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Effectiveness of a School Drinking Water Promotion and Access Program for Overweight Prevention

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Abstract

BACKGROUND AND OBJECTIVE: Drinking water promotion and access shows promise for preventing weight gain. This study evaluated the impact of Water First, a school-based water promotion and access intervention on changes in overweight.

METHODS: Low-income, ethnically diverse elementary schools in California's Bay Area were cluster-randomized to intervention and control groups. Water First includes classroom lessons, water stations, and schoolwide water promotion over 1 school year. The primary outcome was overweight prevalence (BMI-for-age-and-sex ≥85th percentile). Students (n = 1249) in 56 fourth-

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Dr Patel conceptualized, designed, and implemented the study, led the development of the intervention, provided detailed oversight of data analysis, interpreted the data, drafted the initial manuscript, and reviewed and revised the manuscript critically for important intellectual content; Dr Schmidt contributed to study conceptualization, study design, data collection, and interpretation, reviewed, and revised the manuscript critically for important intellectual content; Dr McCulloch contributed to study conceptualization, study design, data collection, provided specific expertise in data analysis and interpretation, and reviewed and revised the manuscript critically for important intellectual content; Ms Blacker participated in data collection, helped lead the intervention, performed data cleaning and data analysis, provided input in data interpretation, and reviewed and revised the manuscript critically for important intellectual content; Dr Cabana provided high-level oversight of the study conceptualization and design and reviewed and revised the manuscript critically for important intellectual content; Dr Brindis provided high-level oversight of the study conceptualization and design and reviewed and revised the manuscript critically for important intellectual content; Dr Ritchie contributed to study conceptualization, study design, led the collection, cleaning, and analysis of food and beverage diary data, provided input on interpretation of study findings, and reviewed, and revised the manuscript critically for important intellectual content; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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grade classes in 18 schools (9 intervention, 9 control) from 2016 to 2019 participated in evaluation at baseline, 7, and 15 months. Data collection was interrupted in 8 additional recruited schools because of coronavirus disease 2019.

RESULTS: Of 1262 students from 18 schools, 1249 (47.4% girls; mean [SD] age, 9.6 [0.4] years; 63.4% Hispanic) were recruited. From baseline to 7 months, there was no significant difference in changes in overweight prevalence in intervention schools (−0.2%) compared to control schools (−0.4%) (adjusted ratio of odds ratios [ORs]: 0.7 [confidence interval (CI): 0.2–2.9] $P = 0.68$). From baseline to 15-months, increases in overweight prevalence were significantly greater in control schools (3.7%) compared to intervention schools (0.5%). At 15 months, intervention students had a significantly lower change in overweight prevalence (adjusted ratio of ORs: 0.1 [CI: 0.03–0.7] $P = .017$) compared to control students. There were no intervention effects for obesity prevalence.

CONCLUSIONS: Water First prevented increases in the prevalence of overweight, but not obesity, in elementary school students.

Experiencing overweight in childhood increases the likelihood of the same in adulthood,[1–3] along with increasing the risk of chronic illnesses including type 2 diabetes, dyslipidemia, hypertension, and nonalcoholic fatty liver disease,[4–7] particularly among low-income populations and people of color.[8,9] Nearly 1 in 3 US children met criteria for overweight or obesity before the coronavirus disease 2019 (COVID-19) pandemic and rates have increased since.[10–12] Sugar-sweetened beverage (SSB) consumption is a major contributor to overweight and obesity in children.[13–15] Although many efforts have targeted reductions in SSB consumption in schools,[16–20] fewer have explored the promotion of water intake as a substitute.[21–26]

Two experimental studies have evaluated the impact of school-based drinking water interventions on weight status.[21,22] In 1 study, administrative data from 1227 New York City elementary and middle schools were linked to data on school water dispensers, student BMI, and cafeteria flavored milk purchases. Investigators found that providing water dispensers and cups in cafeterias led to 0.6% and 1.2% reductions in overweight (≥85th BMI%) in girls and boys, respectively, along with reductions in flavored milk purchases.[22] Second, a cluster–randomized control trial (RCT) in 32 German elementary schools examined the impact of a water promotion and access intervention (installation of water dispensers, distribution of reusable water bottles, and water promotion lessons). Although the investigators found a 1.8% reduction in overweight prevalence,[21] they found no effects of the intervention on SSB or juice consumption. Neither of these studies examined the impacts of water promotion and access on comprehensive measures of dietary intake, even though increases in water consumption can diminish food intake by increasing satiety.[27,28]

