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RESEARCH ARTICLE

Children's Obesogenic Behaviors During Summer Versus School: A Within-Person Comparison

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ABSTRACT

BACKGROUND: Evidence consistently shows children in the United States gain 3 to 5 times more weight during summer vacation (~2.5 months) compared to the 9-month school year. The purpose of this study is to examine within-child differences in 4 obesogenic behaviors (physical activity [PA], sedentary/screen-time, diet, and sleep) during school versus summer.

METHODS: We used a repeated-measures within-subjects design. Children (N = 30 mean age = 8.2 years; 57% female; 37% overweight/obese; 100% African American) wore accelerometers on the nondominant wrist for 24 hr/d over 9 consecutive days during school and summer of 2016 to capture PA, sedentary time, and sleep. Parents completed a daily diary to report bed/wake times, diet, and screen-time of their child each day. Mixed-effect models compared summer and school behaviors.

RESULTS: Children spent more time sedentary (69% vs 67% of wake wear time), less time in light PA (25% vs 23% of wake wear time), had higher screen-time (242 vs 123 minutes/day), slept longer (428 vs 413 minutes/night), and consumed more sugar-based foods (6 days vs 2.5 days/week) and fruit (7 days vs 4.7 days/week) during summer compared to school ($p < .05$).

CONCLUSION: Initial evidence suggests children are displaying multiple unfavorable obesogenic behaviors during summer compared to school that may contribute to accelerated weight gain during summer.

Keywords: child health; African American health; obesity; summer effects on weight gain.

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The prevalence of childhood obesity among United States children aged 6 to 11 years has quadrupled in the last 5 decades.[1] Children who are classified as overweight or obese are at an increased risk for developing several different chronic health diseases,[2] bringing childhood obesity to the forefront of public health concern.[3] Most intervention strategies targeting obesity prevention have focused on 4 obesogenic behaviors: physical activity (PA), sedentary/screen-time, diet, and more recently, sleep.[4-6] Understandably, studies examining these behaviors have been conducted in settings where children spend the majority of their time, such as during the 9 months of the school year, hereon referred to as "school."[3] The scientific community has acknowledged that modest improvements can be made to weight status and obesogenic behaviors while children are in school,[7] yet evidence is gathering that suggests these improvements are undermined as children are released to summer

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vacation.[8] Specifically, children return to school after summer vacation displaying accelerated weight gain relative to the weight gain occurring during the school year,[9,10] and fitness gains children achieved during the school year are erased over summer months.[11] The occurrence of these negative health outcomes are most pronounced in children who are already overweight or obese, of ethnic minority, and from low socioeconomic-status (SES) households.[8] This trend is similar to the decline observed in low-income children's academic performance during summer in comparison to their middle-to-upper-income peers.[12]

Currently, only a handful of studies have examined differences in children's obesogenic behaviors during summer versus school.[13-15] One cross-sectional study reported children were more physically active and had higher TV viewing during school holidays compared to school, with no reported dietary or sleep differences.[13] An analysis of secondary data of US children from the National Health and Nutrition Examination Survey (NHANES 2003-2008) reported children were more active, had less healthful diets, and watched more television during school breaks compared to school.[14] Although an objective measurement of PA was used, winter and summer break data were combined and 30-day recall methods for TV and diet overlapped between school break and in-school periods, limiting conclusions drawn solely for summer. Another key limitation is the use of a between-subjects design employed in both of the previous studies.[13,14] Despite demographic similarities, children may have different behavior patterns and between-subjects approaches do not capture unique, intraindividual variability.[16] One study has employed a within-subjects study design to investigate differences in children's obesogenic behaviors during summer versus school. McCue et al[15] reported data on a sample of 14 children (10 years old; non-Hispanic white) for PA; assessed by a 7-day accelerometer protocol, and diet; assessed by a food-frequency questionnaire. The authors reported children spent a greater percent of time in light and moderate PA, less time sedentary during school versus summer, and no reported dietary differences.[15] The occurrence of negative health outcomes during summer is of concern, and given the limited evidence, there is a clear need for further investigation. The purpose of this study is to examine within-child differences in PA, sedentary/screen-time, diet, and sleep during summer versus school in a sample of children from low-income African American households.

