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Impact of a year-round school calendar on children's BMI and fitness: Final outcomes from a natural experiment

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Summary

Background: Structure may mitigate children's accelerated summer BMI gain and cardiorespiratory-fitness (CRF) loss.

Objectives: Examine BMI and CRF change during school and summer for year-round and traditional calendar school children.

Methods: Three schools (N = 2279, 1 year-round) participated in this natural experiment. Children's BMI z-score (zBMI) and CRF (PACER laps) were measured from 2017 to 2019 each May/August. Mixed effects regression estimated monthly zBMI and CRF change during school/ summer. Secondary analyses examined differences by weight status and race. Spline regression models estimated zBMI and CRF growth from kindergarten-sixth grade.

Results: Compared to traditional school, children attending a year-round school gained more zBMI (difference = 0.015; 95CI = 0.002, 0.028) during school, and less zBMI (difference = −0.029; 95CI = −0.041, −0.018), and more CRF (difference = 0.834; 95CI = 0.575, 1.093) monthly during summer. Differences by weight status and race were observed during summer and school. Growth models demonstrated that the magnitude of overall zBMI and CRF change from kindergarten-sixth grade was similar for year-round or traditional school children.

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CONFLICT OF INTERESTS
The authors declare that they have no competing interests.

Conclusions: Contrary to traditional school children zBMI increased during the traditional 9-month school calendar and zBMI decreased during the traditional summer vacation for year-round school children. Structured summer programming may mitigate accelerated summer BMI gain and CRF loss especially for overweight or obese, and/or Black children.

Keywords

children; obesity; policy

1 | INTRODUCTION

In the United States, obesity rates in children and adolescents (2–19 years) have nearly doubled over the last three decades, and in 2016 one in five children were classified as obese.[1] Cardiorespiratory-fitness (CRF) of youth has also declined by approximately 7.0% since the 1970s.[2] Childhood obesity is related to a multitude of negative health outcomes including type 2 diabetes, high blood pressure, sleep apnea and asthma,[3–7] while low cardiorespiratory CRF is linked to decreased bone mineral density, increased risk for overweight and obesity, metabolic syndrome and high blood pressure.[8]

The months of the traditional summer vacation have been identified as a period of increased risk for the development of obesity and CRF loss.[9,10] For example, a recent study examined the Early Childhood Longitudinal Study data which collected heights and weights on a nationally representative complex random sample of 18 170 U.S. children in the fall and spring from the kindergarten year of school (2011) to the spring of second grade (2013).[11] These data demonstrated that all BMI gain occurred during the months of traditional summer vacation (ie, May–August) and that the prevalence of children with overweight and obesity increased during the months of traditional summer vacation and decreased during the months of the traditional school year (ie, August–May). These findings mirror similar analyses done by the same authors using data from the Early Childhood Longitudinal Study collected from 1998–2000[12] and a number of other longitudinal observational studies from independent research groups.[13–17] In addition, evidence is mounting that children are at risk for CRF loss during the months of traditional summer vacation,[14,17–19] though relatively fewer studies have examined this phenomenon.

The structure afforded by school may protect children from excessive BMI gain and CRF loss. The protective effect of the school year on children's BMI and CRF is demonstrated by studies that show accelerated summer BMI gain[13–17] and CRF loss,[14,17–19] and may be explained by the structured days hypothesis.[20] The structured days hypothesis posits that structure, defined as a pre-planned, segmented, and adult-supervised compulsory environment, plays an overall protective role for children against obesogenic behaviours and, ultimately, prevents the occurrence of negative health-outcomes, including excessive BMI gain and CRF loss. The structured days hypothesis draws upon the "filled-time perspective", which suggests that time filled with favourable activities cannot be filled with unfavourable activities.[20] This perspective leads to the hypothesis that children engage in a greater number of obesogenic behaviours that lead to increased BMI gain and CRF loss during times that are less-structured (eg, time outside of school and summer days) than during times that are more structured (eg, school days). Behavioural mechanisms identified by the structured days hypothesis that may explain accelerated summer BMI gain and fitness loss include: (a) increased time spent sedentary,[16,21–24] (b) reduced engagement in physical activity,[16,21,24] (c) displaced and unstable sleep patterns[23,25–27] and (d) unhealthy diet[22,28] during the summer. At least one study has estimated that total daily energy expenditure is 5.4% lower during the summer when compared to the school year,[24] and a number of studies have linked later and less stable bed and wake times to increased risk of overweight and obesity.[29–31] A recent review of 190 studies comparing obesogenic behaviours on less structured to more structured days shows that 80% of the studies support this hypothesis.[20] Behavioural findings from a subsample of children in the current study also support the structured days hypothesis. For instance, when children were not attending school they were less active, engaged in more screen-time, and sleep timing shifted later.[23,32] Further, this subsample showed accelerated summer BMI gain and fitness loss.