This study reports findings from a cluster-RCT of Water First, a school-based program that combines water promotion with changes to the school environment that increase drinking water access in a US context. This was the first such CRT conducted in a US context where sugar-sweetened milks and juices are available in schools. Our primary aim was to evaluate the impact of Water First on changes in overweight or obese prevalence (ie,

≥85%) in schools serving low-income and ethnically diverse public elementary students, students more likely to drink SSBs[29,30] and to suffer the health consequences of overweight or obesity.[8,9] We hypothesized that Water First would prevent transitions to overweight or obese status in intervention students compared to controls. Our secondary aim was to explore dietary mechanisms that could explain any effects of the intervention on weight. Although previous studies suggest that increased water consumption may displace SSBs in the diet and promote satiety,[27,28] previous evaluations of school-based water interventions have not systematically examined impacts on food or other beverage consumption. Our hypothesis was that Water First would lead to increases in water intake and reductions in SSB intake but no change in energy intake (calories) from food.

METHODS

Study Design and Participants

This was a parallel arm cluster-RCT in 26 public elementary schools.[31] Because of staffing needed to implement the study, 6 to 8 schools participated annually for 4 consecutive years. Each annual cohort of schools was randomized using a 1:1 allocation ratio after recruitment but before baseline assessment. Follow-up assessments occurred at 7- and 15-months postbaseline. Follow-up data collection was precluded in the final cohort of 8 schools at month 7 because of COVID-19 pandemic school closures. The detailed protocol following CONSORT guidelines (Fig 1) is published[31] and preregistered at clinicaltrials.gov (NCT03181971).[32] Institutional review boards at the University of California, San Francisco, and Stanford University approved study protocols.

Eligible schools were in northern California, served low-income students (≥50% free/reduced-price meal-eligible), did not promote water, and had sufficient fourth grade students (n >65 per school). Participatory research methods were used to develop the intervention and to engage school districts and school staff.[31,33] Students received a movie voucher for participating in the evaluation, with additional gift card incentives for schools. Parent consent and student assent were required and all study information was available in Spanish and English.

Of the 1544 fourth-grade students eligible from 3 cohorts, 1262 enrolled in the study and 1249 completed baseline assessments, between August 2016 and March 2020 (Fig 1). Reasons for not participating included ineligibility (n = 30; moved grade or school, had a medical condition that precluded drinking water, could not complete assessments because of developmental delay, or the student and/or parent did not speak English or Spanish), refusal (n = 159), and no return of consent form (n = 93). Follow-up assessments were completed by 95.7% (n = 1195) and 84.7% (n = 1058) of participants at 7 and 15 months, respectively.

Intervention

The Water First program, based on theory[34,35] and previous studies,[23,24] is administered during a single school year (for details, see Moreno et al[31]). Tap water stations (3 per school), with water tested and remediated for lead,[36,37] are installed in intervention school playgrounds, high-traffic areas, and in cafeterias in which cups were also available.

Schoolwide promotion included a kickoff assembly,[38] signage, and modest prizes for students observed drinking water at lunch, which have proven effective in previous studies.[39] Students received eight 15-minute in-class lessons with family home engagement activities on health, fiscal, and environmental benefits of drinking water.

Outcomes

Primary outcome: Height and weight of students were measured by researchers using standardized protocols from the NHANES at baseline, 7-months, and 15-months.[40] These measures yielded BMI percentile, mean BMI, BMI *z*-score, and prevalence of overweight and obesity in students using Centers for Disease Control and Prevention growth curves (BMI percentile for age and sex: ≥85% = overweight; ≥95% = obesity).[41]

Secondary outcomes: At baseline and 7-months, daily food and beverage calories were measured using a gold standard 24-hour dietary recall adapted from the National Health and Nutrition Examination Study[42] that was augmented with a validated food and beverage diary method used widely in studies of school-aged children.[43–45] After a researcher-led training on diary use, students took home the diary (in English or Spanish), which included pictured measuring aids, measuring cups and spoons, and instructions to have an adult assist in measuring and recording all beverages and foods consumed. The next day, researchers worked with students individually to conduct multiple pass 24-hour recalls. Interviewers verified unusual items or minimal intakes reported and examined distributions of common macronutrients and energy intake for outliers. Of the 1249 study students, 1105 (88.5%) had reliable 24-hour dietary intake data at both timepoints. At all timepoints, a validated instrument[46] also assessed past-week frequency of beverage consumption to examine longer-term changes in water and SSB intake.

