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Shape Up Somerville two-year results: A community-based environmental change intervention sustains weight reduction in children

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ABSTRACT

Objective: The objective of this study was to test the hypothesis that community-based environmental change intervention prevents undesirable weight gain in children.

Method: The method used in this study was a two-year, non-randomized, controlled trial (2003–2005) using community-based participatory methodology in three diverse cities in Massachusetts: one intervention and two socio-demographically-matched control communities (pooled for analysis). Children (n = 1028), with a mean age = 7.61 + 1.04 years participated. Interventions were made to improve energy balance by increasing physical activity options and availability of healthful foods (Year 1). To firmly secure sustainability, the study team supported policies and shifted intervention work to community members (Year 2).

Results: Change in body mass index z-score (BMIz) was assessed by multiple regression, accounting for clustering within communities and adjusting for baseline covariates. Sex-specific overweight/obesity prevalence, incidence and remission were assessed. Over the two-year period, BMIz of children in the intervention community decreased by −0.06 [p = 0.005, 95% confidence interval: −0.08 to −0.04] compared to controls. Prevalence of overweight/obesity decreased in males (OR = 0.61, p = 0.01) and females (OR = 0.78, p = 0.01) and remission increased in males (OR 3.18, p = 0.03) and females (OR 1.93, p = 0.03) in intervention compared to controls.

Conclusion: Results demonstrate promise for preventing childhood obesity using a sustainable multi-level community-based model and reinforce the need for wide-reaching environmental and policy interventions.

Introduction

Once it was clear that pediatric obesity was growing at an alarming rate, it became apparent that environmental influences were major contributors to the problem (Hill et al., 2003). For children and their families, interventions would need to extend beyond the school environment, target the entire community, and focus broadly on increased physical activity, decreased sedentary behavior, and healthier eating (Economos et al., 2007; Gittelsohn and Kumar, 2007; Huang et al., 2009; Institute of Medicine, 2012).

Community-based participatory research (CBPR) combines systematic inquiry, participation, and action to address health problems collaboratively (Jones and Wells, 2007; Leung et al., 2004; Minkler, 2005). Community members help researchers pinpoint needs and wants and may uncover untapped solutions that already exist (Economos et al., 2007). Shape Up Somerville (SUS): Eat Smart, Play Hard™ was a partnership with members of a culturally diverse urban community (Somerville, MA) designed to determine whether an intervention based on CBPR could improve weight status in young children through enhanced access and availability of physical activity options and healthy food throughout their entire day.

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We previously reported that over Year 1 of SUS body mass index z-score (BMIz) decreased in children in the intervention community compared to those in two control communities (Economos et al., 2007). This paper extends the analysis through Year 2 when implementation and responsibility were largely institutionalized into the community.

Participants and methods

The study design, a non-randomized controlled trial, using CBPR methodology has been described in detail (Economos et al., 2007). Three communities were studied from September 2002 to August 2005. Year 1 was spent on recruitment and community planning. Data presented here are for the intervention period conducted over two school years (September 2003–June 2005). Children in grades 1–3 attending public school in the three communities were recruited for participation. Data were collected at four time points: Year 1 Fall 2003 (YR1F), Year 1 Spring 2004 (YR1S), Year 2 Fall 2004 (YR2F) and Year 2 Spring 2005 (YR2S). Fall measurements were conducted in September/October and spring measurements in May/June.

Somerville was selected as the intervention community because an established relationship between the community and the research team existed (Minkler, 2005). Two socio-demographically-matched communities (Control 1 and Control 2) served as controls. All three communities were cities outside of Boston with similar demographic characteristics, (U.S. Census Bureau, 2000a, 2000b). All 30 public elementary schools in the three communities participated: 10 in the intervention, 15 in Control 1, and 5 in Control 2. Parental informed consent was obtained for all participating children. Of the 5940 eligible children, 1721 participated. In Somerville, a total of 647 of 1201 eligible children enrolled, a 53.9% response rate. In control communities, 1074 of 4739 were consented, a 22.7% response rate. That includes 25 children consented after Year 1 and therefore not included in either the one- or two-year change analysis. Fig. 1 presents the number of consented children, and the total number included in the analyses. Recruitment and study procedures were approved and monitored by the Tufts University Institutional Review Board.

Intervention program

Using a community participatory process, intervention activities were developed and implemented to influence every part of an early elementary school child's day. During Year 1, interventions were monitored and modified in response to community feedback. During Year 2, the research staff supported implementation through continued trainings and parent engagement, while focusing on sustainability and policy changes.