METHODS

Study Overview

A repeated measures observational within-subjects study design was conducted. In total, children from one elementary school located within the southeastern region of the United States were invited to be part of the pilot study. Information fliers were sent home with ~100 children (first through fourth grade) during physical education class inviting children/parents to be part of the study. The school was located in a district that primarily serves African American families from low-income households. Children enrolled in the elementary school were 85% African American, and 96.4% of children were on free/reduced lunch. Parents provided written informed consent for the child. Each parent-child dyad received a $50 gift card for participating in school and summer measurement protocols ($100 total).

Study Protocol

Children/parents with completed consent forms (N = 55) were given data collection materials for a 9-day period during school and summer. These materials consisted of a waterproof wrist-based activity monitor and a parent survey packet (including a 9-day daily diary). Parents were sent text message reminders over the course of the 9 days to remind them to complete the parent survey packet. For school, consented children were given the activity monitor and parent survey packet to take home in their bags during scheduled physical education (PE) class. The materials were distributed by a research assistant with support from the PE teacher. After 9 days, the child returned the accelerometer and completed parent survey packets to the PE teacher. School data were collected early May 2016. For summer, the same materials were distributed for 9 days during the summer protocol; however, distribution of materials differed due to the school being closed over summer. Because of its familiarity to the families/children involved in the study, the elementary school was selected as the pick-up/drop-off location for the summer data collection materials. Three different dates were provided during the month of July (2016) and research assistants offered a 4-hour window on each date.

Measurements

Anthropometric assessment. Using a portable stadiometer (Model S100, Ayrton Corp., Prior Lake, MN) and digital scale (Healthometer model 500KL, Health o meter, McCook, IL), children's heights (nearest 0.1 cm) and weights (nearest 0.01 lbs), without shoes, were collected by 2 research assistants during a separate visit to the school in May.

Physical activity/sedentary time assessment. Children's PA and sedentary time was captured via a wrist-based activity monitor (ActiGraph Link GT9X+ accelerometer, Shalimar, FL). During school and summer, a trained research assistant strapped the accelerometer to each child's nondominant wrist and

encouraged the child to wear the waterproof device for 9 days (day and night) without removal. The epoch was set at 5-second intervals to account for the transitory PA patterns of children[17] and to align with the validation epoch length.[18,19] Validated nondominant wrist-based cut points of ≤161, 162-529, and ≥ 530 accelerometer counts per 5 seconds were used to distill sedentary time, light, and moderate-to-vigorous physical activity (MVPA), respectively.[19] A valid day of accelerometer data was total wear time ≥ 600 minutes per day (excluding sleep) with removal of non-wear time identified as consecutive zeros for 30 minutes or more.[20]

Screen-time assessment. During school and summer protocols, children's daily screen-time estimates were reported by parents for 9 days by completing a daily diary, a section within the parent survey packet. Parents reported whether or not their child engaged in screen-time on that particular day and if so, estimated the total amount of time (hours and minutes) their child spent in front of a screen (eg, TV, computer, video-game, smartphone, tablet). In accordance with other studies using similar screen-time protocols, hours were converted to minutes, summed to provide a daily screen-time duration, and an average calculated by dividing the summed value by the number of days the daily diary was completed.[21,22]

Diet assessment. Children's diet was assessed using the Beverage and Snack Questionnaire (BSQ).[23] The BSQ is a cost-effective, easy-to-use tool to assess frequency of consumption of foods, and beverages high in energy but poor in nutrients (eg, savory snacks, sweets). Parents were asked to complete this 19-item checklist with their child every day for 9 days. There were a total of 4 response categories with individual items scored 0 (''child did not consume'') to 3 (''child consumed a lot''). For this study, individual BSQ items were grouped in accordance with the Healthy Meal Index (HMI)[24] food categories as follows: fruits; vegetables; dairy; convenience foods; sweets and desserts; and sugar-sweetened beverages. Reported consumption was dichotomized (ie, ''did'' vs ''did not'' consume) and standardized to represent mean days per 7-day week.[23] For example, if a parent/child reported eating fruit on 5 of the 9 days (55% of days), this was transformed to 3.9 days/week (55% of 7 days). A BSQ was completed during the school 9-day protocol, and again during the summer 9-day protocol.

Sleep assessment. Children's sleep was captured via the wrist-worn ActiGraph Link GT9X+ accelerometer (Shalimar, FL). This procedure has been validated as a measure of sleep, is used extensively in studies evaluating sleep of elementary school-aged children, and is preferred to hip-based accelerometer placement for sleep detection.[25-27] Proprietary ActiGraph sleep algorithms validated for children (Sadeh Algorithm) were used to determine total sleep duration.[28] Individual files were reintegrated to 60-second epochs and analyzed for inconsistencies with sleep duration ≤4 and ≥ 15 hours per night removed from further analysis.[29] In addition, parents reported the bed and wake times for their child as part of the 9-day daily diary. Parent-reported sleep duration was calculated by assessing the amount of time that had lapsed between the bedtime reported for the previous night and the wake-time for the current day.