Control variables included students' demographics including self-reported age, sex, and race and ethnicity, screen time, and physical activity adapted from widely used instruments. Students reported the amount of time they spent the day before the survey playing video or computer games, watching movies or programs, and doing other things on the computer or phone.[47] Students categorized the level of physical activity that made them breathe hard or sweat in the previous week as: none, sometimes (1–2 times), often (3–4 times), quite often (5–6 times), or very often (7 or more times).[48]

We used direct observation methods at all timepoints[49–51] to document student use of school water sources during lunchtime, fourth-grade physical education classes, and recess. At baseline, monthly during the intervention period, and again at 7-months and 15-months, researchers tallied the number of students using water sources and the student census in the area to estimate the proportion using stations or fountains. Because of large numbers of students at lunch, 2 researchers conducted lunchtime observations with reconciliation of any differences between observers; one observer monitored physical activity and recess.

Sample Size Justification

With 26 schools, at least 50 fourth-grade students per school, and an intraclass correlation of 0.005, we had 80% power to detect a 5% between-group difference in the change in overweight prevalence at 15 months.[21,31]

Statistical Analysis

Analyses were performed in StataSE version 15.1.[52] Mixed-effects logistic regression models examined between-group changes in the adjusted prevalence of overweight and obesity between baseline and 7- and 15-months follow-up. The primary predictor was the intervention status by time interaction. To account for clustering, models included random intercepts for student, school, and class. Models also included random slopes that allowed for differential changes among individual students over time. We adjusted for year to capture secular trends, and controlled for students' self-reported race and ethnicity, sex, and age, and physical activity and screen time at baseline. Similar mixed effects linear regression models assessed secondary continuous outcomes of weight status (BMI percentile, mean BMI, BMI *z*-score), dietary outcomes including total calories from foods and beverages, beverage frequency, and the proportion of students in schools observed drinking water. Because of skewed distributions, dietary outcomes were log-transformed and regression coefficients were exponentiated to derive the percent change in outcomes by intervention status over time.

Given loss of the last 8 schools because of the COVID-19 pandemic, we conducted sensitivity analyses to predict changes in study findings had all completed the study.[53,54] We also conducted sensitivity analyses to examine the proportion of students moving across different weight status categories (eg, normal weight, overweight) over time. Methods and results are described in the Supplementary Materials (Supplemental Table 4–7).

RESULTS

No significant differences were found in students' baseline characteristics between intervention and control groups (Table 1). Students' mean age was 9.6 years (SD = 0.4), 47.4% were female, and a majority (63.4%) were Hispanic. Enrolled students were representative of students in study schools on sex (47.8% female) and Hispanic ethnicity (68.7%). However, a greater proportion of enrolled students were of other race and ethnicity compared to students in schools overall (11.5% vs 3.7%; standardized difference 0.30). Although student-level household income was not ascertained, 69.4% of students in study schools were eligible for free or reduced-price meals.[55]

There were negligible changes in the adjusted proportion of students classified as overweight between intervention and control schools from baseline to 7 months (Table 2). At 15 months, intervention students had a significantly lower adjusted change in overweight prevalence (adjusted ratio of ORs: 0.1 [confidence interval (CI): 0.03–0.7] $P = .017$) compared to control students. Adjusted between-group differences in changes in secondary weight status measures from baseline to 15-months were not statistically significant. Sensitivity analyses based on the projected full sample (Supplemental Table 4) and of students with complete data at all timepoints demonstrated no substantive differences in results for weight measures. Analyses examining turnover across weight status measures from baseline to 15-months found that proportionately more intervention students (compared to controls) stayed at normal weight status rather than progressing to overweight, and more moved from overweight to normal status (Supplemental Table 6 and 7). No intervention effect was observed for students who had obesity or severe obesity.

