about 13.7 million children and adolescents. Data also indicates that childhood obesity in the US has been steadily increasing for the past four decades (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018). More recently, data shows that the incidence of obesity has remained relatively stable but has not decreased, thus, childhood obesity in the US is still an alarming public health concern.

Several factors contribute to the incidence of obesity among children. The most common behaviours associated with childhood obesity include the obesogenic behaviors of diet, physical activity, sedentary behaviour and sleep (Laurson, Lee, Gentile, Walsh, & Eisenmann, 2014; Rennie, Wells, McCaffrey, & Livingstone, 2006). Studies have shown how short sleep duration, decreased physical activity levels, sedentary lifestyles and less healthy diets individually contribute to increased rates of childhood obesity (Chen, Beydoun, & Wang, 2008; Sallis & Glanz, 2006). Socioeconomic status has also shown to have an impact on childhood obesity with children in high income families having a lower incidence of obesity (10.9%) in comparison to their low-income counterparts (18.9%) (R. Cain). In addition, middle income families exhibited the highest incidences of childhood obesity with a rate of 19.9%.

A systematic literature review that compared differences in childhood obesity among urban and rural children found 10 studies, out of which 5 studies were used for the meta-analysis (Tremblay et al., 2011). All contributing studies, with the exception of one, indicated that living in rural areas was associated with higher rates of childhood obesity. Since obesity

rates are higher among rural children public health policy makers should be aware of this disparity, and future research should prioritize this area.

Discrepancies in obesogenic behaviours also exist among urban and rural children living in the US. However, there is a limited amount of evidence. One study compared differences in obesogenic behaviours among urban and rural children. The authors reported that rural children consumed 90 more kcal/day on average than urban children.⁸ It was also noted that rural children were more active than their urban peers. Rural children met the required daily intake of 2-3 cups of dairy but failed to meet the required daily intake of fruit. Despite the study's attempts to make some interventions in the health, diet and physical activity levels; rural children had a 30% higher chance of being overweight or obese, leading the authors to speculate that rural children live in a relatively more obesogenic environment. Due to distinct lack of research in the area of rural children's obesogenic behaviours it is difficult to decipher the role that certain behaviours such as sedentary time, physical activity, sleep and diet have in contributing towards children's weight status. Further, the contribution of other environmental factors towards rural children's obesity status such as the affordability of and access to healthy food choices, and proximity to community-based facilities and programs is relatively unknown, leaving areas for future obesity research to be conducted.

Sedentary Time and Screen Time

The amount of time a child spends sedentary, sometimes referred to as sedentary behaviour, has an influence on the physiological and psychological health of school children (Pearson, Braithwaite, Biddle, van Sluijs, & Atkin, 2014). Any behaviour that requires the child to spend very little energy could be characterized as sedentary behaviour. This could involve activities such as sitting down, laying down, reclining, and watching TV. Nearly 47% of U.S. children spend more than two hours a day engaged in sedentary activities (e.g., watching TV,

playing computer/videogames). An increase in the number of hours spent doing sedentary activities has been known to have an impact on weight gain (Brazendale et al., 2018; Prentice-Dunn & Prentice-Dunn, 2012). A study that measured children's obesogenic behaviours during summer versus school months indicated that children (mean age 8.9 years) spent 67-69% of their waking hours sedentary (Brazendale et al., 2018). Although the sample size of this study was small, it incorporated a within-person study design and sedentary time was measured using accelerometers which the children wore for 24 hours over a period of 9-days during two school and summer month data collection periods.

A meta-analysis conducted by NHANES quantified the mean sedentary time spent by a child to be 354 minutes. This analysis included 20,871 children between the ages of 4-18 years from studies conducted in Brazil, Australia, Europe and the United States. Accelerometers were used to measure the sedentary time spent by children in these studies. Two of the studies included were conducted in the United States and data from these studies is presented in Table 1. (Ekelund et al., 2012). Another study used the data from NHANES to quantify the mean sedentary time as 365 minutes, and indicated sedentary time above this limit as high sedentary activity (Beck, Chard, Hilzendegen, Hill, & Stroebele-Benschop, 2016).