Year-round schools operate on a 180-day schedule, similar to traditional schools. However, year-round schools incorporate shorter, more frequent breaks throughout the entire year rather than taking one prolonged 2- to 3-month break over summer. For example, a typical year-round school could follow a 45/15 schedule where the school operates for 45 weekdays in a row (9 weeks) and then takes a 15-day break (3 weeks). Because of this unique schedule children that attend schools following a year-round school calendar will experience relatively less structure during the traditional months of the school year (ie, August–May) and relatively more structure during the months of the traditional summer vacation (ie, May–August). This unique calendar presents an opportunity to test the structured days hypothesis.

The primary aim of this study was to compare BMI z-score (zBMI) and CRF change during the traditional months of the school year (ie, August–May) and summer vacation (ie, May–August) for children attending schools following a year-round or traditional school calendar. Because there is evidence that children classified as overweight or obese and children who are minorities are particularly susceptible to accelerated summer BMI gain,[10] the secondary aim of this study was to examine if changes in zBMI and CRF differed by weight status and race. Finally, we modelled the developmental trajectory of zBMI and CRF from kindergarten through the sixth grade for children attending schools following a year-round and traditional calendar. Based on the structured days hypothesis, we hypothesized that children attending traditional schools would experience greater zBMI gain and CRF loss when compared to children attending a year-round school during the traditional months of summer. Conversely, we hypothesized that children attending traditional schools would experience less zBMI and more CRF gain than children attending a year-round school during the traditional months of the school year. These analyses will replicate and extend the analyses from our previous work that explored behaviours and corresponding changes in zBMI of a subsample of children in this study.[23] The previous subsample included 285 children and because of the limited size did not allow for the exploration of changes zBMI and CRF in subgroups (ie, weight status, race) or for the estimation of zBMI and CRF from kindergarten through sixth grade.

2 | METHODS

2.1 | Setting and participants

Three schools in a single school district in South Carolina participated in the study. One school (ie, school A) followed a year-round school calendar while the two comparison schools (ie, schools B and C) followed a traditional 9-month school calendar (see Figure 1). Comparison schools were selected because they were similar to the school following the year-round school calendar in terms of school level student race, gender, number of students enrolled, age/grade levels served, percentage of students receiving free and reduced lunch and academic test scores. During the traditional months of the school year (August–May), the year-round school was in session for 9 weeks in a row and then took a 3-week break from school. This translated into the year-round school taking a total of ~45 break days during the traditional months of the school each year. This is contrary to the traditional schools that took ~18 break days during the traditional months of the school each year. During the traditional months of summer vacation (May–August), the opposite was true. The year-round school took a ~6-week break (ie, ~30 break days) from school while the traditional school took an ~11-week break from school (ie, ~60 break days). While the schedule between the schools differed, it is important to note that the total number of school days was 180 for both the year-round and traditional schools. Prior to each data collection wave, a letter with information about the study and data collection protocols was sent home with instructions on how parents 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 Institutional Review Board. A total of 2489 children attended the participating schools during the three years of the study. Children who were absent on all study measurement days (n = 198) and whose parents opted them out of the study (n = 12) were not included resulting in a final sample size of 2279 children. The average daily high/low temperature during the traditional school year was 67°F and 48°F, respectively. The average daily high/low temperature during the traditional summer was 88°F and 70°F, respectively.

2.2 | Study design

This study was a natural experiment. A natural experiment is similar to a quasi-experiment with the exception that the independent variable is not manipulated by the study team.[33] Causal inference can be established using a natural experimental design if there is temporal precedence, a plausible counterfactual, and participants do not self-select into groups.[33] In this study, the independent variable was the structure provided by the school day (ie, operationalized as the school calendar, year-round or traditional, followed by the school that the participating children attended). This structure was increased/decreased at different times of the year based on the child's school schedule (ie, year-round or traditional). Akin to ABA designs in single-subject studies structure was added and removed at different times for children attending the traditional and year-round schools.[33] For instance, there were more structured days during the school year for traditional students and fewer during the summer. The opposite was true for year-round school students (ie, relatively *fewer* structured days during the traditional school year and *more* structured days during the summer, compared to the traditional school calendar). By adding and removing the independent variable in this way, we can establish temporal precedence. This study also had both a within- and between-group counterfactual. The within-group counter-factual was the summer compared to the school year. For the year-round school children, the between-group counterfactual was the traditional school children during each time period (traditional school year or summer vacation). Finally, since students were allocated to school according to their home address by the school district, it can be argued that families did not self-select either the traditional or year-round school calendar.

2.3 | Procedures

All children at the participating schools had their heights, weights and CRF measured at the beginning (ie, August) and end (ie, May) of the traditional school year. Measures were collected for the 2017/2018 and 2018/2019 academic years (August–May) and for the 2017, 2018 and 2019 summer vacations (ie, May–August). All measurements in both the year-round and traditional schools were collected within the first and last three weeks of the traditional school year. All measures were obtained during regularly scheduled PE lessons by trained research assistants with the help of the PE teacher. At the beginning of each PE class period, children were divided into sex specific groups. One data collector administered the CRF test (eg, PACER) with one group of children, while the other data collector measured heights and weights for the other group of children. This was repeated until all children in the PE class were assessed.