Based on 24-hour dietary recalls at baseline and 7 months, between group changes in calories from foods and beverages and grams of water consumed were not statistically significant (Table 3). Sensitivity analyses with the full projected sample showed no considerable differences in these results (Supplemental Table 5).

As reported on 1-week beverage frequency questionnaires, from baseline to 7 months, intervention students reported a significantly greater increase in the frequency of water consumed (1 time per day) as compared to control students (−0.5 time per day); (adjusted percent difference in change: 23.2% [CI: 13.1–34.2]) (Table 3). This change in frequency of water consumed was sustained at 15 months (intervention 0.1 time per day versus control −0.9 time/day; adjusted percent difference: 14.7% [CI: 4.5–25.9]). At 7 months, there was a greater decreased change in the frequency of SSBs consumed in intervention students (−1.1 time per day) compared to control students (−0.7 time per day) that did not reach statistical significance (adjusted percent difference in change: −8.0% [CI: −15.7 to 0.4]). Sensitivity analyses based on the projected full sample suggested a statistically significant reduction in change in frequency of SSB intake between intervention and control students from baseline to 7-months that did not persist at 15-months (Supplemental Table 5).

Direct observations carried out from baseline to 7-months found a significant increase in the adjusted change in the proportion of intervention versus control students drinking water during lunch (intervention 34.8% vs control −0.1%; adjusted percent difference in change: 31.3% [CI: 21.2–42.2]) and recess (intervention 22.8% vs control 0.5%; adjusted percent difference in change: 17.0% [CI: 2.6–33.3]) (Table 3). These percent increases in the change in proportion of students drinking water at lunch and recess were not sustained at 15-months. No significant differences were observed for the change in proportion of students drinking water during physical education periods.

DISCUSSION

This cluster-RCT found that Water First, a school-based drinking water promotion and access program prevented increases in overweight prevalence for students in ethnically diverse, low-income elementary schools. We observed a 3.2% difference in change in overweight prevalence between intervention and control students from baseline to 15-months follow-up. This finding was robust against a decline in statistical power because of COVID-19 trial disruptions.

Although 2 other experimental evaluations of school-based drinking water interventions found favorable impacts on overweight status, this trial found a larger effect size: a 3.2% difference in the change in overweight prevalence among intervention versus control students compared to 0.06% and 1.8% in the previous studies.[21,22] The Water First intervention was more comprehensive than previous interventions because it coupled water education and promotion with the installation of appealing drinking water sources throughout the school. The larger effect found here could also result from differences in school food environments or differences in baseline weight status, since previous studies were conducted in New York City and Germany. German and US schools differ in that the latter often serve juice and flavored (sugar-sweetened) milk.[57] The Community Preventive

Services Task Force notes that there is insufficient evidence to determine the role of school-based drinking water access interventions in obesity prevention and control because of a lack of rigorous studies.[58] This trial adds to the evidence.

National standards set by Healthy People call for a 2.3% reduction in childhood obesity by 2030 (17.8%–15.5%).[59] Although Water First did not affect obesity prevalence, it achieved comparable prevention of overweight, an important target for addressing obesity in adulthood. Despite the small effects of school-based obesity prevention programs like Water First, they have the potential to impact large numbers of children at a lower cost than more intensive clinical interventions. Previous cost-effectiveness analyses of water promotion interventions in low-income schools suggest that over a 10-year period in the United States these interventions could prevent nearly 180 000 cases of childhood obesity, saving nearly $390 million dollars in health care costs.[60]

It is notable that impacts of the Water First intervention were confined to overweight status and did not extend to obesity or severe obesity. Although it is promising that Water First prevents increases in overweight, more intensive clinical interventions, and more comprehensive prevention efforts targeting the home environment may be needed to improve the weight status of students who already have obesity or severe obesity. This is consistent with the American Academy of Pediatrics guidelines that call for 26 hours of face-to-face intensive health behavior and lifestyle treatment over 3 months for families of children with obesity.[61]

The Water First program also changed secondary outcomes in some expected directions. Although statistical power was limited because of pandemic school closures, sensitivity analyses suggested that increases in the frequency of water consumed at 7- and 15-months could have led to reductions in SSB consumption in a fully powered sample. In contrast to data from dietary frequency questionnaires, recall data did not demonstrate similarly significant impacts on changes in the quantity of water, food, or other beverages. Null findings for dietary recall data may have been because of random error and inability to detect relatively small daily changes.[56]