Study	Age Range	Number of boys	Number of girls	Sedentary or screen time	Mean Estimate (±SD)
NHANES (2005)	6-18 years	1193	1154	Sedentary	375 minutes/day
NHANES (2005)	6-18 years	1193	1154	Sedentary	375 minutes/day
Colleen (2017)	10.3 years	71	82	Sedentary*	630 minutes/day
Katzmarzyk (2015)	9-11 years	2985	3554	Sedentary	513 minutes/day
Pelotas (2008)	13-14 years	238	217	Sedentary	491 minutes/day
Speedy (2008)	9-11 years	878	1098	Sedentary	352 minutes/day
Peach (2009)	10-13 years	605	635	Sedentary	362 minutes/day
Jeremy (2020)	9-10 years	6188	5681	Screen time	228 minutes/day
Gerson (2019)	9-11 years	246	222	Screen time	234 minutes/day
Treuth (2012)	7-19 years	99	130	Sedentary*	490 minutes/day

*Participants of this study include rural children

Table 1: Mean time spent sedentary or engaged in screen time by children

A systematic review examined the existing relationship among objectively and subjectively measured sedentary time and health indicators among children 5-17 years of age (Carson et al., 2016). This substantial review included 235 peer reviewed studies representing 1.5 million participants from 71 different countries. The authors concluded that higher durations of sedentary time, classified as screen time by the majority of the studies included in this review, was associated with unfavourable behavioural conduct, low self-esteem and lower fitness. Increased durations of sedentary time that was spent reading and doing homework was associated with higher academic achievement. There was not enough quality evidence to find a correlation between sedentary time and body fat composition because only 40 out of 138 studies measured described the psychometric properties of sedentary time measured. Thus, the study concluded that the type of sedentary behaviour engaged in had a different impact on health outcomes. However, collectively, less screen time was associated with overall better health. The limitations of this study are that most of the studies that measured sedentary time were self-reported and hence could not be deemed reliable. Higher quality studies using objective measures of sedentary time are required to confirm the findings of this review.

Studies conducted examining the effects of sedentary time on weight gain in children taking into account physical activity levels of children show mixed findings. With some studies concluding that independent of physical activity levels, sedentary time has a positive association with weight gain. However, other studies have reported that sedentary time is associated with weight gain only when the child also exhibits decreasing physical activity levels (Mitchell et al., 2009) (Leatherdale & Wong, 2009). This paradox could be due to the heterogeneity of the populations studied (e.g., differences in gender, age, ethnicity and sample size). In addition, the majority of the studies were self-reported which could have contributed to the inconsistency in conclusions as well (Carson et al., 2016; Herman, Sabiston, Mathieu,

Tremblay, & Paradis, 2014). Further, there are limited studies exploring sedentary time in less-understood samples of children, such as those from rural areas in the US.

With the increasing usage of technology, screen time is a well-known contributor to the average sedentary time a child engages in a day. This has enabled various researchers to use screen time as a proxy for sedentary time (Arluk, Branch, Swain, & Dowling, 2003; Carson et al., 2016). However, it has been identified that screen time only contributes to one third of the sedentary time spent by the child (Biddle, Gorely, & Marshall, 2009). This makes it important to distinguish screen time and sedentary time as two distinct variables especially when associations with obesity are considered (LeBlanc et al., 2015). To investigate screen time and sedentary time within the same population, a study was conducted by ISCOLE (The International Study of Childhood Obesity, Lifestyle and Environment). A diverse sample of 5,844 children within the age range of 9-11 years from several different regions such as Australia, Brazil, Canada, China, and India. were chosen to participate in this study. An accelerometer that was worn by the child for 7 consecutive days for 24 hours was used to objectively measure sedentary time. Screen time was self-reported by the child in the Diet and Lifestyle questionnaire that was provided. Anthropometric data such as the height, weight, waist circumference and percent body fat were measured by the researchers present on the site where the study was conducted. The results from this study indicated that the average sedentary time of a child was 8.6 hours/day. Based on the self-report, 54.2% children failed to meet the screen time guidelines of ≤ 2 hours a day. Boys engaged in more screen time than girls, and girls engaged in more sedentary time than boys. Although these findings provide representative data on sedentary and screen time across different nationalities, and can help inform future intervention research examining sedentary time and screen time in boys and girls, results from

this comprehensive assessment did not separate results by geographic location (i.e., urban versus rural).

