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Effects of a before-school program on student physical activity levels

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ABSTRACT

Many children are not sufficiently physically active. This study uses a quasi-experimental design to evaluate whether participation in a before-school physical activity program called Build Our Kids' Success (BOKS) increases physical activity. Participants (n = 426) were students in Fall, 2016 enrolled in BOKS programming and matched non-BOKS control students from the same grades (Kindergarten-6) and schools in Massachusetts and Rhode Island. Analyses conducted in 2017 examined differences between children in BOKS versus controls in total daily steps, minutes of moderate-to-vigorous (MVPA), vigorous (VPA), and total physical activity (TPA) assessed via Fitbit Charge HR™ monitors. Additional analyses compared physical activity on program days and non-program days. Students (mean age = 8.6 y; 47% female, 58% White, Non-Hispanic) wore monitors an average of 21.7 h/day on 3.2 days during the school week. Compared with controls, on BOKS days, BOKS participants accumulated more steps (1147, 95% confidence interval (CI): 583–1712, $P < 0.001$), MVPA minutes (13.4, 95% CI: 6.6–20.3, $P < 0.001$), and VPA minutes (4.0, 95% CI: 1.2–6.7, $P = 0.005$). Across all school days, BOKS participants accumulated more total steps than controls (716, 95% CI: 228–1204, $P = 0.004$). Compared to days without BOKS programming, on BOKS days, BOKS participants accumulated more steps (1153; 95% CI: 841–1464, $P < 0.001$) and daily minutes of MVPA (8.8, 95% CI: 5.3–12.2, $P < 0.001$), VPA (3.0, 95% CI: 1.6–4.5, $P < 0.001$), and TPA (20.8, 95% CI: 13.6–28.1, $P < 0.001$). BOKS programming promotes engagement in additional accumulated steps during the school week and physical activity on days that students participate.

Clinical Trial Registration: www.ClinicalTrials.gov, NCT03403816, available at: https://clinicaltrials.gov/ct2/show/NCT03403816?term=NCT03403816&rank=1

1. Introduction

Just four in ten U.S. children are sufficiently physically active to meet national guidelines (The National Physical Activity Plan Alliance, 2016; U.S. Department of Health and Human Services, 2018), obtaining at least 60 min of accumulated physical activity each day. Less than half of adolescents meet cardiorespiratory fitness standards, and girls (34%) fare worse than boys (50%) by early adolescence (The National Physical Activity Plan Alliance, 2016). Schools are recommended settings for physical activity promotion. Guidance for school physical activity programs includes strategies to increase physical activity in the periods before, during and after school (U.S. Department of Health and Human Services, 2018). Potential options include modifying existing programs to increase the intensity of physical activity, increasing the duration of current opportunities, or offering new programs replacing sedentary activities with active ones (Beets et al., 2016). Strategies to promote physical activity during the school day have been studied extensively (Messing et al., 2019). However, as children age, physical activity levels decline particularly during the periods outside of school hours (Brooke et al., 2016; Wickel and Belton, 2016).

Researchers have evaluated the effectiveness of intervention strategies in the afterschool period (Beets et al., 2009; Cradock et al., 2016; Mears and Jago, 2016), a time where accumulated physical activity levels decline with age (Brooke et al., 2016; Wickel and Belton, 2016) and vary by gender (Hubbard et al., 2016; Long et al., 2013). However, fewer studies have evaluated programs that operate before school opens

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(Stylianou et al., 2016; Westcott et al., 2015), a less-active period of the day (Long et al., 2013). One non-controlled study conducted in two schools found evidence for increased activity levels attributed to a 15–20 min running club program in one school (Stylianou et al., 2016). Prior evaluations of the Build our Kids' Success (BOKS) program found improvements in aerobic performance (Westcott et al., 2015) and social-emotional wellness and healthy weight outcomes (Whooten et al., 2018) comparing BOKS participants and non-participants, but did not measure physical activity directly. Meanwhile, multiple studies suggest that acute physical activity participation is associated with increased subsequent on-task behavior (Watson et al., 2017). In this study, we collect objective measures of physical activity and use quasi-experimental designs to evaluate whether participation in a before-school physical activity program leads to increased levels of physical activity.