2.4 | Measures

2.4.1 | Body mass index—Using a portable stadiometre (Model S100, Ayrton Corp., Prior Lake, Minn.) and digital scale (Healthometer model 500KL, Health o meter, McCook, Ill.), children's heights (nearest 0.1 cm) and weights (nearest 0.1 lbs.), without shoes, were collected by research assistants. BMI was calculated (BMI = kg/m^2) and transformed into age and sex specific z-scores.[34]

2.4.2 | Cardiorespiratory fitness—The Progressive Aerobic Cardiovascular Endurance Run (PACER) was administered during regularly scheduled PE.[35–41] This test produces valid estimates of elementary school-aged children's CRF. The PACER was carried out by one trained data collector and the PE teacher, either on a marked outdoor green space or indoor gymnasium (depending on the school). Children were instructed to run from one cone marker to another cone placed at a length of 20 m. 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 two occasions, the test was ended, and the number of successful laps was recorded.

2.5 | Statistical analyses

All analyses were completed in Stata (v16.1, College Station, TX) during September of 2020. Prior to completing the primary analyses, descriptive means and standard deviations of school and child characteristics were examined. The Pearson product-moment correlation between the two main outcomes of interest was also calculated. Children with at least one valid measure of BMI or PACER Fitnessgram at any timepoint were included.[42–44]

All primary and secondary analyses used maximum likelihood estimators to account for missing data, which has been shown to produce unbiased results.[45,46] The primary analyses were designed to explore the mean monthly change in zBMI and PACER laps during the traditional school year and summer vacation across years of assessment using multi-level mixed effects models with measures, nested within children, and children nested within school. Monthly zBMI change was estimated in order to account for the differing lengths of time during the school year and summer vacation (ie, 9 months vs 3 months). Changes in zBMI were divided by the months between measurement periods to produce monthly change. Separate models with monthly change in zBMI and PACER laps as the dependent variables and school calendar (ie, traditional or year-round), time (school or summer vacation) and school calendar-by-time interaction (ie, differential change between school calendars during different times) were estimated for all participants. Secondary analyses were conducted stratified by weight status: normal weight, overweight, or obese at first measure; and race: White, Black or identified as another race. To control for multiple comparisons while preserving power for the primary analyses we adopted a serial gatekeeping approach.[47] For this study, alpha was predetermined at $P \leq 0.05$. We then tested our primary analyses at the predetermined alpha. If the findings were statistically significant for a calendar-by-time interaction, we moved on to testing the secondary analyses for that interaction again at the predetermined alpha of 0.05. If the findings of the primary analyses were not statistically significant, all further downstream testing was suspended and contrasts were determined to not be statistically significant.

Finally, we also estimated the developmental trend in zBMI and CRF from kindergarten through sixth grade by school calendar type. While the study only collected data for two school years and three summer vacations, we are able to estimate the trajectory of growth by employing the principles of accelerated cohort designs.[48,49] Contrary to single-cohort designs where all participants start at the same age (ie, grade in this study), accelerated cohort designs follow multiple cohorts with each cohort entering the study at a different grade.[48] The main advantage of accelerated cohort designs is the ability to estimate a developmental timeframe of interest (ie, kindergarten to sixth grade) in a shorter period of time (ie, two school years and three summer vacations) than possible with a single cohort. Linear mixed effect spline models with measurements nested within children, and children nested within schools were conducted predict monthly change in zBMI and PACER laps during the school year and summer vacation across grades. Separate spline models were estimated with zBMI and PACER laps as the dependent variables and measurement wave by grade and school calendar type (traditional and year-round) as the independent variables. Spline knots were placed at each measurement wave (ie, kindergarten fall, kindergarten spring, first grade fall, first grade spring, second grade fall, second grade spring, third grade fall, third grade spring, fourth grade fall, fourth grade spring, fifth grade fall, fifth grade spring, sixth grade fall, sixth grade spring). This allowed for separate slopes to be estimated for the school year and summer vacation in each grade. Consistent with previous research,[11,12] monthly change estimates were then multiplied by the number of months of exposure to each school year (monthly change multiplied by 9 months) and summer (monthly change multiplied by 3 months) in order to estimate zBMI and PACER laps at the end of each summer and school year. All primary and secondary analyses controlled for sex, age, race and each participant's level of the dependent variable at first measurement.

3 | RESULTS

Characteristics of the participating schools and children are presented in Table 1. The number of participants measured during each data collection wave is presented in Table 2. Results of the primary analyses are presented in Figure 2 and Table 3. The correlation between zBMI and CRF was weak and negative $r = -0.29$.

3.1 | Traditional months of the school year (August–May)

3.1.1 | School year change in zBMI—During the months of the traditional school year, zBMI decreased by −0.002 per month for children in the traditional calendar schools and zBMI increased by 0.012 per month for children in the year-round calendar school. These differences represented a 0.015 (95CI = 0.002, 0.028) greater increase in monthly zBMI change for children attending the year-round school compared to children in the traditional schools.

3.1.2 | School year change in PACER laps—Traditional school children experienced a 0.287 increase while year-round children experienced a 0.194 increase in laps per month during the months of the traditional school year. These changes in PACER laps did not represent a statistically significant difference (−0.093, 95CI = −0.366, 0.180) between year-round and traditional school children.