Data Analysis

Only children with data from both school and summer that met the following criteria were included for analysis: ≥4 days (including 1 weekend day) of valid PA/sedentary data,[30] ≥5 nights (including 1 weekend night) of valid sleep,[29] and ≥ 7 days with complete daily diaries for screen-time and diet outcomes, including 1 weekend day. Independent sample *t* tests examined differences between the children who did and did not return for the summer protocol across demographics and obesogenic behaviors. Paired samples *t* tests were used to compare school and summer data for diet ($p < .05$). Mixed-effects models were employed to assess differences that existed between school and summer on repeated measures data for PA, sedentary/screen-time, and sleep. All the models took into account clustering at the child level, and controlled for age, sex, and weight status. All statistical analyses were performed using Stata (v.14.1, College Station, TX).

RESULTS

A total of 55 children/parents expressed interest in the study during the school spring semester. Of these, 3 children were unavailable for summer data collection, 16 children/parents did not respond for summer data collection, and 6 children had either lost/broke their activity monitor or did not have accelerometer data meeting inclusion criteria. This left a final sample of 30 children for within-subject analysis. No statistical differences existed in terms of baseline child-level demographics or obesogenic behaviors among the children who returned for the summer and those who did not. Table 1 displays the child-level and family-level demographics for the final within-subjects sample. Children (mean age = 8.2 years; 57% female; 100% African American; 37% overweight/obese) mainly came from single-parent (66.7%) households that included at least 2 other siblings/children (53.3%) and reported an annual household income of $19,999 or less per annum (46.6%).

On average, children wore the activity monitors for 8.3 and 8.7 valid days during summer and school, respectively. Wake wear time

Table 1. **Child and Family-Level Demographics of Within-Subjects Sample (N = 30)**

Child-Level	All	Boys	Girls
N	30	13	17
Age—years (mean ± SD)	8.2 (1.2)	8.0 (1.4)	8.4 (1.1)
African American—N (%)	30 (100.0)	15 (100.0)	15 (100.0)
BMI classification—N (%)			
Normal weight	17 (56.7)	7 (53.9)	10 (58.8)
Overweight/obese	11 (36.7)	5 (38.5)	6 (35.2)
Missing	2 (6.7)	1 (7.7)	1 (5.9)
Family-level	**N**	**Percent**	
Parent/guardian			
Mother	27	90	
Father	2	6.7	
Grandmother	1	3.3	
Education			
No high school diploma	2	6.7	
High school diploma	17	56.7	
College degree	11	36.7	
Marital status			
Married	7	23.3	
Single and never married	20	66.7	
Widowed/divorced/separated	3	10.0	
Annual household income			
$19,999 or less	14	46.6	
$20,000-$39,999	9	30.0	
$40,000 or more	7	23.3	
No. of people in household*			
3 or fewer	8	26.7	
4 or more	22	73.3	
No. of children in household†			
2 or fewer	14	46.7	
3 or more	16	53.3	

BMI, body mass index.
*Including respondent.
†Including child participant.

between school (934.9 minutes/day) and summer (892.7 minutes/day) was statistically significant so PA data were expressed as a percent of time (Table 2). Children had a reduced percent of time in light-intensity PA (−2.0%, 95% CI = −2.8, −1.1), a greater percent of time sedentary (+2.2%, 95% CI = 0.9, 3.4), more screen-time (+120.6 minutes/day, 95% CI = 100.5, 140.7), more sleep (+14.3 minutes/night, 95% CI = 1.2, 27.4), and a higher frequency of consumption of both fruits (+2.3 days/week, $p < .01$) and sweets and desserts (+3.5 days/week, $p < .01$), during summer compared to school.

DISCUSSION

This study investigated within-child differences during summer versus school in PA, sedentary/screen-time, diet, and sleep. Over summer children were less active, more sedentary, engaged in higher amounts of screen-time, slept longer, and more frequently consumed sugar-sweetened foods and fruit. In total, results from this study suggest children, on average, are displaying multiple unfavorable health behaviors during the summer months compared to school. In addition, the observed differences provide preliminary evidence for targets of an intervention directed at minimizing children's accelerated weight gain and losses in cardiorespiratory fitness (CRF) during summer.