2. Methods

2.1. Design and sample

This study employed quasi-experimental designs including a comparison to controls (between-person) and a cross-over analysis (within-person). Physical activity data were collected in Fall 2016 (October 17 through December 16, 2016) and analyzed in 2017 through April 2019. Researchers investigated the impact of a before school physical activity program called BOKS on the activity levels of BOKS participants compared to children who did not attend the program and also activity levels among participating children on days they attended BOKs compared with days they did not attend. The study was conducted in seven schools with existing BOKS before-school programming in two communities in Rhode Island and Massachusetts. Together, these communities enroll over 12,000 students (5900 and 6500 each), 63% of whom are white, 8% black, 19% Hispanic/Latino, 5% Asian, 4% other race/ethnicity or multiracial, and 50% of whom are eligible for free or reduced price lunch (Massachusetts Department of Elementary and Secondary Education, 2017; Rhode Island Department of Elementary and Secondary Education, 2017; U.S. Department of Education, 2017). Median household income in the census tracts where the schools are located ($58,320, range $45,099 to $74,604) is similar to the national average ($55,322) (U.S. Census Bureau, 2018). Participants were students in grades Kindergarten through 6 participating in BOKS before-school programming and students at the same schools who were not participating in BOKS before-school programming, recruited from the same grades and classrooms as BOKS participants. There was no blinding to study condition assignment among BOKS program leaders, data collectors, or those assessing study outcomes.

2.2. Sample size calculations

This study was powered to detect differences in the primary outcome of total daily step counts on days when students participate in the BOKS before-school program compared with days when they do not. Sample size calculations conducted prior to data collection based on previous studies of Actigraph accelerometers (Barrett et al., 2013; Cradock et al., 2014; Cradock et al., 2016; Gortmaker et al., 2012) suggested that enrolling 250 BOKS program participants clustered within 8 schools would allow for detection of a mean difference of 2193 steps on BOKS days compared with non-BOKS days equivalent with 95% power, assuming a correlation of 0.6 across days within students, with 85% of students providing complete data.

2.3. District and school recruitment

Fig. 1 shows the flow of participants in the study. Researchers worked with BOKS-Central staff to identify communities proximate to the primary research facility with four or more schools operating BOKS programs on two or more days per week to enable comparison of days with and without programming. Researchers communicated with district-level administrators and BOKS area-level coordinators in five communities in September 2016 to explain the study purpose, providing descriptions of study goals and methods as requested by school leaders. School and district leadership in two communities agreed to participate, and principals at schools with existing BOKS programs in each district provided written approval for research activities.

2.4. Student recruitment

All BOKS program participants were invited to enroll in the study via an invitation letter addressed to parents/guardians and an informed consent form that researchers disseminated during BOKS program time in the weeks before scheduled data collection. After BOKS students enrolled in the study at each school, researchers used a quota sampling strategy (Sudman, 1976) to enroll a similar number of students enrolled in the same schools and grades as BOKS study participants. These students were invited to participate via invitation letters addressed to parents/guardians and an informed consent form distributed via backpack mail by school staff in the classrooms with BOKS study participants. Study information and informed consent forms were made available in multiple languages as specified by each district. Parents or guardians provided active, written consent for students to participate. Overall, 76% of BOKS program participants enrolled in the study. Researchers obtained verbal child assent from students on the first day of data collection. Designated school personnel distributed participant incentives, $25 gift cards, upon completion of data collection. The Harvard T.H. Chan School of Public Health Institutional Review Board approved the study.

2.5. Intervention

BOKS is a before-school program offered at no cost to participating families, currently operating across all 50 states and 4 countries that shows promise in promoting student health and wellness (Westcott et al., 2015; Whooten et al., 2018). BOKS-central coordinators provide online resources and free, monthly training opportunities for local, school-based BOKS trainers delivering the program at schools. The BOKS curriculum includes 12 weeks per semester of physical activity instruction and brief nutrition lessons offered 2–3 times per week. Each BOKS session includes 40 min of structured physical activity, including free play, running, skills, games, and warm-up/cool-down. Schools may also include BOKS sessions during the school day or short in-school physical activity breaks called BOKS Bursts.

2.6. Data collection

Researchers visited each school for one week to distribute physical activity monitors and document BOKS program activities. Researchers observed BOKS program sessions, recording session characteristics (i.e., activity time, duration of program, and location) and participation. Individual participants' start and end time of attendance at each BOKS session was not recorded. School start and end times and BOKS program schedules were obtained from school administrators and BOKS trainers. Child demographic information, including sex, race/ethnicity, grade, and age, was reported by parents on consent forms. Researchers reached study participant recruitment goals after completing data collection in seven schools.