3.2 | Traditional months of summer vacation (May–August)

3.2.1 | Summer change in zBMI—During the months of the traditional summer vacation, year-round school children's zBMI increased by 0.014 per month, while traditional school children's zBMI decreased by −0.015 per month. These findings indicate that year-round school children gained −0.029 (95CI = −0.041, −0.018) less zBMI than traditional school children during the traditional months of summer vacation.

3.2.2 | Summer change in PACER laps—During summer, traditional school children's PACER laps decreased by −0.158 per month while year-round school children's PACER laps increased by 0.676 per month. This difference in PACER laps change was statistically significantly different between the traditional and year-round school children (difference = 0.834, 95CI = 0.575, 1.093), with year-round school children gaining more PACER laps per month that traditional school children.

3.3 | Secondary analyses

Secondary analyses stratified by weight status at first measure and race are presented in Table 3.

3.3.1 | Weight status—Year-round school children who entered the study with normal weight, overweight or obesity did not experience any differences in zBMI gain per month when compared to their normal overweight or obese counterparts attending the traditional schools during the months of the traditional school year. However, during the months of the traditional summer vacation, the opposite was true with normal weight, overweight and obese year-round school children gaining −0.028 (95CI = (−0.044, −0.013), −0.026 (95CI = −0.051, −0.000) and − 0.033 (95CI = −0.049, −0.017) less zBMI per month than their traditional school counterparts. Differences in PACER laps by weight status during the months of the traditional school year were not explored, based on our serial gatekeeping approach, because the primary analyses were not statistically significant. During the months of the traditional summer vacation, year-round school children who entered the study with normal weight, overweight or obesity gained 1.130 (95CI = 0.751, 1.508), 0.693 (95CI = 0.186, 1.199) 0.612 (95CI = 0.381, 0.843) more PACER laps per month, respectively, than their traditional school counterparts.

3.3.2 | Race—For race, children following the year-round school calendar who were Black experienced a 0.016 (95CI = 0.000, 0.031) greater increase in zBMI during the months of the traditional school year when compared to their counterparts attending schools following a traditional school calendar. During the months of the traditional summer year-round school children who are Black gained −0.039 (95CI = −0.053, −0.025) less zBMI than their traditional school counterparts. No differences in zBMI gain were observed during the months of the traditional school year or summer between year-round and traditional schools for children who are White or identified as another race. Primary analyses of PACER laps were not statistically significant, thus differences in PACER laps by race during the months of the traditional school year were not explored, per our serial gatekeeping approach. During the months of the traditional summer, year-round school children who are White or Black experienced 1.022 (95CI = 0.689, 1.355) and 0.936 (95CI = 0.605, 1.266) greater gains, respectively, in PACER laps per month than their traditional school counterparts.

3.4 | Spline growth models

The growth trajectories of zBMI and PACER laps for children attending traditional and year-round schools are presented in Figure 3.

4 | DISCUSSION

This study is one of the first to examine the impact of year-round school calendar on changes in children's zBMI and CRF during the summer and traditional school-year. Consistent with our hypotheses, this study found that children attending a year-round school experienced zBMI gain during the traditional 9-month school calendar and zBMI *losses* during the traditional summer vacation. These results contrast with trajectories of children in schools which follow a traditional school calendar. Children in the year-round school gained CRF during both the traditional school year and summer vacation, but gains were greater during summer vacation.

Consistent with past research,[10–12,14,17,50] children in this study that attended a school following a traditional school calendar experienced accelerated increases in zBMI and losses in CRF over summer vacation. However, the opposite pattern was observed for children attending a year-round school. This pattern is consistent with the preliminary findings from this study,[51] and is consistent with the "dose" of structure the children received during the months of the traditional school year (ie, August–May) and summer (ie, May–August). The year-round school in the current study followed a 45–15 calendar during the traditional school year (ie, 9 weeks or 45 weekdays attending school followed by a 3 week or 15 weekday break from school) and took a 5 week summer vacation. Thus, during the months of the traditional school year, children attending the year-round school were exposed to *fewer* structured days compared to traditional school children; during the months of the traditional summer vacation, they were exposed to *more* structured days.

Only one other study has explored the impact of a year-round school calendar on BMI gain and CRF loss during the months of the traditional summer vacation. This study included 328 elementary-aged children attending a traditional school or a year-round school.[52] Children attending the year-round school either had a 3-week or 7-week summer vacation while children attending the traditional school had a 12-week summer vacation. This study found that, over the traditional months of the summer vacation, children attending the year-round school experienced statistically significantly less zBMI gain than children attending the traditional school. Similar studies have also explored the influence of other structured programming during the summer (ie, summer day camp and summer school) on children's BMI gain and CRF loss.[14,53,54] One study examined the impact of an 8-week, multicomponent summer program on 87 elementary children's weight status. This study found that children did not experience an increase in zBMI over the summer. The second study measured 138 ninth-grade students on a variety of weight and fitness markers prior to and following summer school (n = 70 attended; n = 68 did not attend). Consistent with the findings from the current study, students who did not attend summer school experienced statistically significantly greater weight gains and CRF loss over the three months of summer.[14] Finally, a third study examined the impact of a summer learning loss prevention program for children (n = 31, 6.4 years, 45% female and 80% Black) at one school serving low-income children.[54] All children except one maintained their weight status (eg, normal weight, overweight) from the first week to the last week of the program and no statistically significant unhealthy changes in median zBMI (pre: 0.12, post: 0.11) were observed. These findings are consistent with the findings of the current study. Combined with the findings of the current study, there is growing evidence that structure during summer vacation may positively impact BMI and CRF. The findings of the current study also expand on past studies by exploring BMI and CRF of children with relatively less structure during the months of the traditional school year (year-round school children). The current study, which showed year-round school children gained zBMI at a greater rate during the months of the traditional school year, provides preliminary yet novel evidence in support of the structured days hypothesis.