This study found that Water First's impacts on water and SSB intake tapered off between the 7- and 15-month follow-ups. Although intervention students had access to water stations for the study duration, class lessons and promotion ceased after 6 months. The decay in intervention effects suggest the need for school champions and regular boosters.[62] The impact on overweight observed at the 15-month follow-up when there were smaller changes in beverage intake may relate to the cumulative effects of small changes in beverage consumption over time. Additionally, intervention students may have adopted healthy beverage intake patterns during summer months, when students may gain weight because of the lack of school structure.[63] To sustain long-term effects in dietary behaviors, school-based interventions may need to continue longer than a single academic school year.

This study had several limitations. Because of pandemic-related school closures, the study was incomplete in 8 of the 26 study schools, significantly reducing statistical power. However, we conducted sensitivity analyses to predict changes in *P* values and confidence intervals if all 26 schools had completed the study. Although our maximum-likelihood-based analysis protects against bias because of data that are missing at random, it may not provide protection when data are missing not at random.[64] Sensitivity analyses using a sample including students with complete data at all timepoints, however, did not lead to any substantial changes in results. Also, we only collected 1 day of dietary recall at baseline and 7-months and not at 15-months because of resource-intensiveness and because we hypothesized that the intervention would be most likely to affect overall dietary outcomes, including intake of food calories, in the short-term. Lastly, as the study intentionally targeted schools with students from low-income backgrounds to reduce socioeconomic disparities in obesity, findings may not be generalizable to other populations.

CONCLUSIONS

The Water First program promotes and increases access to drinking water in elementary schools. This CRT found that Water First holds promise for preventing overweight in children, with a greater effect size than previous school-based water interventions. The study adds substantively to the limited rigorous evidence examining the impact of school-based drinking water promotion and access programs on overweight for children from low-income, ethnically diverse backgrounds who are at greatest risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

CI	confidence interval
COVID-19	coronavirus disease 2019
OR	odds ratio
RCT	randomized controlled trial
SSB	Sugar-sweetened beverages

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WHAT'S KNOWN ON THIS SUBJECT:

Although promotion of drinking water intake in schools has shown promise in preventing weight gain, no large studies have comprehensively examined how this strategy can change children's overall dietary patterns and weight status.

WHAT THIS STUDY ADDS:

At 15-months, there were smaller increases in overweight prevalence in intervention students = (0.5%) compared to control students (3.7%). Intervention students had a lower adjusted change in overweight (OR: 0.1 [CI: 0.03 to 0.7] P =.017) compared to control students.