2.7. Outcome measures

The primary outcome measure was total daily step counts measured by Fitbit Charge HR™ monitors (Fitbit Inc., San Francisco, CA, USA) (Fitbit Inc, 2017). Secondary outcomes included daily minutes of Moderate-to-Vigorous Physical Activity (MVPA), Vigorous Physical Activity (VPA) and Total Physical Activity (TPA) including light,

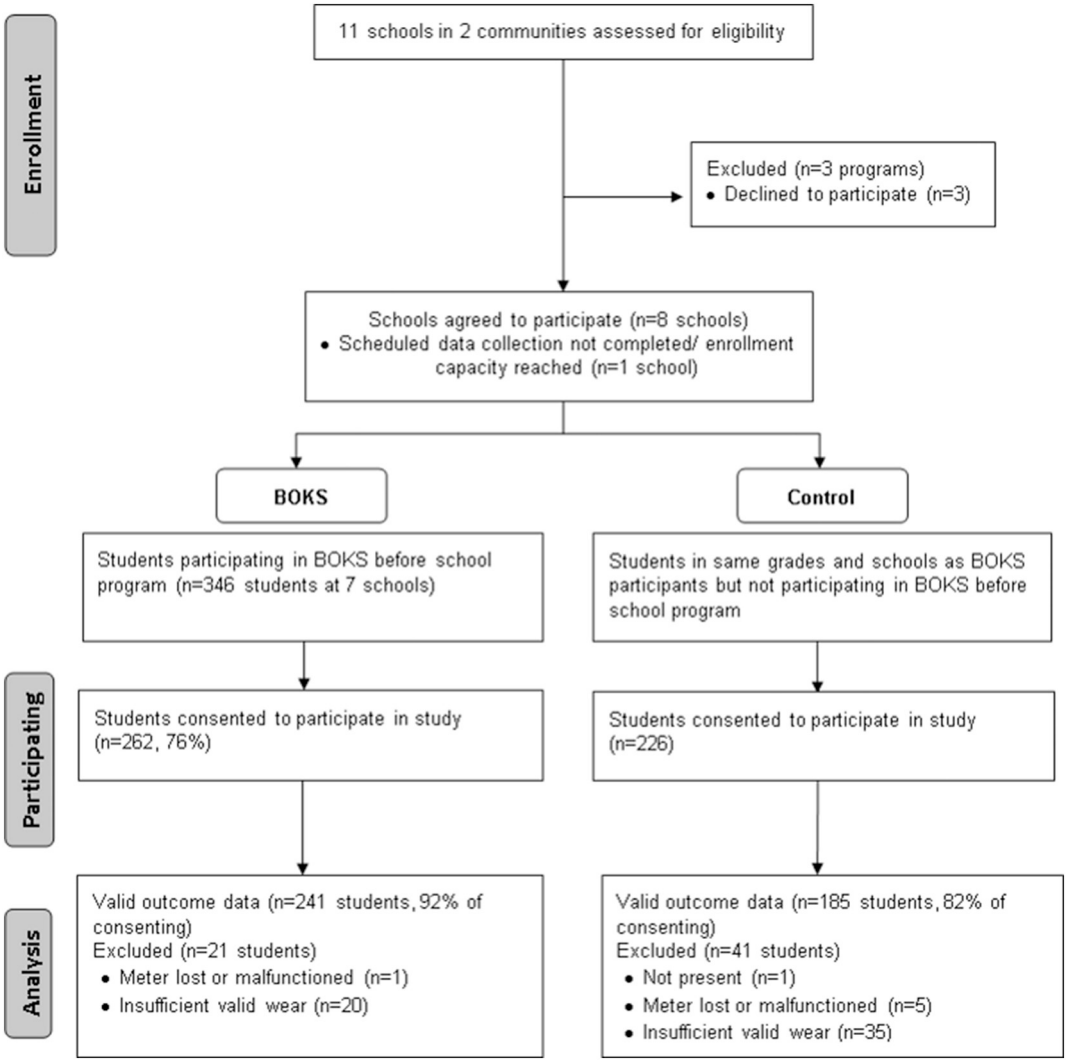

Fig. 1. Flow of individual participants through the study in Massachusetts and Rhode Island, Fall 2016.