On average, children engaged in less light-intensity PA and spent more time sedentary during summer compared to school, with no observed differences in MVPA. This finding is in agreement with another within-subject study investigating children's PA during summer versus school,[15] and one study using a summer comparison group of children to compare to children measured during school.[31] The majority of children from this study appear to find ways to achieve health-enhancing PA on summer and school days, with ∼8% of wake wear time spent in MVPA (∼72 minutes/day). One area worthy of further investigation is sedentary time. During school sedentary time was replaced by more light-intensity PA. This could be a result of the various intentional (eg, recess, PE) and unintentional (eg, walk to/from school, transition between classes) PA opportunities that exist in a typical school day. Beck et al[32] reported children were more sedentary during outside of school hours versus during school hours. This shift in light intensity PA to sedentary during summer is concerning given the health and obesity risks associated with sedentary time independent of MVPA.[33]

Parents reported children had almost double the amount of daily screen-time during summer versus school. This finding is not particularly surprising given the presence of the 6-hour school day which can limit screen-time opportunities to mainly before/after school, evenings, and weekends. A handful of studies that also used parent self-report estimates of screen-time during summer versus school reported similar findings,[13,14,34,35] although the screen-time estimate of the difference in this study was greater in comparison (+120 minutes/day versus + 18 minutes/day[14] +30 minutes/day[13]). Further, when screen-time does exist in school, duration and frequency is likely regulated. During summer, the potential for unsupervised and open-ended screen-time over the course of a day is relatively high. In light of these findings, increased screen-time during summer carries several important implications. Studies have found a positive association between screen-time and overweight/obesity among US children,[36] with a meta-analysis concluding a 1-hour per day increment in TV watching corresponded to a 13% increased risk of obesity.[37] Further, screen-time could be playing a role as a mediator to other unhealthy behaviors. For example, research has found associations between increased screen-time and over-consumption of calorie-dense low-nutrient foods and increased TV

Table 2. **Child-Level Obesogenic Behaviors During School Versus Summer**

	School			Summer			Statistical Test for Difference*	
Obesogenic Behavior	**Mean**	**±SD**	**(Range)**	**Mean**	**±SD**	**(Range)**	**Paired Sample *t* Test (p-Value)**	**Mixed Effects Model † (95% CI)**
Activity								
Wake wear time (minutes/day)	934.9	83	(662-1310)	892.7	112	(615-1200)	n/a	**(−58.8, −25.5)**
Sedentary (% of time)	66.7	7	(43-91)	68.9	9	(44-94)	n/a	**(0.9, 3.4)**
Light-intensity PA (% of time)	24.9	5	(8-40)	22.9	6	(5-43)	n/a	**(−2.8, −1.1)**
Moderate-to-vigorous PA (% of time)	8.3	3	(2-21)	8.1	3	(1-22)	n/a	(−0.7, 0.2)
Total PA (% of time)	33.2	7	(10-57)	31.0	9	(7-56)	n/a	**(−3.4, −0.9)**
Screen-time (minutes/day)								
Screen-time	123.6	91	(0-475)	244.2	172	(0-1010)	n/a	**(100.5, 140.7)**
Sleep (minutes/night)								
Sleep duration—Accelerometer	413.8	74	(241-654)	428.1	89	(235-761)	n/a	**(1.2, 27.4)**
Sleep duration—Parent-report	563.0	86	(300-830)	604.8	93	(300-865)	n/a	**(27.1, 56.8)**
Diet—Daily diary‡ (days per week)								
Fruits	4.7	2.1	(0.0-7.0)	7.0	0.0	(7.0-7.0)	**<.01**	n/a
Vegetables	5.3	2.0	(0.0-7.0)	5.7	1.5	(1.5-7.0)	.18	n/a
Dairy	2.7	2.5	(0.0-7.0)	3.2	2.8	(0.0-7.0)	.22	n/a
Convenience foods	2.3	1.8	(0.0-7.0)	2.8	1.6	(0.0-6.2)	.23	n/a
Sweets and desserts	2.5	1.5	(0.4-7.0)	6.0	0.9	(4.3-7.0)	**<.01**	n/a
Sugar sweetened beverages	2.1	1.5	(0.0-6.4)	2.5	1.5	(0.1-5.8)	.13	n/a

PA, physical activity; 95% CI, 95% confidence interval.
*Bolded values indicate statistical significance ($p < .05$).
†Mixed effects model including age and sex as covariates and accounting for children nested within observations.
‡Beverage and Snack Questionnaire (BSQ).

