

Original article

The potential of a year-round school calendar for maintaining children's weight status and fitness: Preliminary outcomes from a natural experiment

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Abstract

Purpose: To evaluate the potential of a year-round school calendar (180-day school year distributed across 12 months) as an intervention compared to a traditional school calendar (180-day school year distributed across 9 months) for mitigating children's weight gain and fitness loss via a natural experiment.

Methods: Height, weight, and cardiorespiratory fitness (CRF) (i.e., Fitnessgram Progressive Aerobic Cardiovascular Endurance Run) were measured in children (5–12 years old) in 3 schools (2 traditional, 1 year-round, $n = 990$ students, age = 8.6 ± 2.4 years, 53.1% male, 68.9% African American) from 1 school district. Structure (represented by the presence of a school day) was the independent variable. Changes in body mass index (BMI), age- and sex-specific BMI z-scores (zBMI), BMI percentile, percent of overweight or obese children, and CRF (Progressive Aerobic Cardiovascular Endurance Run laps completed) were assessed for summer 2017 (May–August 2017), school year 2017/2018 (August 2017–May 2018), and summer 2018 (May–August 2018). Primary analyses examined the overall change in weight and CRF from summer 2017 until summer 2018 via multilevel mixed effects regression, with group (traditional vs. year-round calendar), time, and a group-by-time interaction as the independent variables. Secondary regression analyses estimated differences in change within and between groups during each time period, separately.

Results: Year-round students gained less BMI (difference in $\Delta = -0.44$, 95% confidence interval (CI): -0.67 to -0.03) and less CRF (difference in $\Delta = -1.92$, 95%CI: -3.56 to -0.28) than students attending a traditional school overall. Compared with traditional students, during both summers, year-round students gained less BMI (summer 2017 difference in $\Delta = -0.15$, 95%CI: -0.21 to -0.08 ; summer 2018 difference in $\Delta = -0.16$, 95%CI: -0.24 to -0.07) and zBMI (summer 2017 difference in $\Delta = -0.032$, 95%CI: -0.050 to -0.010 ; summer 2018 difference in $\Delta = -0.033$, 95%CI: -0.056 to -0.009), and increased CRF (summer 2017 difference in $\Delta = 0.40$, 95%CI: 0.02 – 0.85 ; summer 2018 difference in $\Delta = 0.23$, 95%CI: -0.25 to 0.74). However, the opposite was observed for the school year, with traditional students gaining less BMI and zBMI and increasing CRF compared with year-round students (difference in BMI $\Delta = 0.05$, 95%CI: 0.03 – 0.07 ; difference in zBMI $\Delta = 0.012$, 95%CI: 0.005 – 0.019 ; difference in Progressive Aerobic Cardiovascular Endurance Run laps $\Delta = -0.43$, 95%CI: -0.58 to -0.28).

Conclusion: The year-round school calendar had a small beneficial impact on children's weight status but not CRF. It is unclear if this benefit to children's weight would be maintained because gains made in the summer were largely erased during the school year. Trajectories of weight and CRF gain/loss were consistent with the structured days hypothesis.

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1. Introduction

Most childhood obesity interventions have targeted school settings. A recent review of childhood obesity interventions

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funded by the National Heart, Lung, and Blood Institute revealed that 70% were conducted in schools.¹ Furthermore, in the most comprehensive review to date, Wang et al.² identified 139 childhood obesity interventions, with 115 interventions (82%) targeting schools. Finally, the most recent review of childhood obesity prevention interventions included 56 total interventions. A total of 41 of these interventions (73%) were primarily conducted in schools.³

Nearly all youth attend school (about 95% of youth aged 5–18 years in the United States),⁴ and schools have the infrastructure, facilities, and staff in place to decrease children's engagement in negative obesogenic behaviors. Thus, the concerted focus on the school setting to address obesity is not surprising. However, interventions that target schools have largely failed to decrease rates of childhood obesity⁵ and related behaviors.⁶ Thus, after decades of ineffective school-based interventions it may be time to shift the focus away from schools. In fact, there is growing evidence that schools are not the root of the childhood obesity epidemic. In fact, a multitude of evidence indicates children gain more weight during the summer (i.e., June–August) than during the 9 months of the school year (i.e., August–May).^{7–9} For instance, a recent study of 18,170 children in the Early Childhood Longitudinal Program Kindergarten cohort of 2011 showed that from kindergarten through the second grade, children's weight gain occurred exclusively during the summer.¹⁰ There is also evidence showing that children gain cardiorespiratory fitness (CRF) during the school year while losing CRF during the summer.^{8,9} This evidence indicates that routine practice at schools may be an important and overlooked obesity and CRF intervention in and of itself.