Structured Days Hypothesis

It has been established that reduced physical activity levels, poor diets, an increase in sedentary time, and irregular sleep schedules have been positively associated with weight gain (Kenney & Gortmaker, 2017). Accordingly, the scientific community has thereby made interventions to provide a healthier environment for children, with the majority of efforts taking place during the school months. Recent evidence has shown that children exhibit accelerated levels of weight gain during their summer months. With a lack of scientific evidence directly examining obesogenic behaviours during school versus summer months, Brazendale et al developed the ‘Structured Day Hypothesis’ (SDH), proposing that a possible cause for weight gain could be the lack of ‘structure’ during summer days (Brazendale et al., 2017).

The authors suggest that summer days are analogous to weekend days in that they are less structured and allow more flexibility for children to engage in obesogenic behaviours such as increased sedentary activities. The authors hypothesize that obesogenic behaviours are restricted when children are in school, as school provides a consistent, adult-supervised environment and the structure provided by the school system limits the amount of time that children can spend being sedentary and/or engaged in sedentary activities. Even though children spend a significant amount of time sitting during the school day, children engage in physical activities during physical education classes and recess which breaks up the amount of time a child spends being seated in class. In addition, there are other unintentional and intentional activity opportunities that present themselves during a structured school day, such as active transport to and from school, transitions between classes, and activity breaks in the classroom. On the other hand, during weekend days children might spend more hours being

sedentary since there may be less supervision and planned activities. Anecdotally, children could lose track of time and spend hours playing video games, watching TV and snacking while watching TV. To support the SDH, Brazendale and colleagues examined empirical data collected on a weekend (less structured) and a weekday (structured). Data from 190 studies. A total of 155 studies supported the SDH; elementary-aged children's obesogenic behaviours were less favourable (i.e., increased sedentary time) on weekend days. Out of 62 studies which analysed the sedentary time among 6-12-year-old children, it was identified that children watched 60 more minutes of TV during the weekend days in comparison to the week days.

The conclusions drawn out of the SDH will be used to identify if rural children's sedentary time and screen time estimates during structured days, such as when children attend school, differ to less-structured days. This is intended to add more evidence to the SDH which proposes that children are more likely to exhibit less-favorable behaviors which can lead to gain weight during less structured days. A better understanding of obesogenic behaviours, particularly sedentary time and screen time, during less-structured days versus structured days is essential to better inform future interventions in underrepresented children, such as children from rural areas.

Thus, the research aims of this proposal are as follows:

AIM 1: Determine device-measured estimates of sedentary time and screen time of rural children.

AIM 2: Examine differences in sedentary time and screen time of rural children during structured days (school days) vs less-structured days (non-school days).

I hypothesize that children will exhibit greater sedentary time and screen time on days when they have less structure (non-school days) compared to days when they have more structure (school days).

In order to implement effective interventions, public health policy makers need to be aware of disparities that exist between urban and rural children in America. The primary contribution of this research would be directed towards bridging the knowledge gap that exists in the scientific literature pertaining to children who live in rural settings, and how certain obesogenic behaviors may differ on school versus non-school days.

Methodology

Study Overview

This study is an observational within-subjects study design. The study took place over a 2-week period (See **Table 2**) during spring 2020 capturing behaviours during one week of spring break and one week of regular school. The children were recruited from an afterschool program operated by the Boys and Girls Club of Central Florida (BGCCF) that serves predominantly rural children and families in Lake County, Florida. The timeline followed for the collection of data is presented

in the Table 2.

Activity	Timeline
Meet and Greet Program Staff	Week 1
Consent Forms Distributed to Parents	Week 2
Drop off Accelerometers and Survey Packets	Week 3
Drop off Accelerometers and Survey Packets (make-up day)	Week 3
2-week Data Collection Begins: 1 Week School & 1 Week Spring Break	Week 3 and 4
Pick up Accelerometers and Survey Packets/ Incentive Distributed	Week 5
Pick up Accelerometers and Survey Packets/ Incentive Distributed (make-up day)	Week 6

Table 2. Study Timeline and Activities

Sample and Participant Selection

The children recruited were participants of the BGCCF's afterschool program. Strategies were taken from a study conducted by Brazendale et. al. (2017) in which authors successfully recruited children and families from elementary schools. Children who are a part of the BGCCF within the ages of 6-14 years were invited to participate in this study. The research team provided the children and the leaders of BGCCF with information about the study during the meet and greet visit on Week 1. A short description of the study with an attached consent form was printed and handed to all the parents of the students attending the BGCCF during week 2. The study excluded participants who exhibited an intellectual disability such as Fragile X, Fetal Alcohol syndrome, Down syndrome or a physical disability which restrains the participants ability to move. This exclusion criteria was chosen due to the lack of resources that would be required to accurately observe the behaviour of these children. Further, given the small sample size it would not be possible to make adequate conclusions based on the few children that would participate in this study.