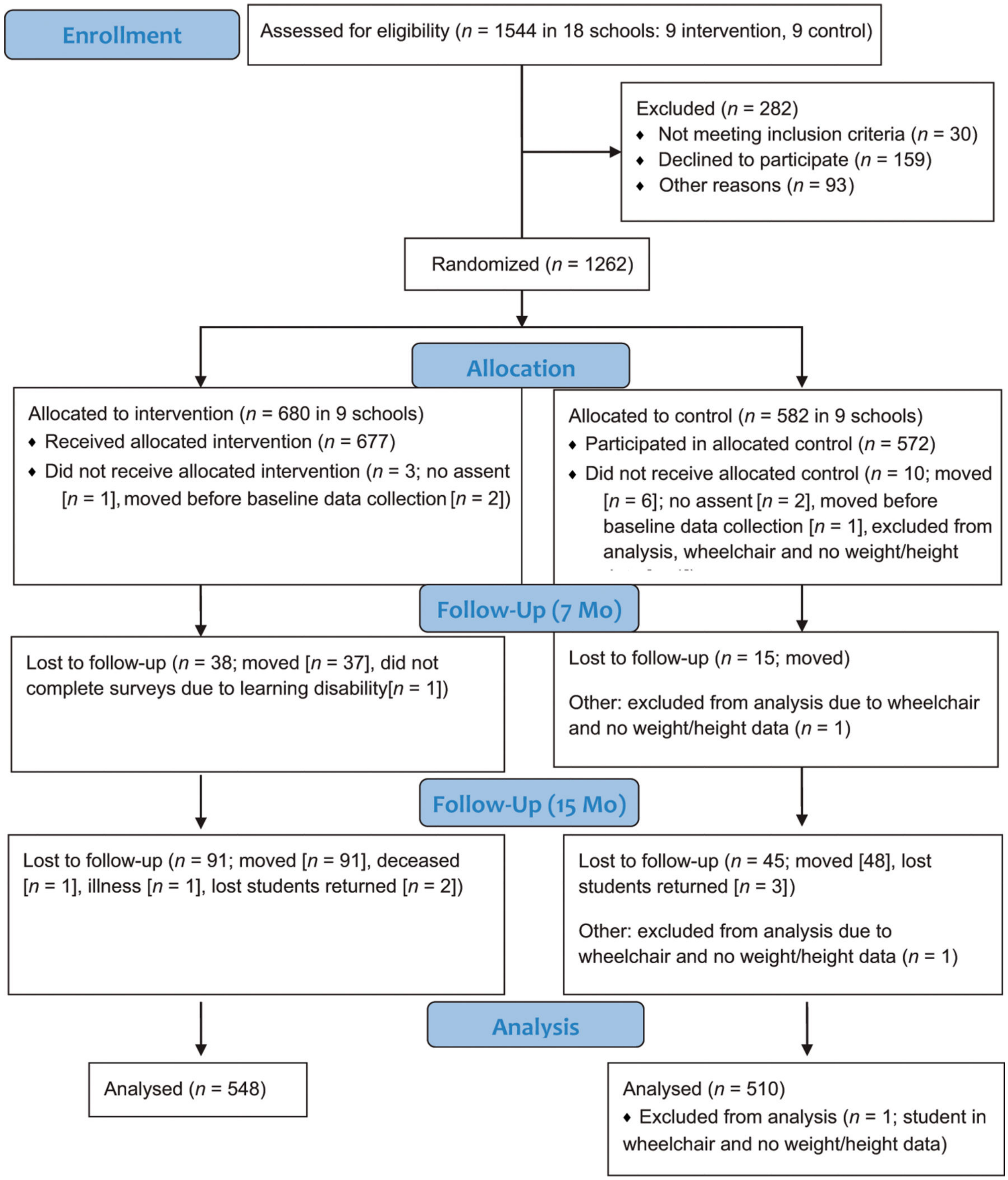

FIGURE 1.
CONSORT flow diagram.

TABLE 1

Baseline Characteristics of Water First Evaluation Study Participants

Characteristic	Total[a] (*n* = 1249)	Intervention (*n* = 677)	Control[b] (*n* = 572)
Student participants per school, mean (SD)	69.4 (20.5)	75.2 (16.2)	63.6 (23.6)
Age in y, mean (SD)	9.6 (0.4)	9.6 (0.4)	9.6 (0.4)
Female, No. (%)	592 (47.4)	318 (47.0)	274 (47.9)
Race and ethnicity, No. (%)			
Mexican American, Latino, Hispanic	792 (63.4)	455 (67.2)	337 (58.9)
Non-Hispanic Asian	174 (13.9)	80 (11.8)	94 (16.4)
Non-Hispanic Black	51 (4.1)	26 (3.8)	25 (4.4)
Non-Hispanic White	88 (7.1)	43 (6.4)	45 (7.9)
Other (American Indian)	144 (11.5)	73 (10.8)	71 (12.4)
Physical activity times per week, No. (%)[b,c]			
0 times	122 (9.8)	68 (10.1)	54 (9.4)
1–2 times	481 (38.6)	261 (38.7)	220 (38.5)
3–4 times	248 (19.9)	130 (19.3)	118 (20.6)
5–6 times	162 (13.0)	89 (13.2)	73 (12.8)
7 or more times	234 (18.8)	127 (18.8)	107 (18.7)
Screen time yesterday in h, mean (SD)	3.2 (2.9)	3.3 (2.8)	3.1 (3.1)

[a]Totals vary because of missing data for 2 students.

[b]There were no significant differences in student characteristics by intervention status. Differences in age and hours of screen time yesterday by intervention status were assessed using mixed effects linear regression models accounting for school and class effects. Percentage of female students, race and ethnicity and frequency of physical activity per week were assessed using mixed effects logistic regression models accounting for school and class effects. Student participants per school were examined using linear regression clustering on school.