Differences in zBMI and CRF gain during the months of the traditional school year and summer varied by weight status in this study. For instance, no differences in zBMI gain were observed between the year-round and traditional school children during the months of the school year for children who entered the study with normal weight, overweight, or obesity. However, the contrary was true for the summer where differences in zBMI gain were greater for traditional school children with normal weight, overweight, and obesity when compared to year-round school children. Past studies have shown that summer is a time when children with overweight or obesity gain BMI at a greater rate than their counterparts who are have normal weight.[55] This study indicates that structure during the summer may be an effective strategy for mitigating BMI gain for children with overweight or obesity. Regarding race, children who are Black were the only race group to experience differences in zBMI gain by school calendar during the months of the traditional school year or summer. While this may have been a function of diminished power due to smaller subgroup sample sizes, these findings are consistent with past studies that have shown that the traditional months of summer vacation present increased risk for zBMI gain for children who are Black.[10] Reasons for more pronounced accelerated weight gain for children who are overweight or obese and children who are Black are unclear. However, one mechanism that may be driving this increased risk is socioeconomic status. Children from minority households are more likely to be from low-income households.[56,57] Further children from low-income households are at increased risk for overweight or obesity.[58–61] The health gap hypothesis posits that low-income children are more susceptible to accelerated summer BMI gain because they have less access to fee-for-service summer programming which may mitigate summer BMI gain.[9] Future research should examine the factors (lack of resources, structural racism, etc.) that are driving accelerated summer BMI gain for children from minority and low-income households. Whatever the mechanism, this study builds on past findings demonstrating that providing structured programming (eg, school-like environments such as day camps or programs) during the summer may effectively reduce accelerated summer weight gain for those children most at risk.

This is also the first study to estimate zBMI and CRF growth from kindergarten through sixth grade in children attending a traditional or year-round school. These models demonstrate trends in growth that have the potential to inform future interventions. For instance, it does not appear that year-round schools are superior to traditional schools for maintaining weight status and CRF. Trajectories of BMI and CRF gain were dramatically different during the months of the traditional school year and summer for children attending year-round schools when compared to children attending traditional schools. For instance, consistent with past research, during most summers children attending the traditional schools gained zBMI. The opposite was true for year-round school children. This led to a pattern of year-round school children losing more zBMI during the months of summer vacation with traditional school children catching them during the months of the traditional school year. This is similar to academic studies of year-round schools which show year-round school students surge ahead during the months of traditional summer but traditional school students catch up during the months of the traditional school year.[62] Thus, this preliminary evidence suggests that year-round schools should not be advocated for in order to mitigate accelerated summer BMI gain. Rather, providing families access to structured programming during times when school is not in session (ie, summer vacation) may be a more effective approach. Further, it appears that the months of the traditional summer vacation do not negatively impact traditional school children's CRF gain until they reach upper elementary school (ie, ≥third grade). While this finding is consistent with past studies,[19,63] future work should confirm the findings herein. However, it appears that the children attending the year-round schools did not experience these same declines in CRF during the summer of upper elementary school. In fact, these children gained CRF during the months of the traditional summer vacation. Thus, CRF interventions that target the months of the traditional summer vacation (eg, providing access to structured summer programming) in upper elementary school may be particularly effective for attenuating summer CRF loss.

The strengths of this study include the reliance on a conceptual framework (ie, structured days hypothesis) to guide design and interpretation of results, a large sample that is representative of the included schools, the use of valid and reliable objective measures of BMI and CRF, and the replication of results over multiples school years and summers across multiple grades. The limitations of this study include a limited sample of schools (ie, one year-round and two traditional) in a single geographic location (ie, southeastern United States), and the lack of randomization to study condition. Children's attendance at structured programs was not directly measured either. Thus, this study cannot determine if children attended school while it was in session or if children attended other structured programming during school breaks (eg, summer camps). Additionally, behavioural mechanisms were only assessed in a subsample of participants, presented elsewhere,[23] so we cannot fully explore the mechanisms driving these differences in change. Future studies should attempt to include schools in more regions of the United States and internationally, examine multiple school years and summers, directly measure attendance at structured programming and randomize children to receiving structure during the months of summer vacation.