The structured days hypothesis (SDH)¹¹ may explain why school attendance mitigates weight gain and CRF loss. This hypothesis posits that structure, defined as a pre-planned, segmented, and adult-supervised compulsory environment, plays a protective role for children against obesogenic behaviors and, ultimately, prevents the occurrence of negative health outcomes (e.g., excessive weight gain and loss in CRF). The SDH draws on concepts in the filled-time perspective literature, which posits that time filled with favorable activities cannot be filled with unfavorable activities.¹² This perspective leads to the hypothesis that children engage in a greater number of obesogenic behaviors that lead to increased weight gain during times that are less structured—in this case, days without school—compared with times that are more structured, such as school days. Negative obesogenic behaviors include (1) increased time spent sedentary,¹³ (2) decreased engagement in physical activity,^{13,14} (3) displaced and unstable sleep patterns,^{15,16} and (4) unhealthy diet.^{17–19} A review of 190 studies reporting outcomes across these obesogenic behaviors supports this hypothesis, with approximately 80% of the studies showing that obesogenic behaviors were less favorable on less structured days, represented by weekend days, compared with more structured days, represented by school days.¹¹

One potentially effective intervention strategy to address obesity, founded on the SDH might be to alter the school calendar to

interrupt long stretches of less structured time, like the 3-month summer vacation, with structured school days. An example of this strategy of interrupting less structured time is a year-round school calendar. Schools following a year-round calendar operate on the same 180-day schedule but take more frequent and shorter breaks (e.g., 45 school days followed by 15 break days) rather than having 1 long summer break. Recent data indicate that 3700 public schools²⁰ serving more than 2,000,000 students across 45 states operate on a year-round school calendar.²¹ However, no studies have explored the potential of this type of scheduling as an intervention strategy for mitigating weight gain and CRF loss.

The objective of this natural experiment was to evaluate the potential of a year-round school calendar for treating and preventing children's weight gain and CRF loss compared to children attending a school following a traditional calendar over a 15-month period. A secondary objective was to test the SDH by examining weight gain and CRF loss during the traditional months of summer (i.e., June–August) and the school year (i.e., August–May) in children attending a year-round school compared to children attending a traditional school. Based on the SDH it is hypothesized that the year-round school will experience smaller increases in mean body mass index (BMI), age- and sex-specific BMI z-scores (zBMI), BMI percentile, and percent of children classified as overweight or obese and greater increases in CRF over the traditional summer. However, it is hypothesized that, during the traditional school year, children attending the year-round and traditional schools will experience more similar increases in BMI, zBMI, BMI percentile, and overweight or obesity percent and increases in CRF. Furthermore, it is hypothesized that the relatively smaller increases in BMI, zBMI, BMI percentile, and overweight or obesity percent and greater increases in CRF during the summer that children attending the year-round school experience will lead to smaller overall increases in BMI, zBMI, BMI percentile, and overweight or obesity percent and greater increases in CRF over a 15-month period.

2. Methods

2.1. Setting and participants

Characteristics of the participating schools and children ($n = 990$) are presented in [Table 1](#). Three schools in 1 school district participated in the study. Schools were selected because 1 school (i.e., School A, followed a year-round schedule) and the 2 other schools (i.e., Schools B and C, followed a traditional schedule) were matched based on school level, student race/ethnicity, gender, number of students enrolled, age/grade levels served, percentage of students receiving free and reduced lunch, and academic test scores. Prior to each data collection wave, a letter with information about the study and data collection protocols was sent home to parents with instructions on how they could opt for their children not to participate. Children provided verbal assent prior to each measurement occasion. All protocols were approved by the lead author's University of South Carolina Institutional Review Board.

Table 1
Characteristics of participant schools and students at baseline.

School	A Year-round calendar	B Traditional calendar	C Traditional calendar	All schools	<i>p</i> ^a
School characteristics					
Total students (<i>n</i>)	438	456	389	1283	
Percent male (%)	53.3	60.5	49.9	54.6	
Grades served	Pre-K–6	Pre-K–6	K–6	Pre-K–6	
Race (%)					
White	29.5	23.5	32.8	28.6	
Percent Black	63.0	67.6	57.8	62.8	
Other race/ethnicity (including all race/ ethnicities other than Black or Whites)	7.5	8.9	9.4	8.6	
Free and reduced lunch	81.0	87.0	84.0	84.0	
Participant characteristics					
<i>n</i>	375	289	326	990	
Male (%)	50.8	57.4	51.2	53.1	0.64
Mean grade (SD)	3.1 ± 2.0	2.9 ± 1.8	3.1 ± 1.9	3.0 ± 1.9	0.30
Mean age (year, SD)	8.5 ± 2.5	8.9 ± 2.0	8.5 ± 2.2	8.6 ± 2.4	0.18
Race (%)					0.40
White	27.4	18.9	30.1	25.7	
Black	67.8	75.3	64.5	68.9	
Other race/ethnicity (including all race/ ethnicities other than Black or Whites)	4.8	5.8	5.4	5.4	
Mean PACER laps completed	16.5 ± 8.9	13.6 ± 8.5	14.2 ± 8.5	15.0 ± 8.8	<0.01
Mean BMI (kg/m ² , SD)	20.1 ± 5.4	20.1 ± 5.5	19.6 ± 5.0	20.0 ± 5.3	0.20
Mean zBMI (SD)	0.91 ± 1.10	0.80 ± 1.23	0.76 ± 1.16	0.83 ± 1.16	0.08
Mean BMI percentile (% , SD)	73.6 ± 27.3	70.6 ± 29.1	69.0 ± 30.7	71.3 ± 28.9	<0.01
Weight status (%)					
Underweight	1.6	2.8	3.4	2.6	
Normal weight	50.0	52.1	51.4	51.1	
Overweight	16.9	15.3	18.4	16.9	
Obese	31.5	29.8	26.8	29.4	