Measures

The measures followed in the study utilized techniques and followed procedures that were known to produce valid and reliable data without adding a lot of burden to the participants, families of participants and participating community partner.

Anthropometry and Demographics

All participating children had their height and weight measured using standard procedures (digital scale in kg, stadiometer in cm, without shoes, and light clothing). Age, sex, and race/ethnicity of the child participant was also collected.

Sedentary Time Assessment

Time (minutes per day) spent sedentary was collected for 14 days using the ActiGraph Link on the non-dominant wrist. This water-resistant device, allowed for us to capture water-based activities and is consistent with large data collection protocols in the US (e.g., NHANES study protocol). A minimum of 10 hours of wear time per day was considered as valid data based on widely accepted protocols. (K. L. Cain, Sallis, Conway, Van Dyck, & Calhoun, 2013; Moore, Beets, Morris, & Kolbe, 2014). Sedentary time was classified using recently published cut points (Chandler et al., 2018).

Screen time assessment

Screen time (minutes per day) was assessed for 14 days using parental self-report as part of a larger parent-survey packet. The survey packet included a 'Daily Diary' section that included the following three questions parents responded to each day: Did your child watch any TV/engage in any screen time (Yes/No)? If 'Yes', how many minutes did they spend watching TV/engaged in screen time? How many minutes after 8:00pm did your child spend watching TV/engaged in screen time? The parent was asked to complete a daily diary every day for 14 days. At the beginning of the survey packet, the parents were asked about accessibility of screen time devices in this child's bedroom and if the child owned their own screen time device.

Protocol summary

At the start of data collection (Table 2, week 3), children who had parental consent, and who gave verbal assent, had their height and weight taken. They were given an accelerometer to wear on their non-dominant wrist for 2 weeks. Each parent was also given a parent survey packet to report their child's daily screen time every day for 14 days. This packet was distributed at the end of program time during 'pick up' for parents/guardians.

Participant Incentives

All participating children/parents received an incentive of \$50 upon completion of the parent survey packet (and included daily diaries) and when the accelerometer was returned to the research team during week 5 of the study (**See Table 2**).

Analysis Plan

Descriptive characteristics are presented and only children with ≥ 4 days (including 1 weekend day) of valid sedentary data were used for the main analysis. Separate mixed effects models were employed to assess differences that exist between school versus non-school days (Independent Variable), on the repeated measures data for sedentary time (Dependent variable 1) and screen time (Dependent Variable 2). All models took into account clustering at the child level and controlled for age and sex. All statistical analyses were performed using Stata (v.16.1, College Station, TX).

Human Subjects Research Plan.

All children who attended the program, and their parents/guardians, were asked to participate in the study. Informed consent was collected from each child's parent/guardian prior to data collection activities. Family members and children were encouraged to ask questions throughout the data collection period regarding any study-related procedures. The University of Central Florida's Institutional Review Board (IRB) approved all procedures and protocols prior to data collection. For children, written informed consent from at least one parent/guardian and child voluntary assent was obtained prior to participation in the study.

Results

Study Sample

The final sample size for this study was 54 children and the average age of the participants was 9.1 years (\pm SD 2.0). A total of 57 participants were recruited and data of 3 participants were not considered for data analysis due to wear-time less than 10 hours/day for less than four days. The percentage of girls in the study were 61.1%. The majority of the children participating in this study had a BMI percentile classification that falls within ‘normal weight’ category (See Figure 1), with approximately 20% of the sample classified as overweight or obese.

