Pilot Intervention Targeting Sugary Drink Intake Associated With Improvements in Adolescent Sleep Duration

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ABSTRACT

Objective: To examine temporal associations between participation in a community-based intervention targeting sugary drink intake and sleep outcomes among children.

Methods: Data are from an ethnically diverse sample of 100 children aged 9–12 years from 2 Massachusetts Boys and Girls Club (BGC) sites who participated in a pilot-site randomized trial (usual BGC programming plus *H₂GO!* intervention vs usual BGC programming). Secondary outcomes of the trial (sleep duration and adequate sleep duration [≥ 9 h/night]) were assessed via a self-report survey at baseline, 2 months, and 6 months. Generalized linear and logistic regression models estimated intervention effects associated with outcomes.

Results: The intervention was associated with increased sleep duration ($\beta = 0.74$; 95% confidence interval, 0.03–1.45) and higher odds of adequate sleep (odds ratio, 2.47; 95% confidence interval, 1.06–5.74) at 2 months. Sleep did not differ by treatment condition at 6 months.

Conclusions and Implications: This community-based sugary drink intake intervention may be a potential avenue to improve child sleep outcomes in the short term.

Key Words: sugar-sweetened beverage consumption, sleep, childhood obesity intervention, community-based (*J Nutr Educ Behav.* 2022;54:276–281.)

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INTRODUCTION

Insufficient sleep among children and adolescents is associated with increased risk for obesity,^{1–4} depression,^{1,2} and poorer cognitive performance and behavior problems.^{2,5} The American Academy of Sleep Medicine recommends that children aged 6–12 years sleep 9–12 h/d.² Data from the 2015 Youth Risk Behavior Survey (YRBS) indicated that more than half (57.8%) of

middle school students reported short sleep duration on an average school night (< 9 hours per night for students aged 6–12 years and < 8 hours per night for students aged ≥ 13 years).⁶ The prevalence of short sleep duration among middle school students was significantly higher among non-Hispanic Black (61.1%) and Native Hawaiian/Pacific Islander (64.2%) students compared with non-Hispanic White (56.6%), Hispanic (57.3%), and Asian (55.5%)

students.⁶ Another study of middle school students indicated shorter sleep duration among those from lower socioeconomic status households.⁷

Multiple cross-sectional studies have found an association between consumption of sugar-sweetened beverages (SSBs) and shorter sleep duration in children and adolescents.^{8–11} Most of these studies hypothesize that shorter sleep duration could lead to altered SSB intake but acknowledge that the relationship may also operate in the opposite direction, in which intake of caffeine-containing SSBs could lead to altered sleep patterns. Data examining longitudinal associations between SSB intake and sleep and from intervention studies targeting SSB intake among child populations are lacking. Furthermore, no studies could be identified that examine the extent to which a childhood obesity prevention intervention solely targeting SSB intake may also impact sleep outcomes over time. This study aims to assess the extent to which a community-based behavioral intervention targeting SSB consumption

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impacts secondary outcomes related to sleep among an ethnically diverse sample of early and preadolescent youth. The hypothesis for this analysis was that participation in the SSB intervention would be associated with increased short-term school-night sleep duration and higher odds of adequate sleep (≥ 9 h/night) at 2 and 6 months.

METHODS

Study Design

This study was a secondary data analysis of data from a randomized pilot trial of a community-based youth empowerment intervention aimed at decreasing SSB consumption among children.^{12,13} Two Boys and Girls Clubs (BGC) afterschool program sites in Massachusetts were pair-matched for the number of children enrolled and racial/ethnic composition. One BGC site was randomly selected to receive the *H2GO!* intervention in addition to usual BGC programming, and the other served as the comparison site (usual BGC programming). Outcomes and covariates of interest were measured via self-administered survey assessments at baseline, 2 months, and 6 months. All study protocol and procedures were approved by the Boston University Medical Center Institutional Review Board. This trial was registered at ClinicalTrials.gov (NCT0289-0056).

Study Setting and Participants

Boys and Girls Clubs provide a multitude of programs for children from predominantly low socioeconomic backgrounds, including afterschool programs for children aged 9–12 years. Parent-child pairs from the BGC study sites were recruited in-person by BGC and study staff.^{12,13} Inclusion criteria for children included: aged 9–12 years, a current member of the BGC site, and able to understand and communicate in English. Children were excluded if they had a medical condition that limited their ability to change beverage consumption behaviors. Consent for participation in the study was obtained through written consent

forms completed by both child participants and a parent/caregiver.