^a *p* value for comparison between year-round and traditional schools at baseline. Continuous variables compared using two-sample *t* tests; categorical variables compared using χ^2 tests.

Abbreviations: BMI = body mass index; PACER = Progressive Aerobic Cardiovascular Endurance Run; K = Kindergarten; SD = standard deviation; zBMI = age- and sex-specific BMI z-scores.

2.2. Study design

This study was a natural experiment. A natural experiment is a study that investigates the effects of a naturally occurring event when the independent variable is not manipulated by the study team.²² Although natural experiments are not randomized trials, causal inference can be made if there is temporal precedence, a plausible counterfactual, and no self-selection by participants into groups. In this study the independent variable is the structure provided by the school day. This structure is added/removed at different times of the year, but this timing was not determined by our study team. Furthermore, the study is similar to an ABA design in single-subject studies²² in that more structured days are added during the school year for traditional students and removed during the summer. The opposite is true for year-round school students (i.e., they have relatively lower levels of structured days during the traditional school year and higher levels of structure during the summer when compared to the traditional school calendar). By adding and removing the independent variable in this way, temporal precedence can be established. Furthermore, this study has both a within-group and between-group counterfactual.

The within-group counterfactual is the summer compared to the school year, or *vice versa*, for each group. The between-group counterfactual is the children attending the opposite school calendar during each time period (traditional summer or school year). Finally, because students are allocated to school according to their home address by the school district, families are not self-selecting either the traditional or year-round school calendar.

2.3. School calendars

The main contrast of interest in the current natural experiment was the difference in the number of structured days (i.e., school days). The type of school calendar that the participating schools followed (i.e., traditional vs. year-round) affected when more structured days were available to children. School calendars are presented in Figs. 1A and 1B. Traditional schools follow a calendar that condenses the 180-day school year into 9 months, typically late August through May, and provides an extended 3-month vacation from school during the summer, typically June through early August. Year-round schools follow a 180-day school year as well, but school days

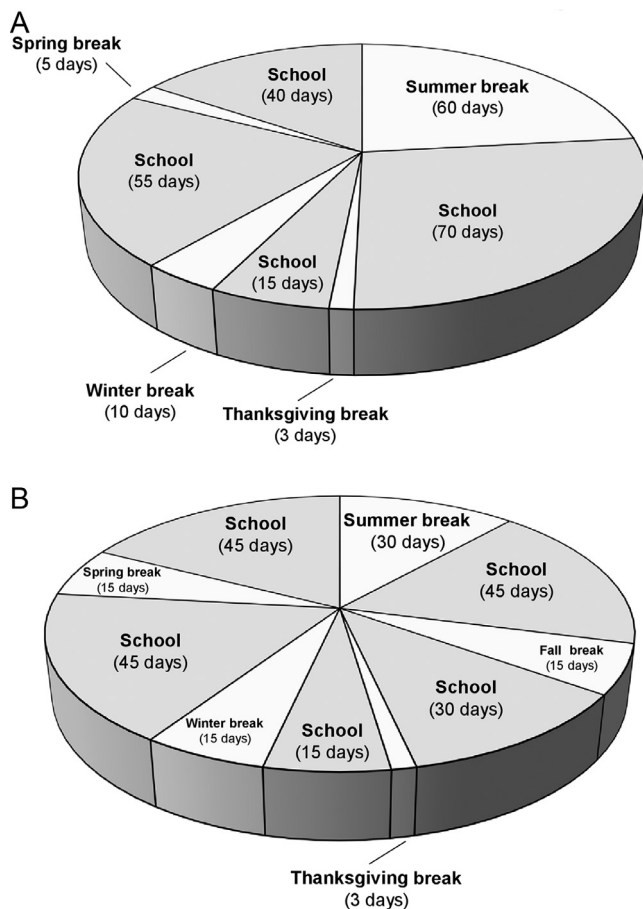


Fig. 1. (A) Traditional school calendar; (B) Year-round school calendar.

are equally spread throughout the calendar year by taking more frequent but shorter breaks. The year-round school in this study followed a 45-on, 15-off schedule. That is, children attended school for 45 weekdays (i.e., 9 weeks) and then did not attend school for 15 weekdays (i.e., 3 weeks). During the summer, the year-round school provided a 5-week break from school, while the traditional schools provided a 10-week break from school.