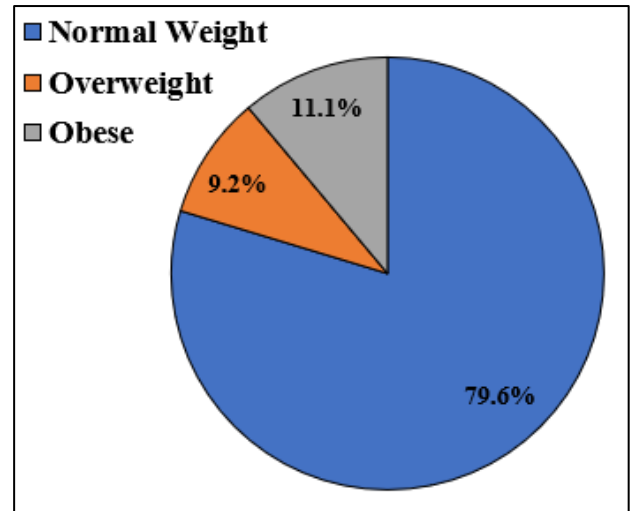


Figure 1: Body Mass Index (BMI) classification of study participants (n=54)

Family Demographics and Characteristics

Across the total sample, 78% of the parent-survey packets were completed by the mother of the child (See Figure 2). The majority of household incomes were under \$69,000 per year and the majority of parents (83%) completing the survey packet reported their highest education level as ‘some high school’ or ‘completed high school’ education. The questions on the living environment indicated that 57% of the children resided in a house, and 37% staying in a recreational vehicle (RV), Trailer or mobile home as their primary residence.

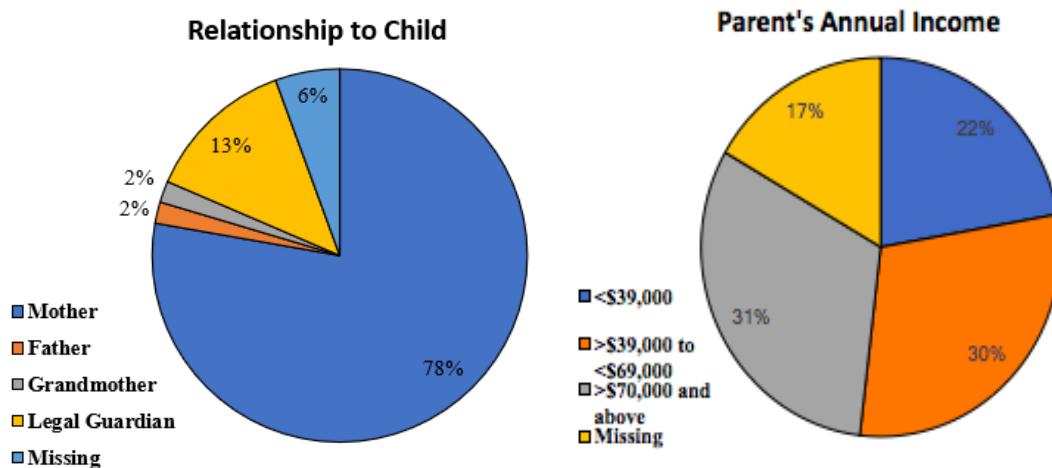


Figure 2a. Family-level demographic information – Relationship to Child and Parent’s Annual Household Income.

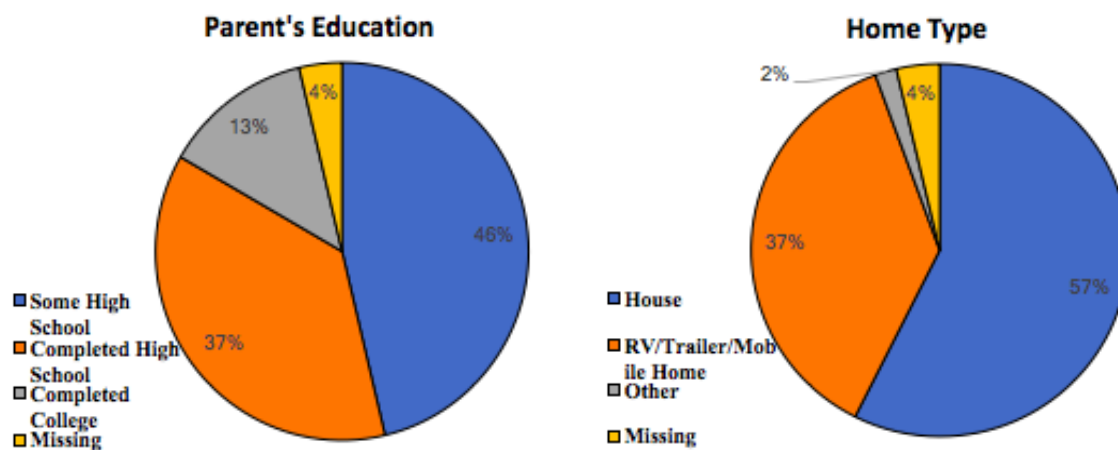


Figure 2b. Family-level demographic information – Parent’s Education and Home Type