moderate and vigorous levels defined by Fitbit Inc. proprietary algorithms. The Fitbit Charge HR™ measures total sleep time, which was used to examine potential variations in sleep duration due to participation in a before-school program. The Fitbit Charge HR™ and other wrist-worn Fitbit monitors have demonstrated reasonable accuracy of daily step counts (Chu et al., 2017; Reid et al., 2017) and energy expenditure measures (Bai et al., 2016; Brooke et al., 2017) in adults. A study among youth suggests strong agreement between daily steps measured using the Fitbit Charge HR™ and Actigraph accelerometers (Intraclass Correlation Coefficient (ICC) = 0.855, $P < 0.001$),but poorer agreement for activity intensities (Voss et al., 2017)(i.e., ICCs < 0.7). The monitor demonstrates good agreement with polysomnography in measuring total sleep time among adolescents (de Zambotti et al., 2016). Among children, wear compliance may be higher using wrist-worn compared with hip-worn monitors (Fairclough et al., 2016). Researchers assessed physical activity outcomes during the before school (12:00 am to school start time) and during school (school start time to end time) periods, in addition to the total day.

2.8. Fitbit Charge HR™ Data Collection

Each Fitbit monitor was assigned a unique participant identifier and profile at Fitbit.com and synced prior to use with each participant. Researchers assigned to each student's profile the gender-and-age-specific median height and weight according to national reference data (Centers for Disease Control and Prevention, National Center for Health Statistics, 2015) and an age of 13 years, the minimum age allowable for use of the Fitbit online portal (https://www.fitbit.com/legal/privacy-policy). Researchers linked Fitbit.com profiles to Fitabase (San Diego, CA, USA), a cloud-based service that uses Fitbit Partner API to generate access to fine resolution data including Fitbit-defined metrics (Fitabase, 2017; Fitbit Inc, 2017). Students received monitors at the beginning of the week upon arrival to school and were instructed to wear the monitor on their non-dominant wrist continuously for the school week, removing for bathing or water activities.

2.9. Data processing

Data describing Fitbit-derived steps, activity intensity, sleep, and heart rate by unique participant identifier (by minute, or for heart rate, at variable intervals of 5 s or more) were downloaded from Fitabase. Steps and minutes spent lightly active, active, and very active were summed per person per day for the total day and by period (before school, during school). MVPA was defined as the sum of active and very active minutes, VPA as very active minutes, and TPA as the sum of lightly active, active, and very active minutes. Nighttime sleep windows were defined as sequential minutes when sleep values (i.e., asleep, restless or awake) were recorded according to the Fitbit sleep algorithm, where sleep onset was 6:00 pm or later and wake time was before 10:00 am the next day. Total sleep time per night was calculated as the

number of hours spent asleep during the nighttime sleep window. Based on visual inspection, nights with total sleep time < 4.5 or > 11.5 h were considered outliers for this population and were excluded. Non-wear periods of 60 min or more, identified using a modified protocol for Actigraph accelerometer data (Centers for Disease Control and Prevention, National Center for Health Statistics, 2015), were excluded from analysis. Minutes were classified as non-wear if 0 steps and no heart rate data were recorded while not nighttime sleep, allowing up to 2 consecutive minutes with 1–10 steps or a recorded heart rate. Only participants with 2 or more days with at least 10 total wear hours per day, 3 h before school, and 3 h during school, were included in the analysis. All days with complete data on BOKS program days and other days were included in analyses regardless of BOKS participation status. Among these participants, those with at least 2 days of sleep data were included in further analysis.

2.10. Statistical analysis

Linear mixed-effects models were used to construct contrasts of children's physical activity levels by BOKS participation status (i.e., BOKS versus control) and participation day (i.e., BOKS program day versus not). All models adjusted for age and sex, and models examining physical activity outcomes adjusted for the child's daily monitor wear time. School-level random intercepts accounted for the clustering of students within schools. Researchers used a compound symmetry covariance structure to account for repeated daily observations within students (Singer and Willett, 2003). Analyses were conducted between January and December 2017 using SAS statistical software (SAS, version 9.4; SAS Institute, Inc., Cary, NC). A two-tailed significant level was set at $P < 0.05$.

In between-person analyses (i.e., BOKS versus controls), the effect of BOKS participation was estimated by an indicator of BOKS program participation vs. non-participation (control). Comparisons of total sleep time were also examined.

In analyses performed among BOKS program participants only (within-person analysis), the effect of BOKS participation was estimated by an indicator for days when the BOKS before-school program was provided vs. days when BOKS was not provided. Data from BOKS participants with only two program or non-program days were included, though these data do not contribute to the within-subject estimates of BOKS participation on physical activity due to the lack of variability in exposure (Allison, 2005). Researchers adjusted for physical activity during school when comparing total daily physical activity outcomes on program versus non-program days to adjust for any differential day-to-day school-day physical activity offerings (besides BOKS).