2.4. Measures

2.4.1. Height and weight

Using a portable stadiometer (Model S100, Ayrtion Corp., Prior Lake, MN, USA) and digital scale (Healthometer model 500KL, Health o meter, McCook, IL, USA), children's heights (nearest 0.1 cm) and weights (nearest 0.01 lbs.), without shoes, were collected by 2 research assistants. To measure heights, the research assistants instructed children to stand upright with arms and hands parallel to the body. Next, the assistants instructed children to stand on a digital scale to have their weight recorded. BMI was then calculated ($BMI = \text{kg}/\text{m}^2$) and transformed into age- and gender-specific z-scores.²³ All students in Grade Kindergarten to Grade 5 who attended one of the 3 participating schools were eligible to participate in the study.

2.4.2. CRF

The Fitnessgram Progressive Aerobic Cardiovascular Endurance Run (PACER) was administered during regularly scheduled physical education (PE).^{24–30} This test produces valid estimates of elementary school-aged children's CRF. The PACER was carried out by 1 trained data collector and the PE teacher, either on a marked outdoor green space or in an indoor gymnasium (depending on the school). Children were instructed to run from 1 cone marker to another cone placed 20 m apart. Music and voice instructions were used to prompt children to run and stop within an allotted amount of time. As the test progressed, the allotted time to run the 20 m incrementally decreased. If the child failed to reach the cone/ marker within the allotted time frame on 2 occasions, the test was ended and the laps score was recorded.

2.5. Procedures

Changes in children's heights, weights, and CRF were measured for summer 2017 (May–August 2017), school year 2017/2018 (August 2017–May 2018), and summer 2018 (May–August 2018). A schedule of measures is presented in Fig. 2. All measures in both the year-round and traditional schools were based on the traditional school calendar and occurred during the same 2-week period. Measures were completed during the last (end of school year) or first (beginning of school year) 2 weeks of the traditional school year. All measures were obtained during regularly scheduled PE class time in all schools. At the beginning of each PE class period, children were divided into sex-specific groups. One data collector administered the CRF test (e.g., PACER) with 1 group of children, while the other data collector measured heights and weights for the other group. This pattern was repeated until all consenting children in the PE class had their measures taken.

2.6. Statistical analyses

All analyses were conducted using STATA (Version 14.2; College Station, TX, USA). The data from all children with at least 1 valid measure of BMI or PACER at any time point were included in the analyses.^{31–33} All models used full information, maximum likelihood estimators to account for missing outcome data. Descriptive statistics (i.e., means, standard deviations, percentages—dichotomous variables) were computed for child demographics, BMI, and PACER data. Separate multilevel mixed effects linear regression models were used. BMI, zBMI, BMI percentile, percent of children overweight or obese, and PACER laps as the dependent variables. Group (i.e., traditional or year-round), measurement wave (i.e., the beginning of summer 2017 to the end of summer 2018), and group-by-wave interaction (i.e., differential change between groups over time) were estimated and used as the independent variables. The group-by-wave interaction was interpreted as the difference in change in the dependent variable between children attending the year-round school and the traditional schools. These models accounted for the nested nature of the data, with measurements nested within children. Data were not nested at the school level because school-level nesting confounded with group condition (i.e., only 1 school followed a year-round calendar). The

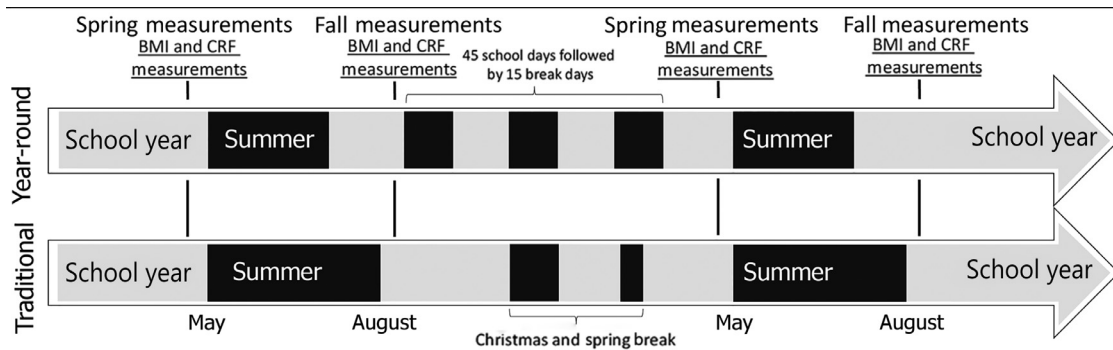


Fig. 2. Schedule of measurement. BMI = body mass index; CRF = cardiorespiratory fitness.