Screen time

The self-reported data regarding the accessibility of devices to children indicated that 84.3% of children owned their own screen time device and had access to a screen in their own bedroom.

Screen time estimates

Mean screen time accumulated by children across all days was 166.1 minutes/day (\pm SD 147.6). The mean screen time all children accumulated after 8:00pm was 65.3 minutes/day (\pm SD 67.7). Among the children, boys and girls accumulated a screen time of 186.2 minutes/day (\pm SD 157.4) and 153.1 minutes/day (\pm SD 139.6), respectively. After 8:00pm, boys accumulated screen time of 74 minutes/day (\pm SD70) and girls accumulated screen time of 59.3 minutes/day (\pm SD 65.5).

Group	Screentime	All Days				School Days				Non-School Days				School vs. Non-School Day Diff* (95%CI)
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
All Children	Daily	166.1	147.6	0	860	90.7	64.0	0.0	300.0	192.5	159.1	0.0	860.0	-103.3 (-120.0, -86.5)
	After 8:00PM	65.3	67.7	0	540	42.0	56.2	0.0	540.0	73.8	69.6	0.0	345.0	-32.7 (-41.0, -24.5)
Boys	Daily	186.2	157.4	0	860	95.5	63.6	0.0	240.0	215.9	167.4	0.0	860.0	-115.9 (-144.9, -86.9)
	After 8:00PM	74.0	70.0	0	345	51.8	47.1	0.0	240.0	81.7	74.9	0.0	345.0	-29.4 (-42.9, -15.8)
Girls	Daily	153.1	139.6	0	720	87.8	64.3	0.0	300.0	176.9	151.6	0.0	720.0	-95.6 (-116.0, -75.3)
	After 8:00PM	59.3	65.5	0	540	35.6	60.7	0.0	540.0	68.2	65.2	0.0	340.0	-35.0 (-45.4, -24.6)

*Model-derived differences adjusted for age and sex, accordingly. Bolded values indicate a statistically significant difference.

Table 3. Screen time estimates during school days and non-school days

Screen time estimates during school days vs non-school days

Children on average accumulated 90.7 minutes/day (\pm SD 64) of screen time during a school day and 192.5 minutes/day (\pm SD 159.1) of screen time during a non-school day (**See Table. 4**). The mean screen time for all children after 8:00pm was 42 minutes/day (\pm SD 56.2) during school days and 73.8 minutes/day (\pm SD 69.6) during non-school days (**See Table 4**).

Boys exhibited a decrease of -115.9 minutes/day (95%CI: -144.9, -86.9) of screen time during school days in comparison to non-school days. Girls exhibited a decrease of -95.6 minutes/day (95%CI: -116.0, -75.3) of screen time during school days in comparison to non-school days. The screen time differences in boys and girls during school vs non-school days were statistically significant, independently. Screen time after 8:00pm decreased by -29.4 minutes/day (95%CI: -42.9, -15.8) and -35 minutes/day (95%CI: -45.4, -24.6) for boys and girls, respectively.

Sedentary time

The average number of valid days of sedentary data ($>$ 600minutes/day of wear) was 11 days (range 4 to 14 days). Mean sedentary time for all children was 614.6 minutes/day (\pm SD154.5). Among children, boys accumulated a mean sedentary time of 615.4 minutes/day (\pm SD155.8) and girls accumulated a mean sedentary time of 614.1 minutes/day (\pm SD153.9).

Sedentary time estimates during school days vs non-school days

Participants accumulated mean sedentary time of 578.2 (SD± 125.6) sedentary minutes/day (±SD 125.6) during school days and 626.1 minutes/day (±SD 161) during non-school days. This represented a decrease of -46.7 minutes/day (95%CI: -73.3, -20.0) during school days compared to non-school days for all children. (See Table. 4).