3. Results

3.1. Intervention exposure and participation

BOKS before-school programs operated 2–3 days per week, averaging 47 min (range: 42–57) in duration with observed active time of 33 min (range: 18–49). Average daily participation was 40 (range: 28–50) students. Fig. 1 depicts the flow of study participants. Complete Fitbit data were collected from 241 BOKS participants (92%) and 185 control students (82%) (mean age = 8.6 y; 47% female, 58% White, Non-Hispanic). Students wore monitors an average of 21.7 h/day for 3.2 days. Most BOKS participants (87%) provided 3 or 4 days of valid monitor data; among those who provided only 2 days of data, data for 2 participants included BOKS program days only, and data for 3 participants included non-program days only. There were differences in age and monitor wear time between the BOKS students and controls (Table 1); these variables were used in adjusted analyses.

3.2. Outcomes

3.2.1. BOKS versus control

In linear mixed models comparing BOKS students and controls, on the days that BOKS programming occurred before school (Table 2), BOKS participants accumulated significantly more physical activity across the total day including total steps (1147, 95% CI: 583–1712, $P < 0.001$), MVPA minutes (13.4, 95% CI: 6.6–20.3, $P < 0.001$), and VPA minutes (4.0, 95% CI: 1.2–6.7, $P = 0.005$). During the before school period on BOKS days, compared with non-participants, BOKS participants accumulated significantly more steps (1503, 95% CI: 1286–1719, $P < 0.001$), MVPA minutes (13.4, 95% CI: 11.3–15.5, $P < 0.001$), VPA minutes (4.5, 95% CI: 3.6–5.5, $P < 0.001$), and TPA minutes (24.1, 95% CI: 17.3–30.9, $P < 0.001$). Physical activity accumulated during the school day was not significantly different among BOKS participants compared with controls.

Across all school days, compared with controls, BOKS students accumulated significantly more total daily steps than control participants (716, 95% CI: 228–1204, $P = 0.004$) (Table 3). Higher total daily MVPA, VPA, and TPA minutes across all school days were observed among BOKS participants compared with controls, but differences were not statistically significant. During the before school period, BOKS students accumulated more physical activity compared with controls averaged across the school week, including significantly more steps (756, 95% CI: 580–932, $P < 0.001$), MVPA minutes (6.2, 95% CI: 4.9–7.4, $P < 0.001$), VPA minutes (2.2, 95% CI: 1.6–2.7, $P < 0.001$), and TPA minutes (12.0, 95% CI: 6.3–17.8, $P < 0.001$). Physical activity accumulated during the school day across the school week did not differ between BOKS participants and control students.

3.3. Total sleep time

Total sleep time did not differ between BOKS (mean 8.50 h/night, Standard Error (SE): 0.08) and control (mean 8.56 h/night, SE: 0.09) participants on nights prior to or following BOKS program participation (mean difference − 0.06, 95% CI: −0.19, 0.08, $P = 0.41$), adjusting for age and gender.

3.4. Within-person analysis

Table 3 presents data from multivariable linear mixed-effects regression models including only BOKS participants on days with and without BOKS programming. Compared to days without BOKS programming, on BOKS program days, students accumulated more steps (1153, 95% confidence interval (CI): 841–1464, $P < 0.001$), and daily minutes of accumulated MVPA (8.8, 95% CI: 5.3–12.2, $P < 0.001$), VPA (3.0, 95% CI: 1.6–4.5, $P < 0.001$), and TPA (20.8, 95% CI: 13.6–28.1, $P < 0.001$).

4. Discussion

Expanding opportunities for physical activity before school via programs like BOKS may boost student daily physical activity levels without compromising sleep time. Compared with controls, BOKS program participants were more physically active. There was no evidence that total sleep time was impacted by participation in before school programming. On program days, BOKS participants accumulated more daily total steps and moderate-to-vigorous and vigorous physical activity minutes than controls. Also, physical activity occurring during the school day did not differ significantly between BOKS participants and controls suggesting that children were not less active later in school after participating in before school programming. Additionally, using a within-child comparison, this study found that BOKS participants accumulated more steps and total daily moderate-to-vigorous, vigorous and total physical activity minutes on program days than on non-program days. Importantly, this analysis strategy eliminates potential

Table 1
Characteristics of BOKS Study Participants with Activity Monitor Data in 7 Schools in Massachusetts and Rhode Island, Fall 2016.