dependent variable was treated as continuous in all models. Secondary analyses with the same nested structure and dependent variables estimated differences in the change in the dependent variable between children attending the year-round and the traditional schools during each summer (i.e., 2017 and 2018) and the school year separately. For the secondary analyses, all estimates were interpreted as monthly change over time. Estimates were converted by dividing the overall change during the relevant time period (i.e., summer 2017, school year 2017/2018, or summer 2018) by the number of months that passed during that time period (3 months for summer and 9 months for school year). This was done to standardize the change because of the differential lengths of the time periods that were compared. Follow-up sensitivity analyses using the same analytic strategy were completed on the advantageous cohort of children that had data at every data collection time period. All primary and secondary and follow-up sensitivity analyses regression models controlled for gender, age, race, and baseline levels of the dependent variable.

3. Results

Characteristics of the participating schools and students at baseline are presented in Table 1. Results of the primary analyses exploring overall change from the beginning of summer 2017 until the end of summer 2018 (15-month change) are presented in Table 2. Children in the year-round school gained 1.23 (95% confidence interval (CI): 1.00–1.38) in BMI while children in the traditional schools gained 1.67 (95%CI: 1.54–1.83) in BMI. This represented a statistically significant difference in favor of the students attending the year-round school of -0.44 (95%CI: -0.67 to -0.03) in BMI. Children attending the year-round school gained 0.02 (95%CI: -0.05 to 0.08) zBMI units while children at the traditional schools gained 0.09 (95%CI: 0.05–0.14) zBMI units. The difference in change in favor of the students attending the year-round school of -0.07 (95%CI: -0.15 to 0.01) was not statistically significant. Children in the year-round school gained 0.05 in BMI percentile (95%CI: -1.73 to 1.83) while children in the traditional schools gained 1.73 in BMI percentile (95CI:

Table 2
Model estimated 15-month change in BMI, zBMI, percent of children overweight or obese, and pacer laps by school calendar.

	Baseline	15 months	Within group change	95%CI	Group-by-wave interaction	95%CI
BMI (kg/m ²)						
Year-round	20.33	21.56	1.23	1.00 to 1.38	-0.44	-0.67 to -0.03
Traditional	20.35	22.02	1.67	1.54 to 1.83		
zBMI						
Year-round	1.01	1.03	0.02	-0.05 to 0.08	-0.07	-0.15 to 0.01
Traditional	0.96	1.05	0.09	0.05 to 0.14		
BMI (%)						
Year-round	75.81	75.86	0.05	-1.73 to 1.83	-1.67	-3.69 to 0.69
Traditional	73.41	75.13	1.73	0.39 to 3.07		
OWOB (%)						
Year-round	51.45	51.85	0.39	-4.81 to 4.48	-3.82	-9.56 to 1.93
Traditional	51.15	55.37	4.21	0.89 to 8.03		
PACER (laps)						
Year-round	15.51	17.01	1.50	0.00 to 2.49	-1.92	-3.56 to -0.28
Traditional	12.53	15.96	3.43	2.47 to 4.63		

Note: Statistically significant differences are bolded. Baseline values are slightly different from Table 3 baseline values because, as described in the methods, they are derived from different analytic models.

Abbreviations: BMI = body mass index; CI = confidence interval; OWOB = overweight or obese; PACER = Progressive Aerobic Cardiovascular Endurance Run; zBMI = age-sex-specific BMI z-scores.

0.39–3.07). The difference in change in favor of the students attending the year-round school of -1.67 (95%CI: -3.69 to 0.69) BMI percentile points was not statistically significant. The percent of children categorized as overweight or obese increased by 0.39% (95%CI: -4.81% to 4.48%) in the year-round school and 4.21% (95%CI: 0.89% – 8.03%) in the traditional schools. This represented a non-statistically significant difference in change in favor of the students attending the year-round school of -3.82% (95%CI: -9.56% to 1.93%). Children in year-round and traditional schools increased the number of PACER laps completed by 1.50 (95%CI: 0.00 – 2.49) and 3.43 (95%CI: 2.47 – 4.63) laps, respectively. This represented a statistically significant difference in change in favor of the students attending the traditional schools of -1.92 (95%CI: -3.56 to -0.28) laps.

Secondary analyses examining differences in change by school calendar during both summers and the school year are presented in Table 3. During both summer 2017 and summer 2018, children in the year-round school gained 0.00 (95%CI: -0.05 to 0.05) and 0.03 (95%CI: -0.03 to 0.10) BMI units per month, respectively, while children at the traditional schools gained 0.15 (95%CI: 0.11 – 0.19) and 0.19 (95%CI: 0.14 – 0.24) BMI units/month, respectively. These changes of -0.15 (95%CI: -0.21 to -0.08) and -0.16 (95%CI: -0.24 to -0.07) in summer 2017 and summer 2018, respectively, represented a statistically significant difference in monthly BMI units in favor of children attending the year-round school when compared to children attending the traditional schools.