Both boys and girls engaged in more sedentary time during non-school days in comparison to school days. A decrease of -62.1 minutes/day (95%CI: -103.3, -20.9) and -36.8 minutes/day (95%CI: -71.6, -2.1) during school days compared to non-school days was observed for boys and girls, respectively (See Table. 4). The difference in sedentary time during school vs non-school days were statistically significant for boys and girls independently.

Sedentary Time (minutes per day)	All Days (n=565)				School Days (n=135)				Non-School Days (n=430)				School vs. Non-School Day Diff* (95%CI)
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
All Children	614.6	154.5	231.0	1053.8	578.2	125.6	235.9	856.1	626.1	161.0	231.0	1053.8	-46.7 (-73.3, -20.0)
Boys	615.4	155.8	296.3	1026.8	564.0	129.6	296.3	843.4	631.5	160.0	306.5	1026.8	-62.1 (-103.3, -20.9)
Girls	614.1	153.9	231.0	1053.8	587.4	123.0	235.9	856.1	622.5	161.8	231.0	1053.8	-36.8 (-71.6, -2.1)

*Model-derived differences adjusted for age and sex, accordingly. Bolded values indicate a statistically significant difference.

Table 4. Sedentary time estimates during school days and non-school days

Discussion

This study investigated within-child differences in objectively- measured sedentary time and self-reported screen time of rural children during school days vs non-school days. During school days children accumulated less sedentary time and screen time in comparison to non-school days. These findings were consistent among both boys and girls independently. Overall, participants of this study displayed an increase in unfavorable behaviors such as sedentary time and screen time during less-structured days (non-school days). The identified differences provide preliminary evidence in support of the Structured days hypothesis among rural children, and provide key information for future studies looking to intervene on this population.

The key findings of this study indicate that children accumulate an average sedentary time of ~10 hours/day. Based on existing studies conducted on urban children (Table 1), mean device-measured sedentary time of children ranges from 6-9 hours/day. In comparison to urban children around the world, the participants of this study accumulated sedentary time that falls on the higher end of the spectrum (~10 hours/day). Other studies that were conducted on urban children in the U.S. indicated the mean sedentary time of children. Only a handful of studies have reported sedentary time accumulated by rural children in the U.S. Results from these studies found estimates of sedentary time ranged from 7.5 to 8 hours/day (Daly, Foote, & Wadsworth, 2017; Treuth, Hou, Young, & Maynard, 2005). The participants in this current study accumulated an additional 2 hours of sedentary time compared to these earlier studies. The use of different devices used to measure sedentary time, different device cutpoints selected to define sedentary time, and different wear-time criteria for a valid day, could lead to this disparity. Hence, this difference is to be interpreted with caution as future research exploring sedentary time of rural children is required.

Screen time is one of the most common ways children engage in sedentary behavior (Tremblay, 2011). Hence, along with sedentary time, screen time estimates were collected as part of this study. It is important to distinguish the differences observed in self-reported screen time and device-measured sedentary time, since, screen time estimates cannot be used as the only measures of sedentary time. Children can perform various other activities (reading, sitting down, reclining etc.) that require very little expenditure of energy. The American Academy of Pediatrics and the National Heart, Lung, and Blood Institute recommends limiting screen time to 2 hours/day. According to a systematic review of health indicators associated with sedentary behavior, screen time of more than 2 hours/day was associated with unfavourable body composition and decreased fitness (Tremblay, 2011; LeBlanc et al., 2015). Hence, it could be hypothesized that screen time could be more harmful to health than other types of sedentary behaviors. A systematic review which included 11,869 U.S. children (9-11 years old), identified that the mean screen time of children was found to be 3.8 hours/day (Walsh, 2020). These results of this study are consistent with previous findings. The mean screen time accumulated by children in this study was closer to ~3 hours per day. Boys accumulated a higher screen time average of 3.1 hours/day in comparison to girls who accumulated an average of 2.55 hours/day; exceeding the recommended screen time limit of 2 hours/day. Children who fail to meet screen time recommendations have an increased risk of health complaints, lower self-esteem, increased adiposity and lower aerobic fitness (Keane, Kelly, Molcho, & Gabhainn, 2017; Saunders & Vallance, 2017). This highlights the risk excessive screen time poses to rural children.