[c]No. = 1247 total and 675 intervention because of missing data on physical activity.

TABLE 2

Intervention Effects on Primary and Secondary Weight Status Outcomes

Variable	No. Intervention/Control	Intervention	Control	Intervention Versus Control Adjusted Mean Difference Over Time/OR (95% CI)[a]	*P*
Primary outcome					
Overweight prevalence,[b] no. (%)					
Baseline	677/572	335 (49.5)	273 (47.7)	Ref	Ref
7-mo	639/556	315 (49.3)	263 (47.3)	OR, 0.7 (0.2–2.9)	.68
15-mo	548/510	274 (50.0)	262 (51.4)	OR, 0.1 (0.03–0.7)	.017
Secondary outcomes					
Obesity prevalence,[b] no. (%)					
Baseline	677/572	222 (32.8)	165 (28.9)	Ref	Ref
7-mo	639/556	202 (31.6)	159 (28.6)	OR, 0.4 (0.07–2.0)	.24
15-mo	548/510	179 (32.7)	144 (28.2)	OR, 1.0 (0.1–7.0)	.98
BMI percentile, mean (SD)					
Baseline	677/572	73.2 (28.1)	71.9 (28.7)		
7-mo	639/556	73.7 (27.1)	71.8 (28.4)	0.2 (−0.6 to 1.0)	.57
15-mo	548/510	73.5 (28.0)	72.9 (28.5)	−0.5 (−1.5 to 0.6)	.40
BMI, mean (SD)					
Baseline	677/572	20.4 (4.6)	20.1 (4.6)		
7-mo	639/556	20.9 (4.7)	20.5 (4.7)	0.04 (−0.06 to 0.1)	.46
15-mo	548/510	21.4 (5.1)	21.2 (4.9)	−0.02 (−0.2 to 0.1)	.80
BMI *z*-score, mean (SD)					
Baseline	677/572	0.9 (1.1)	0.8 (1.1)		
7-mo	639/556	0.9 (1.1)	0.8 (1.1)	0.001 (−0.03 to 0.03)	.93
15-mo	548/510	0.9 (1.1)	0.9 (1.1)	−0.02 (−0.06 to 0.02)	.36

No., number; OR, odds ratio.

[a]Mixed effects logistic (% overweight, % obese) or linear (BMI percentile, raw, *z*-score) regression models used to examine intervention impacts on changes in weight status of students from baseline to follow-up 1 (7 mo), and baseline to follow-up 2 (15 mo), accounting for school, class, and student intercepts. Models also included random slopes that allowed for differential changes among individual students over time (ie, random slopes), and adjusted for intervention status, time point, cohort year, student age, sex, and race and ethnicity, physical activity, and screen time.

[b] Overweight and obesity are defined as BMI for age and sex ≥85 percentile and ≥95 percentile, respectively based on Centers for Disease Control and Prevention growth curves.

TABLE 3

Intervention Effects on Secondary Dietary Outcomes

Variable	No. Intervention/Control	Intervention	Control	Intervention Versus Control Adjusted Change Over Time, % (95% CI)	*P*
24-hr dietary recall[a]					
Total kcals, mean (SD)					
Baseline	647/548	1636 (796)	1699 (727)	Ref	Ref
7-mo	600/531	1610 (805)	1676 (782)	1.4 (−5.3 to 8.5)	.70
Food kcals, mean (SD)					
Baseline	647/548	1371 (705)	1434 (654)	Ref	Ref
7-mo	600/531	1380 (727)	1425 (696)	3.7 (−3.9 to 12.0)	.35
Beverage kcals, mean (SD)					
Baseline	647/548	265 (214)	265 (212)	Ref	Ref
7-mo	600/531	229 (227)	251 (231)	−10.6 (−29.2 to 8.8)	.35
SSB kcals, mean (SD)					
Baseline	647/548	223 (205)	223 (204)[61]	Ref	Ref
7-mo	600/531	190 (199)	214 (223)	−17.5 (−37.8 to 9.6)	.18
Water grams, mean (SD)					
Baseline	647/548	414 (443)	454 (441)	Ref	Ref
7-mo	600/531	462 (576)	441 (472)	9.1 (−20.6 to 49.9)	.59
Beverage intake frequency in past week[a]					
Water, times/day (SD)					
Baseline	677/572	6.1 (4.3)	5.7 (4.2)	Ref	Ref
7-mo	639/556	7.1 (5.2)	5.2 (3.9)	23.2 (13.1 to 34.2)	<.001
15-mo	548/510	6.2 (4.7)	4.8 (3.8)	14.7 (4.5 to 25.9)	.004
SSB, times/d (SD)					
Baseline	677/572	3.5 (4.2)	3.5 (4.2)	Ref	Ref
7-mo	639/556	2.4 (3.5)	2.8 (3.7)	−8.0 (−15.7 to 0.4)	.063
15-mo	548/510	2.1 (2.8)	2.2 (2.9)	−2.8 (−11.7 to 6.9)	.56
Juice, times/d (SD)					