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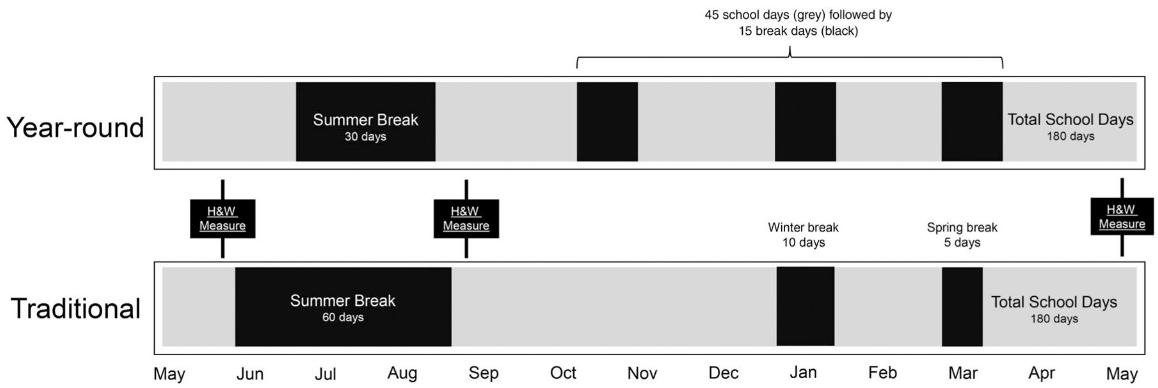

FIGURE 1.
Traditional and year-round school calendars for the participating schools

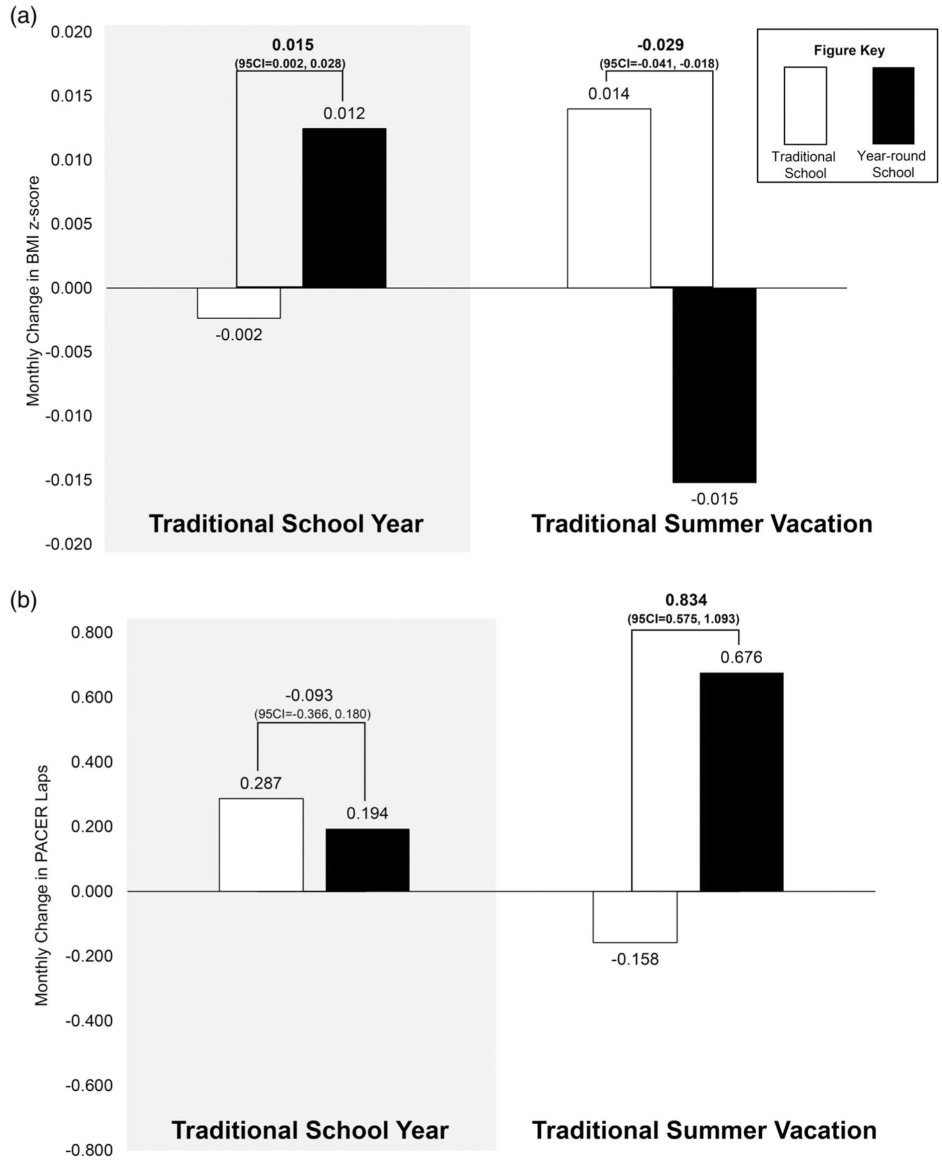

FIGURE 2.