Another goal of this study was to explore the changes in sedentary time and screen time of children during structured vs less-structured days. This is important since there is growing evidence that a lack of structure to a child's day is associated with an increase in unfavorable obesogenic behaviors (Brazendale et al., 2017; Huang & Wong, 2019; Weaver, Beets,

Brazendale, & Brusseau, 2019). In this study, during less-structured days, represented herein as non-school days, children accumulated an additional 45 minutes/day of sedentary time and 103 minutes/day of screen time. Boys exhibited a sedentary time decrease of 62.1 minutes/day and a screen time decrease of 115.9 minutes/day during structured days in comparison to less structured days. Girls exhibited a sedentary time decrease of 36.8 minutes/day and screen time decrease of 95.6 minutes/day during structured days in comparison to less structured days. The findings presented herein are consistent with other studies that have examined children's sedentary time and/or screen time on structured versus less-structured days. For example, one study by Brazendale et al. (2018) examining differences in children's obesogenic behaviors during school months (i.e., structured days) versus summer months (i.e., less-structure) found that children with a mean age of 8.2 years exhibited a 2% increase of sedentary time on summer days. In another study, that explored children's sedentary time in a sample of 154 children during weekday versus weekday during break from school (e.g., school holidays, spring break) observed an increase of 33.1 min/day during break days (i.e., less structured days) (Weaver, Beets, Perry, et al., 2019). Another study indicated that 82% of children met the screen time guidelines during weekdays in comparison to only 76% children meeting the screen time guidelines during the weekend (Schmitz et al., 2004). These differences observed among structured versus less-structured days could be attributed to the different components that encompass a school day that can break up the time that a child remains sedentary. Examples of these are transitions in-and-between classes, the commute to and from school, the 'active' components of school such as recess, physical education class, classroom activity breaks, and any additional programming that the children may attend that is an extension of the school day (e.g., before or after school programs). All or some of these components may not be present on non-school days, and children may be choosing to spend their time engaging in less-favorable behaviors such as watching TV, playing video games, sitting for extended period of time. In

addition, the present study found that screen time estimates were lower after 8:00pm on school days (nights) compared to non-school nights. It is plausible that on school days (nights) children have more of a routine or 'structure' at home (e.g., dinner, homework, set bedtime in preparation for school the next day) and, therefore, have less time to engage in screen time activities, especially later in the evening. Although, further contextual information is needed to support this notion. Nonetheless, non-school days could be a potential target for future intervention studies targeting obesity in rural children (Beck et al., 2016; Felső, Lohner, Hollódy, Erhardt, & Molnár, 2017).

Strengths of this study include exploring sedentary time in rural children, an at-risk population that does not receive sufficient attention. In addition, the use of an objective measure of sedentary time and a longer than typical observation period (~14 days compared to 7 days) is a strength. This study was not without limitation. The sample size was small which limits the generalizability of the findings. Another limitation is that parent self-reported screen time may not be an accurate representation of the actual screen time a child accumulated, especially during the weekday. Future directions for this research could focus on obtaining observations of sedentary time among larger samples of rural children to further explore its influence on childhood obesity, independent of physical activity levels. In addition, future research could target exploring bouts of sedentary time among rural children to investigate if prolonged periods of sedentary are more common during school versus on-school days.

Conclusion

Childhood obesity continues to be a public health concern, and rural children have a 26% higher chance of developing obesity in comparison to urban children (Johnson, 2015). Understanding sedentary time of children is of particular importance as existing research has demonstrated an association between sedentary time and weight-gain in children, independent of physical activity levels, and a positive correlation between increased screen time and weight-status. This study provides preliminary evidence of sedentary time and screen time of rural children. In addition, this study aligns with the SDH, indicating sedentary time and screen time in this population of rural children were lower during structured days in comparison to less-structured days. Given the fact that rural children exhibit higher rates of obesity than urban children, the results of this study provide important information on two obesogenic behaviors, sedentary time and screen time, that could be used to inform future intervention research in this population. Further, additional research is needed such as longitudinal studies in larger samples of rural children, comparing their behaviors to their urban-dwelling counterparts (Tremblay et al., 2011). Gaining a clearer understanding of the obesogenic risk factors that children engage in is of great importance to inform interventions, strategies and policies targeting rural populations.

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