	Overall (n = 426)	BOKS[a] (n = 241)	Control (n = 185)	P Value for difference BOKS vs. control[b]
Community, no. (%)				0.81
Massachusetts community (4 schools)	239 (56)	134 (56)	105 (57)	
Rhode Island community (3 schools)	187 (44)	107 (44)	80 (43)	
Gender, no. (%)				0.42
Male	226 (53)	132 (55)	94 (51)	
Female	200 (47)	109 (45)	91 (49)	
Grade, no. (%)				0.37
Kindergarten	27 (6)	17 (7)	10 (5)	
1	46 (11)	33 (14)	13 (7)	
2	68 (16)	40 (17)	28 (15)	
3	76 (18)	39 (16)	37 (20)	
4	81 (19)	44 (18)	37 (20)	
5	81 (19)	43 (18)	38 (21)	
6	47 (11)	25 (10)	22 (12)	
Race/Ethnicity, No. (%)				0.73
Non-Hispanic White	249 (58)	138 (57)	111 (60)	
Non-Hispanic Black	17 (4)	9 (4)	8 (4)	
Hispanic/Latino	61 (14)	40 (17)	21 (11)	
Non-Hispanic Asian	28 (7)	14 (6)	14 (8)	
Non-Hispanic Other	31 (7)	18 (7)	13 (7)	
Unknown	40 (9)	22 (9)	18 (10)	
Age, mean (SD), y	8.6 (1.8)	8.4 (1.8)	8.8 (1.7)	**0.03**
Days monitored, mean (SD)	3.2 (0.7)	3.3 (0.7)	3.1 (0.8)	**0.03**
Days monitored when BOKS before school programming was offered, mean (SD)	1.5 (0.5)	1.6 (0.5)	1.5 (0.6)	**0.03**
Days monitored when BOKS before school programming was not offered, mean (SD)	1.7 (0.5)	1.7 (0.5)	1.7 (0.5)	0.36
Monitor Wear Hours/Day, mean (SD)				
Before school	8.8 (0.5)	8.8 (0.5)	8.8 (0.6)	0.13
During school	5.7 (0.7)	5.7 (0.7)	5.7 (0.8)	0.89
Total day	21.7 (3.9)	21.6 (3.9)	21.7 (3.9)	0.74

Abbreviations: BOKS, Build Our Kids' Success; SD, standard deviation.
[a] Students participating in BOKS before school programming.
[b] P-values were obtained from chi-square tests for differences in frequencies and from t-tests for differences in means. Boldface indicates statistical significance ($p < 0.05$).

residual sociodemographic or time-invariant confounding and also accounted for any differential day-to-day school-day physical activity offerings (Allison, 2005).

Very few studies of interventions in the before-school period are available to provide context for physical activity findings. However, a meta-analysis of afterschool program interventions suggests that interventions to increase physical activity conducted in programs occurring directly after the school day may contribute an additional 5 min/day of moderate-to-vigorous activity (Mears and Jago, 2016), approximately half of this study's effect size. A separate non-controlled study of before-school running club participants in two schools found evidence for physical activity effects among participants at only one of two schools studied. However, researchers did not compare running club participants' activity levels to non-participating students or account for differences in other activity offerings (Stylianou et al., 2016). Potentially, the physical activity accrued in a shorter-duration (15–20 min) program like the running club does not contribute substantively to physical activity levels over the course of a week or compensation for higher-intensity activity may have occurred. Here, data suggest no differences in physical activity levels during the school day between BOKS participants and non-participants, though researchers did not collect data on weekend days.

Research highlights how expanding physical activity program options for students not already participating may improve health-related outcomes (Gutin et al., 2008) and be cost-effective (Cradock et al., 2017). This study's findings support such recommendations, particularly during the before-school period where students accumulate a small portion of their daily physical activity (Long et al., 2013). Nationally, fewer than half of elementary schools offer school-operated afterschool physical activity program options (Turner et al., 2014). Some physical activity programs may have difficulty in maintaining program participation (Jago et al., 2015), ensuring adequate implementation of program activities when not led by intervention developers/staff (Mears and Jago, 2016), or may be more successful for some participants (Mears and Jago, 2016). The BOKS program has expanded to > 1500 schools. It offers before-school opportunities for students to participate in a structured program with a standardized curriculum led by instructors that receive training and technical assistance. These BOKS programs did not enroll the majority of students in a school, nor operate each day, however some schools incorporated additional strategies to integrate BOKS programming during the school day for all students. Strategies to expand opportunity for participation are needed. Researchers collected data in each school for one school week and lack data on how BOKS programs are adopted, implemented and maintained at schools. Early school start times and other aspects of program adoption, implementation and maintenance may have implications for spread of BOKS programs in other communities (McGoey et al., 2016).