Variable	No. Intervention/Control	Intervention	Control	Intervention Versus Control Adjusted Change Over Time, % (95% CI)	*P*
Baseline	677/572	0.8 (1.1)	0.8 (1.1)	Ref	Ref
7-mo	639/556	0.6 (1.0)	0.6 (0.8)	1.2 (−4.3 to 7.0)	.68
15-mo	548/510	0.5 (1.0)	0.5 (0.9)	−1.4 (−7.4 to 5.0)	.66
Flavored milk, times/d (SD)					
Baseline	677/572	0.5 (0.9)	0.5 (0.9)	Ref	Ref
7-mo	639/556	0.4 (0.7)	0.4 (0.8)	−4.0 (−8.3 to 0.5)	.079
15-mo	548/510	0.4 (0.8)	0.4 (0.9)	−3.0 (−8.0 to 2.3)	.26
Plain milk, times/d (SD)					
Baseline	677/572	1.2 (1.4)	1.1 (1.3)	Ref	Ref
7-mo	639/556	1.2 (1.6)	1.0 (1.2)	4.4 (−2.2 to 11.5)	.20
15-mo	548/510	1.1 (1.4)	1.0 (1.2)	2.3 (−4.4 to 9.6)	.51
Observations of students drinking water at school[b,c]					
Students drinking water from water source at lunch, % (SD)					
Baseline	4091/3947	3.5 (6.1)	3.7 (6.1)	Ref	Ref
7-mo	4019/3515	38.3 (15.9)	3.6 (4.7)	31.3 (21.2 to 42.2)	<.001
15-mo	3954/3936	9.2 (7.7)	3.2 (3.1)	4.9 (−3.0 to 13.5)	.22
Students drinking water from water source during recess, % (SD)					
Baseline	1475/1239	6.5 (3.4)	6.1 (4.5)	Ref	Ref
7-mo	1463/1265	29.3 (36.5)	6.6 (4.1)	17.0 (2.6 to 33.3)	.02
15-mo	1458/1251	8.8 (3.1)	3.3 (3.0)	4.7 (−8.0 to 19.2)	.48
Students drinking water from water source during physical education, % (SD)					
Baseline	285/353	66.6 (87.8)	47.4 (32.2)	Ref	Ref
7-mo	272/284	89.6 (58.7)	53.2 (65.6)	34.6 (−9.4 to 99.8)	.14
15-mo	271/307	95.0 (56.2)	43.1 (38.1)	32.1 (−11.0 to 96.2)	.16

[a] Mixed effects linear regression models used to examine intervention impacts on changes in outcomes from baseline to follow-up 1 (7 mo only for dietary recall) and baseline to follow-up 2 (15 mo), accounting for school, class, and student effects intercepts. Models also included random effects for student change over time (ie, random slopes), and adjusted for intervention status, timepoint, cohort year, student age, sex, and race and ethnicity.

[b] Lunch observations included students in all grades at the school, recess included fourth graders and in the majority of schools fifth graders, physical education classes included fourth graders only.

[c]Mixed effects linear regression models used to examine intervention impacts on changes in proportion of students drinking from school water sources from baseline to follow-up 1 (7 mo), and baseline to follow-up 2 (15 mo), accounting for school, date, and clustering of observations in schools and adjusting for percentage of female students, percentage of students of racial and ethnic minorities, percentage of students eligible for free- or reduced-price meals, and mean ambient temperature during observation.