Model estimated mean monthly change in, A, BMI z-score and, B, PACER laps across years of assessment bolded values are statistically significant at $P < 0.05$

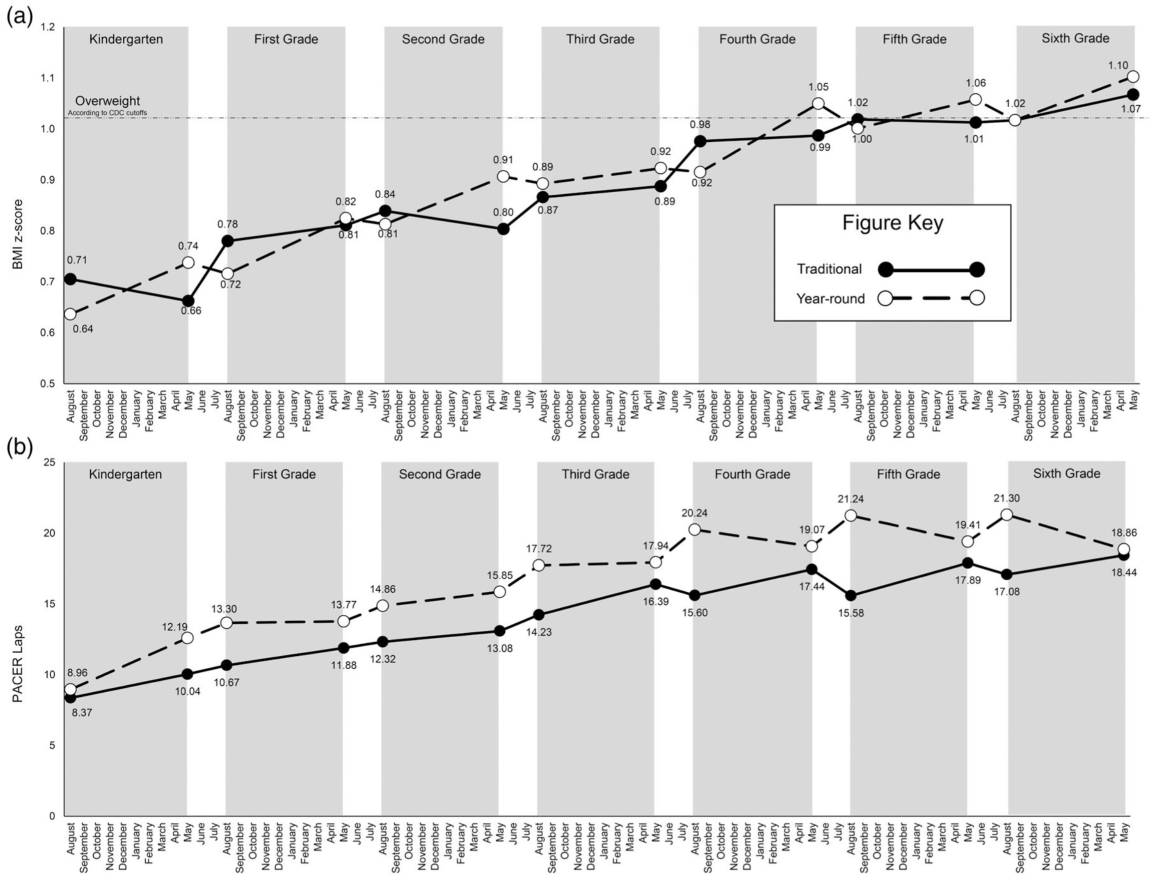

FIGURE 3.
Spline growth models for, A, BMI z-score and, B, fitnessgram PACER laps from kindergarten through sixth grade

TABLE 1

Characteristics of participant schools and students at first measure

	A	B	C	
School	**Year-round Calendar**	**Traditional Calendar**	**Traditional Calendar**	**All Schools**
School Characteristics				
Total Students	851	761	877	2489
Percent Male	52.3	52.9	52.7	52.6
Grades	k-6	k-6	k-6	k-6
Race				
Percent White	26.3	15.4	30.0	23.9
Percent Black	61.1	72.3	56.8	63.4
Percent Other Race *(including all races other than Black or White)*	12.6	12.3	13.2	12.7
Percent Free or Reduced Price Lunch	88.3	80.5	89.0	85.9
Participant Characteristics at First Measure				
Overall Number of Participants	775	700	804	2279
Percent Male	51.1	54.5	50.3	51.8
Mean Grade (SD)	2.2 (2.1)	2.3 (2.1)	2.3 (2.1)	2.3 (2.1)
Mean Age (SD)	7.8 (2.4)	7.9 (2.2)	7.9 (2.3)	7.9 (2.3)
Race				
Percent White non-Hispanic	29.2	18.3	31.9	26.9
Percent Black	65.8	69.9	58.6	64.6
Percent Other Race *(including all races other than Black or White)*	5.0	11.9	9.5	8.6
Mean PACER Laps Completed	14.5 (9.5)	12.5 (7.7)	12.7 (8.5)	13.3 (8.6)
Mean BMI (SD)	19.5	19.6 (5.6)	19.2 (5.4)	19.4 (5.5)
Mean zBMI (SD)	0.90 (1.14)	0.86 (1.25)	0.82 (1.25)	0.88 (1.26)
Mean BMI Percentile (SD)	73.8 (27.1)	70.7 (29.6)	70.2 (29.7)	71.7 (28.8)
Weight Status				
Percent Underweight	1.2	2.5	2.9	2.2
Percent Normal Weight	51.8	50.8	53.8	52.2
Percent Overweight	16.9	16.0	16.1	16.4