During the school year, children in the year-round school gained 0.12 (95%CI: 0.10 – 0.14) BMI units per month compared to 0.07 (95%CI: 0.06 – 0.09) BMI units per month for children attending the traditional schools. This represented a statistically significant difference of 0.05 (95%CI: 0.03 – 0.07) BMI units per month in favor of children attending the traditional schools.

For zBMI, children in the year-round school lost 0.02 (95%CI: -0.04 to -0.01) and 0.01 (95%CI: -0.03 to 0.01) zBMI units per month in summer 2017 and summer 2018, respectively. Children in the traditional schools gained 0.01 (95%CI: -0.01 to 0.02) and 0.02 (95%CI: 0.01 – 0.03) zBMI units per month during summer 2017 and summer 2018, respectively. These changes represented statistically significant differences in monthly zBMI of -0.03 (95%CI: -0.05 to -0.01) and -0.03 (95%CI: -0.06 to -0.01) for summer 2017 and summer 2018, respectively, in favor of children attending the year-round school. During the school year, children in the year-round school gained 0.02 (95%CI: 0.01 – 0.03) zBMI units per month, while children in the traditional schools gained 0.00 (95%CI: -0.01 to 0.01) zBMI units per month. This represented a statistically significant difference in change of 0.02 (95%CI: 0.01 – 0.03) zBMI units per month in favor of children attending the traditional schools.

The percent of children classified as overweight or obese in the year-round school decreased by 0.63% (95%CI: -1.76% to 0.49%) and 0.52% (95%CI: -1.83% to 2.20%) per month in summer 2017 and summer 2018, respectively. The percent of children who were overweight or obese in the traditional schools increased by 0.47% (95%CI: -0.46% to 1.39%) and

Table 3 Model estimated monthly change in BMI, zBMI, percent of children overweight or obese, and PACER laps by school calendar and school year, summer.

	Baseline			Summer 1			Summer 2				
	Monthly change	95%CI	Between group difference	Monthly change	95%CI	Between group difference	Monthly change	95%CI	Between group difference		
										School year	School year
BMI (kg/m ²)											
Year-round	20.32	0.00	-0.15	0.12	0.10 to 0.14	0.05	0.03 to 0.07	0.03	-0.03 to 0.10	-0.16	-0.24 to -0.07
Traditional	20.34	0.15	—	0.07	0.06 to 0.09	—	—	0.19	0.14 to 0.24	—	—
zBMI											
Year-round	1.01	-0.02	-0.03	0.02	0.01 to 0.03	0.02	0.01 to 0.03	-0.01	-0.03 to 0.01	-0.03	-0.06 to -0.01
Traditional	0.96	0.01	—	0.00	-0.01 to 0.01	—	—	0.02	0.01 to 0.03	—	—
BMI (%)											
Year-round	75.77	-0.58	-0.83	0.29	0.15 to 0.44	0.72	0.10 to 1.29	-0.32	-0.80 to 0.15	-0.68	-1.30 to -0.04
Traditional	73.25	0.08	—	0.05	-0.07 to 0.18	—	—	0.36	-0.05 to 0.77	—	—
OWOB (%)											
Year-round	51.58	-0.63	-1.10	0.34	-0.06 to 0.73	0.37	-0.15 to 0.89	-0.52	-1.83 to 2.20	-1.47	-3.13 to 0.31
Traditional	51.22	0.47	—	-0.03	-0.37 to 0.31	—	—	0.95	-0.15 to 2.05	—	—
PACER (laps)											
Year-round	15.50	0.54	0.40	-0.02	-0.14 to 0.09	-0.43	-0.58 to -0.28	-0.01	-0.39 to 0.37	0.23	-0.25 to 0.74
Traditional	12.52	0.13	—	0.41	0.31 to 0.50	—	—	-0.24	-0.56 to 0.08	—	—

Notes: Statistically significant differences are bolded. Baseline values are slightly different from Table 2 baseline values because, as described in the methods, they are derived from different analytic models. Abbreviations: BMI = body mass index; CI = confidence interval; OWOB = overweight or obese; PACER = Progressive Aerobic Cardiovascular Endurance Run; zBMI = age- and sex-specific BMI z-scores.

0.95% (95%CI: -0.15% to 2.05%) per month in summer 2017 and summer 2018, respectively. Although not statistically significant, this represented a difference in monthly change of -1.10% (95%CI: -2.48% to 0.45%) and -1.47% (95%CI: -3.13% to 0.31%) during summer 2017 and summer 2018, respectively, between the percent of children classified as overweight or obese in the year-round school compared to the traditional schools. During the school year, the percent of overweight or obese children in the year-round school increased by 0.34% (95%CI: -0.06% to 0.73%) per month, while the percent of overweight or obese children in the traditional schools was stable ($\Delta = -0.03\%$ per month, 95%CI: -0.37% to 0.31%).