4.1. Limitations

While this study supports the role of expanded opportunities for physical activity through programs such as BOKS, neither schools nor students were randomized. Furthermore, study participants were volunteer BOKS participants, a self-selected group of existing program participants or similarly self-selected volunteers from the same classrooms. However, BOKS study participants and control participants were well-matched on demographic variables related to physical activity, and the within-person analysis accounts for individual, non-time variant factors that may be related to physical activity. Schools and

Table 2
Between-person comparison of physical activity outcomes by segmented and total day among BOKS program vs. control participants in Massachusetts and Rhode Island, Fall 2016[a].

Days when BOKS before school programming was offered (n = 647)

Outcome	Before school[b]				During school[c]				Total day			
	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]
Steps												
BOKS	3190 (1317)	3217 (113)	1503 (1286, 1719)	< **0.001**	4061 (1624)	4037 (227)	78 (−141, 297)	0.48	11,571 (4017)	11,584 (545)	1147 (583, 1712)	< **0.001**
Control	1685 (1005)	1714 (121)			3856 (1428)	3958 (232)			10,387 (4259)	10,437 (557)		
MVPA minutes												
BOKS	15.3 (15.6)	15.5 (1.0)	13.4 (11.3, 15.5)	< **0.001**	12.0 (17.1)	11.6 (1.9)	2.0 (−0.7, 4.7)	0.15	43.7 (48.8)	42.7 (8.0)	13.4 (6.6, 20.3)	< **0.001**
Control	2.4 (6.3)	2.2 (1.1)			9.7 (13.6)	9.6 (2.0)			31.3 (44.1)	29.3 (8.1)		
VPA minutes												
BOKS	4.9 (7.2)	5.0 (0.4)	4.5 (3.6, 5.5)	< **0.001**	3.1 (6.3)	3.0 (0.7)	0.7 (−0.2, 1.7)	0.14	12.6 (19.4)	12.3 (3.0)	4.0 (1.2, 6.7)	**0.005**
Control	0.6 (2.1)	0.5 (0.4)			2.3 (4.9)	2.2 (0.7)			9.0 (18.7)	8.3 (3.0)		
Total PA minutes[f]												
BOKS	90.1 (36.6)	90.4 (3.3)	24.1 (17.3, 30.9)	< **0.001**	169.5 (55.4)	168.4 (5.8)	4.8 (−3.4, 12.9)	0.25	420.3 (117.0)	419.8 (9.8)	15.9 (0.0, 31.9)	0.05
Control	64.2 (34.0)	66.3 (3.6)			158.5 (53.6)	163.7 (6.0)			397.3 (118.8)	403.8 (10.4)		

All school days monitored (n = 1371)

Outcome	Before School[b]				During School[c]				Total Day			
	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]	Unadjusted mean (SD)	Adjusted mean (SE)[d]	Mean difference (95% CI)	*P* value[e]
Steps												
BOKS	2426 (1361)	2452 (121)	756 (580, 932)	< **0.001**	4345 (1766)	4356 (187)	59 (−141, 260)	0.56	10,653 (4316)	10,734 (449)	716 (228, 1204)	**0.004**
Control	1673 (975)	1696 (126)			4276 (1765)	4297 (191)			10,066 (4268)	10,018 (460)		
MVPA minutes												
BOKS	8.7 (13.2)	8.9 (0.5)	6.2 (4.9, 7.4)	< **0.001**	12.1 (18.2)	12.2 (1.6)	−1.1 (−3.5, 1.3)	0.39	34.2 (43.0)	34.5 (5.6)	4.7 (−0.7, 10.1)	0.09
Control	2.8 (7.2)	2.7 (0.6)			13.6 (18.6)	13.2 (1.7)			31.2 (42.2)	29.8 (5.7)		
VPA minutes												
BOKS	2.7 (5.7)	2.8 (0.2)	2.2 (1.6, 2.7)	< **0.001**	3.1 (7.0)	3.2 (0.6)	−0.1 (−1.0, 0.8)	0.79	9.2 (16.6)	9.4 (2.1)	1.1 (−1.0, 3.2)	0.30
Control	0.6 (2.6)	0.6 (0.2)			3.4 (7.3)	3.3 (0.7)			8.7 (17.8)	8.3 (2.2)		
Total PA minutes[f]												
BOKS	77.5 (35.9)	77.7 (3.5)	12.0 (6.3, 17.8)	< **0.001**	174.4 (53.0)	173.4 (4.1)	0.4 (−7.1, 7.9)	0.92	394.8 (123.3)	395.7 (7.6)	6.4 (−7.5, 20.2)	0.37
Control	64.7 (32.3)	65.7 (3.6)			170.3 (55.2)	173.0 (4.4)			386.7 (128.0)	389.3 (8.1)		

Abbreviations: BOKS, Build Our Kids' Success; SE, standard error; CI, confidence interval, MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity; PA, physical activity.