	A	B	C	
School	**Year-round Calendar**	**Traditional Calendar**	**Traditional Calendar**	**All Schools**
Percent Obese	30.1	30.7	27.2	29.3

TABLE 2

Number of participants measured at each wave

	Traditional (n)	Year-Round (n)	Total (n)
Spring 2017	621	385	1006
Fall 2017	651	377	1028
Spring 2018	671	373	1044
Fall 2018	682	380	1062
Spring 2019	631	371	1002
Fall 2019	657	362	1019

TABLE 3

Model estimated monthly change in BMI z-score and PACER laps by weight status at first measure and race

			BMI z-score											
			Months of traditional school year						Months of traditional summer					
			n	Mean change	SD	Model estimated change	Difference in change	95CI	n	Mean change	SD	Model estimated change	Difference in Change	95CI
Weight Status	Normal Weight	Traditional	534	−0.007	(0.067)	−0.007	0.013	(−0.005 0.031)	655	0.000	(0.167)	0.000	**−0.028**	**(−0.044, −0.013)**
		Year-round	325	0.006	(0.054)	0.006			424	−0.029	(0.157)	−0.028		
	Overweight	Traditional	179	0.011	(0.070)	0.015	0.010	(−0.016, 0.036)	187	0.042	(0.145)	0.044	**−0.026**	**(−0.051, −0.000)**
		Year-round	105	0.024	(0.047)	0.025			117	0.015	(0.110)	0.018		
	Obese	Traditional	325	0.003	(0.046)	0.006	0.011	(−0.015, 0.018)	413	0.039	(0.149)	0.041	**−0.033**	**(−0.049, −0.017)**
		Year-round	211	0.016	(0.039)	0.017			254	0.007	(0.061)	0.008		
Race	White	Traditional	295	0.002	(0.066)	0.002	0.007	(−0.015, 0.029)	358	0.005	(0.173)	0.005	−0.014	(−0.034, 0.006)
		Year-round	196	0.009	(0.046)	0.009			262	−0.009	(0.131)	−0.009		
	Black	Traditional	683	−0.003	(0.066)	−0.003	**0.016**	**(0.000, 0.031)**	816	0.020	(0.174)	0.020	**−0.039**	**(−0.053, −0.025)**
		Year-round	435	0.013	(0.050)	0.013			527	−0.019	(0.149)	−0.020		
	Other	Traditional	92	−0.008	(0.059)	−0.008	0.033	(−0.026, 0.091)	116	0.009	(0.158)	0.009	−0.023	(−0.076, 0.029)
		Year-round	19	0.022	(0.037)	0.024			24	−0.017	(0.098)	−0.014		
			PACER Laps											
			Months of traditional school year						Months of traditional summer					
			n	Mean change	SD	Model estimated change	Difference in change	95CI	n	Mean change	SD	Model estimated change	Difference in change	95CI
Weight Status	Normal Weight	Traditional	501	0.403	(1.033)	–	–	– –	595	−0.180	(2.709)	−0.174	**1.130**	**(0.751, 1.508)**
		Year-round	308	0.273	(1.008)	–	–	– –	395	0.960	(3.351)	0.956		
	Overweight	Traditional	167	0.227	(0.920)	–	–	– –	181	0.041	(2.383)	0.051	**0.693**	**(0.186, 1.199)**
		Year-round	95	0.167	(0.829)	–	–	– –	105	0.752	(2.893)	0.743		

	Obese	Traditional	298	0.152	(0.683)	–	–	– –	377	−0.137	(1.526)	−0.129	**0.612**	**(0.381, 0.843)**
		Year-round	202	0.006	(0.542)	–	–	– –	242	0.477	(2.249)	0.483		
Race	White	Traditional	282	0.269	(0.846)	–	–	– –	335	−0.316	(2.330)	−0.343	**1.022**	**(0.689, 1.355)**
		Year-round	183	0.194	(0.763)	–	–	– –	244	0.690	(2.975)	0.678		
	Black	Traditional	648	0.304	(0.990)	–	–	– –	760	−0.079	(2.353)	−0.080	**0.936**	**(0.605, 1.266)**
		Year-round	420	0.156	(0.911)	–	–	– –	499	0.858	(3.032)	0.856		
	Other	Traditional	83	0.268	(0.778)	–	–	– –	107	0.065	(2.110)	0.051	0.079	(−0.702, 0.860)
		Year-round	20	0.139	(0.804)	–	–	– –	21	0.048	(1.927)	0.130		

Note: Bolded values are statistically significant at $P < 0.05$.

Note: "—" Consistent with the serial gatekeeping approach, not tested due to the primary analyses school calendar-by-time interaction not being statistically significant.