Intervention

The *H2GO!* intervention focused on youth empowerment related to SSB consumption and consisted of 12 1-hour in-person group sessions over 6 weeks.^{12,13} Each of the 12 sessions was led by trained BGC staff members and occurred in the BGC setting. The development of the *H2GO!* intervention was informed by the Social Cognitive Theory and the Social Ecological Model.^{12,13} Intervention activities consisted of 3 main components: BGC staff-led interactive sessions focused on knowledge, attitudes, and skills related to decreasing SSB intake (eg, label reading and role-play skits); BGC staff-led narrative sessions and youth sharing of narrative materials produced (eg, print narratives to promote water intake and audio narratives to identify SSBs); and youth-led activities (eg, take-home parent-child activities and an open house healthy beverages event). The intervention activities did not specifically focus on sleep hygiene. Additional details on study protocols and procedures have been previously reported.^{12,13}

Measures

Child participants completed self-report measures administered in-person on the primary outcome (sleep duration) and covariates at baseline, 2 months, and 6 months. Sleep duration was assessed using an item from the 2015 YRBS Middle School Questionnaire¹⁴: “On an average school night, how many hours of sleep do you get?” Given differences in sleep duration on school nights vs weekend nights¹ and to minimize respondent burden, this study focused specifically on school-night sleep duration. Sleep duration was measured and analyzed continuously; adequate sleep (≥ 9 hours per night) was derived from sleep duration and analyzed as a dichotomous variable. Child sociodemographic variables collected included gender, age, and race/ethnicity. Children were asked, “what is your gender?” with response options of male or female. The

children’s race/ethnicity was self-reported by children from a list including White, Black or African American, Hispanic/Latino, Asian, Native American/Alaskan Native, Native Hawaiian/Pacific Islander, other. Individuals were asked to check all that apply. Parental/caregiver sociodemographic characteristics, assessed using self-report surveys, included parental education (highest level attained) and household income level.

Statistical Analysis

Participants who had baseline and at least 1 follow-up assessment were included in the analytic sample. Baseline demographics and characteristics of participants were described using means and standard deviations for continuous variables and frequencies and proportions for categorical variables. Descriptive statistics comparing baseline data between treatment conditions used *t* tests and chi-square tests of homogeneity, as appropriate. Changes in participant school-night sleep duration from baseline to 2 months and baseline to 6 months were estimated using generalized linear mixed regression models, and odds of reporting adequate sleep duration (≥ 9 hours per night) were estimated using logistic regression models. Crude models were used to estimate 2-month and 6-month changes in sleep duration and odds of reporting adequate sleep. Adjusted models controlling for covariates that differed by treatment condition at baseline (child gender and race/ethnicity)¹³ and that have been shown in the literature to be associated with sleep (age¹ and socioeconomic status⁷) estimated adjusted 2-month and 6-month changes in sleep duration and odds of reporting adequate sleep. Measures of socioeconomic status used in this study included parental education level and household income. Analyses were performed using an intent-to-treat approach. A significance level of $\alpha = 0.05$ was used for all statistical tests. Data were analyzed using SAS (version 9.3, SAS Institute, Inc, 2011).

Table 1. Baseline Characteristics of Children in the *H₂GO!* Pilot Study by Treatment Condition (2016–2017)

Characteristics	Total (n = 100)	<i>H₂GO!</i> Intervention + Usual BGC Programming (n = 51)	Usual BGC Programming (n = 49)	<i>P</i> ^a
Gender				
Female	46 (46.0)	29 (56.9)	17 (34.7)	0.03
Age, y	10.1 (1.0)	10.0 (1.1)	10.2 (1.0)	0.48
Race ^b				0.001
White	13 (13.0)	4 (7.8)	9 (18.4)	
Black	38 (38.0)	26 (51.0)	12 (24.5)	
Hispanic/Latino	20 (20.0)	12 (23.5)	8 (16.3)	
Asian	11 (11.0)	0 (0.0)	11 (22.4)	
Multiracial	12 (12.0)	7 (13.7)	5 (10.2)	
Other	5 (5.0)	1 (2.0)	4 (8.1)	
Household income level				0.99
< \$30,000	43 (49.4)	22 (50.0)	21 (48.8)	
\$30,000–\$49,999	25 (28.7)	13 (29.6)	12 (27.9)	
≥ \$50,000	17 (19.5)	8 (18.2)	9 (20.9)	
Parental education level				0.22
High school degree	34 (39.1)	14 (31.8)	20 (46.5)	
Some college	27 (31.0)	15 (34.1)	12 (27.9)	
College degree	23 (26.4)	12 (27.3)	11 (25.6)	
Mean school-night sleep duration, h	8.1 (1.7)	8.0 (1.8)	8.1 (1.6)	0.67
Reported adequate school-night sleep duration, ≥ 9 h/night	46 (46.0)	23 (45.1)	23 (46.9)	0.85

BGC indicates Boys and Girls Clubs.