[a] Between-person comparisons were assessed using multivariable linear mixed-effects regression models. All models are adjusted for age, gender, and daily monitor wear hours and account for repeated days of observation within children and clustering of children within schools.

[b] The Before School period was defined as 12:00 am to (but not including) school start time. School start times were 8:15 am at 1 school, 8:45 am at 3 schools, and 9:20 am at 3 schools.

[c] The During School period was defined as school start time to (but not including) school end time. School hours were 8:45 am to 2:45 pm at 3 schools, 9:20 am to 3:15 pm at 3 schools, and 8:15 am to 2:45 pm at 1 school.

[d] Adjusted means represent mean activity levels for a child wearing the monitor for the mean daily wear time.

[e] Boldface indicates statistical significance ($p < 0.05$).

[f] Total PA minutes include minutes engaged in light, moderate, or vigorous activity.

Table 3
Within-person comparison of total daily physical activity outcomes on BOKS before school program days vs. other days in Massachusetts and Rhode Island, Fall 2016[a].

Outcome	Unadjusted mean (SD)	Adjusted mean (SE)[b]	Adjusted mean difference (95% CI)	*P* value[c]
Steps				
BOKS day	11,571 (4017)	11,291 (238)	1153 (841, 1464)	< **0.001**
Not BOKS day	9815 (4413)	10,138 (236)		
MVPA minutes				
BOKS day	43.7 (48.8)	38.9 (1.4)	8.8 (5.3, 12.2)	< **0.001**
Not BOKS day	25.5 (34.8)	30.2 (1.4)		
VPA minutes				
BOKS day	12.6 (19.4)	10.8 (0.6)	3.0 (1.6, 4.5)	< **0.001**
Not BOKS day	6.1 (12.7)	7.8 (0.5)		
Total PA minutes[d]				
BOKS day	420.3 (117.0)	406.9 (5.1)	20.8 (13.6, 28.1)	< **0.001**
Not BOKS day	371.5 (124.4)	386.1 (5.0)		

Abbreviations: BOKS, Build Our Kids' Success; SE, standard error; CI, confidence interval, MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity; PA, physical activity.

[a] Within-person comparisons were assessed using multivariable linear mixed-effects regression models among the sample of BOKS program participants only ($n = 241$ participants with a total of 792 days of observation). All models are adjusted for age, gender, total daily monitor wear hours, daily monitor wear hours during school, and daily physical activity achieved during school, and account for repeated days of observation within children and clustering of children within schools.

[b] Adjusted means represent mean activity levels for a child wearing the monitor for the mean total daily wear time and mean daily wear time during school and engaging in mean daily physical activity levels during school.

[c] Boldface indicates statistical significance ($p < 0.05$).

[d] Total PA minutes include minutes engaged in light, moderate, or vigorous activity.

districts in this study volunteered to participate; therefore results may not generalize to all students in schools or districts operating a BOKS program. BOKS programs were observed during a single school week. These weeks may not have been representative of usual practices. Additionally, individual participants' start and end times of attendance at each BOKS session were not recorded, therefore researchers may have misclassified the exposure if the participant did not attend full BOKS sessions. However, given hypothesized higher levels of physical activity among BOKS participants, both on BOKS program days in comparison with non-participants and compared with non-program days, misclassifying student program participation time would likely underestimate the effect of BOKS on physical activity levels. Physical activity outcomes were measured in this study using wrist-worn Fitbit monitors. Fitbit uses proprietary algorithms to calculate metrics available to document physical activity, some of which may incorporate age. Researchers accounted for actual student age in analyses. There are limited studies of Fitbit monitor reliability and validity among youth. However, the existing research indicates good accuracy of Fitbit-measured steps in children as young as age 10 (Voss et al., 2017).

5. Conclusions

BOKS participation is associated with more accumulated steps during the weeks of BOKS programming and promotes accumulation of additional physical activity on days that students participate. Expanding opportunities for physical activity via programming like BOKS could boost student physical activity levels during those weeks that students participate.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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