The number of PACER laps completed by children attending the year-round school increased by 0.54 (95%CI: $0.21-0.86$) laps per month during summer 2017 and decreased by 0.01 (95%CI: -0.39 to 0.37) laps per month in summer 2018. For children attending the traditional schools the number of PACER laps increased by 0.13 (95%CI: -0.13 to 0.40) laps per month during summer 2017 and decreased by 0.24 (95%CI: -0.56 to 0.08) laps per month during summer 2018. This represented a statistically significant difference in change of PACER laps per month during summer 2017 between year-round and traditional school students of 0.40 (95%CI: $0.02-0.85$) laps per month. During summer 2018 the difference in change in PACER laps per month between year-round and traditional students was 0.23 (95%CI: -0.25 to 0.74), not reaching statistical significance. During the school year, children in the year-round school lost 0.02 (95%CI: -0.14 to 0.09) PACER laps per month, while children in the traditional schools gained 0.41 (95%CI: $0.31-0.50$) PACER laps per month. This represented a statistically significant difference in change of -0.43 (95%CI: -0.58 to -0.28) PACER laps per month in favor of children attending the traditional schools.

Follow-up sensitivity analyses of the advantageous cohort of children with complete data were consistent with the primary and secondary analyses.

4. Discussion

This study is the first to examine the potential of a year-round school calendar as an intervention strategy for prevention and/or treatment of overweight and obesity and CRF loss in elementary school-aged children. The findings in this study are inconclusive in relation to the usefulness of adjusting the school calendar to include shorter, more frequent breaks (i.e., 3-week breaks after every 9 weeks of school) as an intervention strategy, and thus did not support our primary hypothesis. While children in the year-round school had smaller gains in BMI, zBMI, and BMI percentile and were less frequently classified as overweight or obese at the end of the 15-month study period, these differences were not statistically significant except for BMI. Furthermore, it is unclear if these differences would grow over time since it appears that the benefits experienced by children attending the year-round school were erased during the traditional school year. Finally, changing the school

calendar may slow the development of CRF in children. Our secondary analyses showed that the trajectories of BMI and CRF gain were consistent with the SDH, and thus did support our secondary hypotheses. That is, children attending the year-round school had smaller gains in BMI and lost less CRF during summers than children attending the traditional schools, given that year-round students were exposed to more structured school days during summers. However, the opposite was observed for students attending traditional schools, where students were exposed to more structured school days during the regular school year.

Several recent reviews of childhood obesity treatment^{34,35} and prevention^{1,2,36} interventions have been conducted, including 2 completed by the Cochrane group.^{34,36} The obesity prevention systematic review reported that differences in BMI change between children enrolled in the intervention and control children were -0.15 BMI units (i.e., in favor of intervention) after intervention.³⁶ In our study, differences in BMI change were almost 3 times larger than those reported in the Cochrane review (i.e., -0.44 BMI units). In a recent Cochrane review of childhood obesity treatment interventions, the difference between treatment and control was -0.06 zBMI units in favor of the intervention at 6 months and -0.04 zBMI units in favor of the intervention at 12 months.³⁴ In our study, children in the year-round school gained 0.07 less zBMI units over the 15-month study compared to their counterparts attending the traditional schools, even though this was not statistically significant. What is unclear is if these differences will be maintained because our secondary analyses showed that the gains during the summer in students attending the year-round school were largely erased during the months of the traditional school year. Thus, further studies that evaluate differences in weight outcomes by school calendar over multiple school years and summers are needed. Many of the treatment and prevention interventions in the Cochrane reviews required intensive behavioral interventions and/or prescribed medications, which can be expensive to deliver, have intervention fidelity issues, and may be of questionable acceptability for the target population. Thus, if it proves to be more effective, modifying the school schedule to avoid long periods of unstructured time during the year may be a preferable intervention strategy compared to behavioral or pharmacological interventions.

Consistent with the SDH,¹¹ children in the year-round school in our study gained fewer BMI units than children in the traditional schools during the 15-month study period. Furthermore, during each of the 2 summers, children in the year-round schools gained less weight than their counterparts attending traditional schools. The same pattern was observed in terms of CRF for the first summer but not the second. During the school year, though, this trend was reversed, with children attending the year-round school gaining more weight and less CRF than children in the traditional schools. This pattern was consistent with the “dose” of structure the children received. Children in the year-round school took a 5-week vacation from school, compared to a 10-week vacation from school for traditional school children. Therefore, the SDH

would speculate that year-round children would gain less weight during the traditional 3-month summer. Children in the year-round school attended fewer days of school during the school year compared to the children at the traditional schools. Therefore, the SDH would speculate that year-round children would gain more weight during the traditional 9-month school year. Two other studies have examined the impact of structure during the summer on children's weight gain and CRF loss.^{8,37} The first study examined 138 ninth-grade students who attended ($n = 70$) or did not attend ($n = 68$) summer school. Consistent with the findings from the current study, this study found that students who did not attend summer school experienced statistically significant greater weight gains and CRF loss over the 3 months of summer.⁸ The second study examined the impact of an 8-week, multicomponent summer program on 87 elementary-aged children's weight status. The study found that children did not experience an increase in zBMI over the summer. Thus, combined with the findings of the current study there is preliminary evidence that increased structure via the school day can positively impact weight and CRF outcomes.