^a*P* values reflect results of *t* tests for continuous variables and chi-square tests of homogeneity for categorical variables (significance level of $\alpha = 0.05$); ^bn = 1 missing from *H₂GO!* intervention group.

Note: Values are n (%) or mean (SD).

RESULTS

The analytic sample included 100 participants (46% female; 38% Black, 20% Hispanic) with a mean age of 10.1 years (SD, 1.0). At baseline, children reported that they slept for an average of 8.1 hours (SD, 1.7) on school nights, and 46% of children reported adequate sleep duration on school nights (≥ 9 hours per night). Additional characteristics of the sample at baseline are presented in Table 1. Intervention attendance rates among child participants averaged 78.1% (SD, 10.3) across the 12 *H₂GO!* intervention sessions, with 90.5% of child participants and 74.5% of parent participants attending the final intervention meeting.¹³ The average fidelity score of intervention delivery was 91.0%.¹³ The percentage of children reporting adequate school-night sleep duration in the *H₂GO!* intervention was higher than that of the usual BGC

programming site at 2 months (54.9% vs 40.8%, respectively) and 6 months (43.1% vs 38.8%, respectively) (Table 2).

Crude and adjusted models estimating change from baseline in sleep outcomes between *H₂GO!* intervention and usual BGC programming comparison site participants are presented in Table 2. In unadjusted models, 2- or 6-month change in school-night sleep duration or odds of adequate sleep duration did not differ by treatment condition. In adjusted models, children at *H₂GO!* Intervention sites reported increased sleep duration on a typical school night from baseline to 2 months ($\beta = 0.74$ hours; 95% confidence interval [CI], 0.03–1.45; 44.4 minutes) compared with children from usual BGC programming comparison sites. There was no difference in change in sleep duration by treatment condition from baseline to 6 months. Children from *H₂GO!* intervention sites reported

more than twice the odds of sleeping ≥ 9 h/night (odds ratio [OR], 2.47; 95% CI, 1.06–5.74) at 2 months compared with children from usual BGC programming comparison sites. At 6 months, the odds of adequate sleep duration did not differ by treatment condition.

DISCUSSION

Findings from this study indicated that participation in a community-based intervention targeting sugary drink intake was associated with increased school-night sleep duration among children at 2 months after adjusting for child demographics, parental education, and household income. However, increases in sleep duration were not maintained through 6 months. Given that the *H₂GO!* intervention was previously shown to be associated with reductions in SSB intake at 2 and 6 months,¹³ the finding that children offered the *H₂GO!*

Table 2. Two- and 6-month Change in Sleep Outcomes Associated with the *H₂GO!* Intervention Among Children Aged 9–12 Years (n = 100)

Outcomes	School-Night Sleep Duration, h, Mean (SD)	Change From Baseline Between Treatment Conditions, ^a		Change From Baseline Between Treatment Conditions, ^a	
		Crude Diff (95% CI)	P	Adjusted ^b Diff (95% CI)	P
Baseline					
<i>H₂GO!</i> intervention + Usual BGC Programming	8.0 (1.8)	—	—	—	—
Usual BGC Programming	8.1 (1.6)				
2 mo					
<i>H₂GO!</i> intervention + Usual BGC Programming	8.4 (1.5)	0.58 (−0.08 to 1.25)	0.08	0.74 (0.03 to 1.45)	0.04
Usual BGC Programming	8.0 (1.7)				
6 mo					
<i>H₂GO!</i> intervention + Usual BGC Programming	8.2 (1.4)	0.12 (−0.60 to 0.84)	0.73	0.10 (−0.68 to 0.88)	0.80
Usual BGC Programming	8.2 (1.5)				
Outcomes	Adequate School-Night Sleep Duration, ≥ 9 h/night, n (%)	Change from Baseline Between Treatment Conditions, ^a		Change from Baseline Between Treatment Conditions, ^a	
		Crude OR (95% CI)	P	Adjusted ^b OR (95% CI)	P
Baseline					
<i>H₂GO!</i> intervention + Usual BGC Programming	23 (45.1)	—	—	—	—
Usual BGC Programming	23 (46.9)				
2 mo					
<i>H₂GO!</i> intervention + Usual BGC Programming	28 (54.9)	1.90 (0.89–4.08)	0.10	2.47 (1.06–5.74)	0.04
Usual BGC Programming	20 (40.8)				
6 mo					
<i>H₂GO!</i> intervention + Usual BGC Programming	22 (43.1)	1.29 (0.53–3.13)	0.57	0.81 (0.32–2.07)	0.66
Usual BGC Programming	19 (38.8)				

BGC indicates Boys and Girls Club; CI, confidence interval; Diff, difference; OR, odds ratio.