viewing influences children's food choices through child-targeted food advertisements.[38,39]

Parents and children reported a greater frequency of weekly consumption of fruits and sweets/desserts categories during summer versus school. These findings are in contrast to other studies either reporting lower frequency in consumption of fruit and vegetables during summer compared to school months,[14,40] or concluding no dietary differences exist between summer and school months.[13,15,41] The data shows children are consuming sweets and desserts (eg, candy, doughnuts, cookies etc) on average 6 out of 7 days per week during the summer, compared to school where this frequency drops to 2.5 days per week. Reported frequency of fruit consumption was also greater during summer, along with the remaining food/beverage categories that did not reach statistical significance. It could be the case children are consuming more of everything during summer, with meal assistance programs in schools controlling daily caloric intake by regulating what, when, and how much is served.[42] During summer children may be allowed more freedoms and opportunities to snack unsupervised on foods with low nutritional quality and it is plausible that an energy imbalance (ie, caloric intake > caloric expenditure) is occurring at a greater magnitude during summer compared to school.

This is among one of the first studies to report objective sleep data on the same children for summer and school in the United States. On average, children slept marginally longer during summer compared to school (7.1 vs 6.9 hours/night). One other study reported sleep outcomes derived from a youth survey and found no differences in sleep duration between school term versus school holidays.[13] Parent-reported child sleep duration in this study was longer during summer versus school (10.1 vs 9.4 hours/night), too. Previous studies have concluded that school-age children sleep ~10 hours per night,[6] however; the majority of children's sleep estimates are derived from self-report surveys and time diaries which are open to overestimation.[6] In this study, the accelerometer-derived sleep duration during both summer and school was markedly lower (~7 hours/night), and falls considerably short of the sleep recommendations put forth by the American Academy of Pediatrics (9-12 hours/night) for optimal health.[43] In this regard, children in this study—irrespective of during school or summer—are not getting adequate sleep, which is of concern given the negative association found between weight status and sleep duration in children.[44]

This study has several strengths and limitations. One of the main strengths of this study is the within-subject study design and assessment of a relatively unexplored area (summer). The use of objective measures to capture PA, sedentary, and sleep is also a strength. Children from ethnic minority and low-income families have been identified as one of the at-risk sub-groups more susceptible to accelerated weight gain over summer,[8] and this study provides preliminary evidence of obesogenic behaviors during summer versus school in this population. The final

within-subjects sample size (N = 30) prohibited further analysis stratified by sex, age/grade, or weight status. Retention for summer was a challenge, with 16 parent/child dyads not returning. Other limitations include the generalizability of the findings given the results pertain to children from one school, one region of the United States, and from one school-summer cycle.

In conclusion, preliminary evidence suggests children are displaying multiple unfavorable obesogenic behaviors during summer versus school that may be contributing to accelerated weight gain and losses in CRF during summer. The highly open-ended and unstructured nature of summer days, where children are given more freedoms and autonomy to choose how they spend their time, is a stark comparison to the regulated and structured days that occur during school months. In this light, it is plausible that children are making choices to engage in a host of unfavorable behaviors, sometimes concurrently (eg, excessive screen-time and snacking on energy-dense foods/beverages).[45] The continuous presence of these unhealthy traits over the course of summer could be leading to the adverse health outcomes observed in children when they return to school after summer. Longitudinal evidence investigating multiple summers, with larger, more diverse samples of children is necessary to identify specific behavioral targets for interventions that occur during summer.

IMPLICATIONS FOR SCHOOL HEALTH

Summer is emerging as a window of vulnerability for elementary school-aged children, particularly those from low-income households. Evidence suggests that any improvements gained during the 9 months of the school year are erased as children are released to summer vacation. Research into the causal factors associated with the accelerated weight gain occurring during summer in low income children is severely limited. The findings herein provide preliminary evidence that children are displaying a host of unfavorable obesogenic behaviors during summer compared to school. In light of this evidence schools should look to raise awareness on the importance of maintaining positive health behaviors during summer such as having regular bed/wake times, limiting screen/sedentary time, and regulating eating occasions. This could be done by communicating to the families they serve via newsletter or parent evenings during the months leading up to summer break.

Human Subjects Approval Statement

All study procedures were approved by the author's Institutional Review Board (University of South Carolina: Pro00041896) and parents provided written informed consent for the child. Verbal child assent was also obtained prior to data collection.

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