In contrast with the positive impact that the year-round school calendar had on children's BMI, the year-round calendar had a small detrimental impact on children's development of CRF when compared to children attending traditional schools. It is unclear why children in the traditional schools gained more CRF than children in the year-round school. However, it is important to note that children in the traditional schools were less fit than those in the year-round school at baseline (12.53 vs. 15.51 PACER laps at baseline, respectively) and the difference in the development of CRF indicated that the children in the traditional schools closed the gap between themselves and year-round school children (15.96 vs. 17.01 PACER laps, respectively) by end of the intervention. Furthermore, these are relatively small changes in CRF overall. For instance, in a recent study of summer CRF loss with 1232 elementary-aged children, girls and boys lost 4.5 PACER laps over one 12-week summer.³⁸ Over the 15-month period assessed in our study, children attending the traditional schools gained 3.43 PACER laps while children attending the year-round school only gained 1.50 PACER laps. Thus, these changes are negligible and may be within the margin of error of field tests of CRF. Nonetheless, this study shows that children do not benefit in terms of CRF by attending a school with a year-round calendar.

Although the findings from our study related to changing the school calendar to minimize long breaks from school and mitigate unhealthy weight gain are inconclusive, there was a clear pattern showing that increased structure leads to better weight outcomes. Thus, identifying strategies to provide children with more structure on days that were previously less structured, for example, summer days, could be an effective intervention strategy as well. Summer day camps, which have been shown to provide healthy structured environments, are currently offered as community-based programs. These camps usually operate 8–10 h/day for 8–10 weeks during summer vacations and include a wide variety of activities that engage children. Many summer camps participate in the United States Department of Agriculture Summer Food Service Program, which sets nutritional guidelines

related to quantity and quality of foods served in programs that serve children from low-income households.³⁹ In return, these camps receive federal reimbursement for the foods served. Recent research suggests that meals and snacks served in summer day camps meet nutritional guidelines.⁴⁰ Furthermore, attendance at these camps can help regulate sleep schedules because the camps typically start between 7 a.m. and 9 a.m. Additionally, children attending summer day camps accumulate between 60 and 90 min^{41,42} of moderate-to-vigorous physical activity each day they attend. Finally, summer day camps offer a variety of activities, including enrichment programs, physical activities, lunches/snacks, field trips, and so forth,^{41,43} which effectively limit children's screen time. Providing children with vouchers to attend these programs has been suggested as an intervention strategy to interrupt the long break from school during the summer and in turn mitigate unhealthy weight gain.⁴⁴

Our study has several strengths, including the use of valid and reliable objective measures of BMI and CRF, the use of the SDH to guide interpretation of the results, the inclusion of a large sample that is representative of the schools included in the study, the longitudinal design, and the replication of results over 2 summers. However, the study does have limitations that should be considered when interpreting results. First, findings from this study should be considered preliminary because only 3 schools (i.e., 1 following a year-round calendar and 2 following a traditional school calendar) participated. Furthermore, this study only includes schools in the southeastern United States, and therefore the external validity of these findings may be limited to similar schools in that region. Findings from this study should be replicated over more school years and summers to provide further evidence related to the SDH. Participants in this natural experiment were not randomized to study condition; thus, selection effects may exist in the data. Future studies should attempt to include schools in more regions of the United States, examine multiple school years and summers, and randomize children to receiving structure during the summer months. Finally, weight status and fitness are influenced by a constellation of factors, including but not limited to movement skills, attitudes, motivation, and socioeconomic status. However, these constructs were not measured in our study. Future studies should explore the intersection of other constructs with structure to identify which populations of children accrue greater benefits from structured days.

5. Conclusion

The year-round school calendar may produce a small beneficial impact on children's BMI but not on their CRF. However, it is not clear whether the benefits to BMI are sustainable because the gains made during the summer by children attending the year-round school were diminished over the months of the traditional school year. Patterns of BMI gain and CRF loss during the summer and school year support the SDH. Follow-up studies should seek to replicate our findings and explore the impact of other structured programming on children's BMI and CRF, especially during summer breaks from school.

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Authors' contributions

RGW conceptualized and designed the study, participated in the coordination and execution of the study, performed and reviewed the statistical analyses, and participated in the drafting, writing, and revising of the manuscript; EH and AR participated in coordination and execution of the study and drafting, writing, and revising of the manuscript; MWB, KB, SY, GTM, BS, RRP, and AMO participated in conceptualizing and designing the study, and drafting, writing, and revising of the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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