^aGeneralized Linear and Logistic Mixed Effects Regression Models (significance level of $\alpha = 0.05$); ^badjusted for child age, child gender, child race/ethnicity, parental education level, and household income.

intervention increased their sleep duration by 44 minutes more than children in the comparison site and more than doubled the odds of meeting recommendations for adequate sleep (≥ 9 h/night) at 2 months post-intervention suggests that decreasing SSB intake may be a viable intervention strategy to improve short-term sleep duration among early and preadolescents.

The current study's finding supports existing cross-sectional studies that have shown an inverse association between SSB consumption and sleep duration among

children of similar age.^{8–10} These studies have primarily focused on the association of shorter sleep duration leading to higher SSB intake (possibly because of an overall increase in consumption of energy-dense food/drinks or because of seeking out caffeine and sugar to increase alertness); however, because these cross-sectional studies are not able to establish directionality, it is plausible that higher SSB consumption leads to shorter sleep duration or that the relationship is bidirectional. The specific mechanisms that may

underlie this association are important areas for future investigation.

A potential mechanism for the short-term improvements in sleep duration observed over time in this study is a decrease in caffeine intake, as many SSBs contain caffeine. Caffeine intake by children and adolescents has been linked with decreased sleep duration,^{15,16} difficulty sleeping,¹⁷ and morning tiredness.^{17,18} The relationship between caffeine intake and sleep may be cyclical, in that the stimulating properties of caffeine may disrupt sleep, leading to daytime sleepiness, which may then

lead to further increases in caffeine consumption.¹ Cross-sectional data from fourth- and seventh-grade children indicated that those who slept < 10 hours per day reported more frequent soda (but not juice drink) intake,⁹ which may point to the role of caffeine in the association between SSB consumption and sleep. The significant association between the *H₂GO!* intervention and sleep duration at 2 months relative to the comparison group may not have persisted through 6 months follow-up because of the intervention more broadly targeting a reduction in SSB consumption, and not specifically SSBs containing caffeine.

At baseline, 46% of children in the study reported adequate school-night sleep duration of ≥ 9 hours, slightly higher than the prevalence of 42% reported by middle school respondents in the 2015 YRBS, who were slightly older than children in this study.⁶ Given that similar racial/ethnic and socioeconomic disparities exist in sleep duration,^{6,7} SSB consumption,^{19,20} and obesity^{21,22} among children, findings from this study suggest that intervening on SSB consumption may be a strategy to improve multiple interrelated outcomes (eg, SSB intake, sleep, and childhood obesity outcomes) among a population at higher risk for these adverse health behaviors and health outcomes.

Strengths of this study include the inclusion of a racial/ethnically diverse population of early and pre-adolescent children with relatively low socioeconomic status—a disproportionately burdened population with higher rates of insufficient sleep^{6,7} and SSB consumption.^{19,20} Though data on the accuracy of self-reported sleep for children aged 9–12 years is limited, a recent study comparing the validity of child-reported sleep measures with polysomnography indicated there was a strong agreement for total sleep time (intraclass correlation, 0.722; $P < 0.001$) among children aged 9–17 years.²³ Given that 2^{24,25} out of 4^{24–27} studies investigating the association between seasonality and sleep duration in children and adolescents found longer sleep durations in winter months, it is possible that

seasonality may have partially contributed to sleep outcomes observed in this study (baseline measures were conducted in the fall, 2-month follow-up measures were conducted in the winter, and 6-month follow-up measures were conducted in the spring). However, the inclusion of a comparison group in this study strengthens the ability to rule out seasonality as a confounder of effects associated with the intervention, as baseline, 2 months, and 6 months measures were collected on both intervention and comparison groups. A limitation of this study is that caffeine intake was not specifically assessed when assessing intake of SSBs; thus, it remains unclear whether caffeine intake was reduced as a result of the intervention or whether changes in caffeine intake explain the findings regarding changes in sleep duration. The findings from these analyses should be considered exploratory because changes in sleep duration were not a prespecified primary outcome in this study. In addition, this pilot study was limited to a sample size of 100 participants at 2 study sites in Massachusetts; results may not be generalizable to other populations. Although individuals from the same site may have more similar (correlated) outcomes than individuals from different sites, we only recruited 2 sites in this pilot trial, and thus we did not adjust for clustering at the site level as the study site does not provide additional information beyond treatment condition. Therefore, the results may be overstated.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Results from this study suggest that a community-based youth empowerment intervention targeting SSB consumption may lead to short-term improvements in sleep duration among an ethnically diverse sample of youth. These data support the need for future studies of interventions that target SSB intake to further examine the associations between and mechanisms underlying beverage consumption and changes in sleep duration among youth.

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