SUS intervention components (Economos et al., 2007, 2009; Goldberg et al., 2009) (see http://nutrition.tufts.edu/research/shapeup for more detail) were designed to result in increased energy expenditure of up to 125 kcals per day beyond that needed for normal growth (Ainsworth et al., 2000; American College of Sports Medicine, 1995). This goal was consistent with the energy imbalance estimated to account for the increases in body weight observed in US children (Wang et al., 2006). Specific changes within the before-, during-, and after-school environments providing opportunities for increased physical activity and healthier eating have been described (Economos et al., 2007). Additional changes within the home and the community provided reinforcing opportunities for physical activity and access to healthier food. Many within the community (children, parents, teachers, school food service providers, city departments, policy makers, health care providers, before- and after-school programs, restaurants, and the media) were engaged in the intervention (Economos and Curtatone, 2010). Multiple community-wide policies were developed to promote and sustain change. Environmental and programmatic changes were documented in all three communities.

Outcome measures

BMIz

In all four measurement periods, height and weight were measured and used to calculate BMIz, the primary study outcome. Height and weight measurements, collected using standard measurement techniques, have been previously described (Economos et al., 2007). Follow-up visits were made to most schools, within two weeks of the initial data collection to measure absent children.

Demographic and behavioral measures

Child and family demographic information was collected as previously described (Economos et al., 2007). Race/ethnicity was self-reported as Non-Hispanic White, Non-Hispanic Black, Hispanic, Asian, Multi-racial, Native American/Hawaiian, or other. Multi-racial, Native American/Hawaiian, and other were combined due to small numbers.

Statistical analysis

Variables for analysis were derived from measurements obtained at the four time points: YR1F, YR1S, YR2F and YR2S. Due to the nature of the study, sample sizes differed for each analysis. Of participants with completed consent forms ($n = 1721$; 647 intervention and 1074 control), observations with both YR1F and YR2S measures and valid demographic data ($n = 1028$; 335 intervention and 693 control) were included in the two-year analytic pre–post sample. Observations before and after the summer at time points YR1S and YR2F ($n = 1115$), represented weight change during out-of-school time, a period of approximately three months during the two-year intervention. The 916 participants with measurements at all four time points were used to display the longitudinal changes in BMIz over the entire study period graphically. Of the 1028 participants with two-year data, completed family questionnaires providing additional demographic data for supplementary analyses, including parental education, were available in a sample of 711. Parental education was defined as the highest level achieved by either parent.

Descriptive data are presented as mean ± SD and as percentages. T-tests or chi-square tests were performed on all descriptive variables to test for baseline differences between the intervention and each control community. A multiple regression model was used to assess the primary hypothesis of differences in change in BMIz between the intervention and the pooled control communities as planned *a priori*. Because assignment occurred at the community level, and there were only three communities, the analytic approach (PROC SURVEYREG) accounted for the intra-class correlation or 'clustering effect' that arises due to similarities among subjects who reside within a community (SAS, 2008). Although the three communities were chosen for their aggregate similarity, even small group differences between the intervention and control communities can distort the estimation of standard errors. We adjusted for sex, age, ethnicity, grade, primary language at home, and the child's BMIz at baseline.

We conducted secondary analyses (using Proc MI and MIANALYZE in SAS) (SAS, 2008) using data imputed on the full sample of participants with baseline BMIz data ($n = 1361$) and on participants with BMIz data at any time point ($n = 1545$). We used the same approach as in the main analyses, adjusting for sex, age, race/ethnicity, grade, primary language at home, and the child's BMIz at baseline. Missing data values were imputed to address potential bias due to losses to follow-up and to maximize the sample size.

Changes in overweight/obesity prevalence (percentage of subjects with BMIz ≥85th percentile), incidence (percentage of subjects not initially overweight/obese at baseline, but who became overweight/obese) and remission (percentage of subjects who were overweight/obese at baseline, but were not overweight/obese at follow-up) were evaluated over the two-year intervention period using multivariate logistic regression. Using STATA, odds ratios (ORs) were estimated controlling for baseline covariates (sex, age, grade, primary language spoken, race/ethnicity) and clustering on community (STATA, 2003). Analyses were conducted for overweight and obesity outcomes separately and for the combined overweight/obesity category. We evaluated the presence of interactions by sex by testing the significance of the cross product sex by intervention interaction term, and evaluated stratified models where the interaction was present. The alpha-level was set at $p < 0.05$ for all analyses.

Results

Fig. 1 shows the flow of participants throughout the study. BMIz data were available for 1361 participants at baseline (YR1F); two-year follow-up data (YR2S) were collected on 75% ($n = 1028$). Table 1 summarizes the baseline (YR1F) demographic and weight measures of these 1028 children by community. The majority of losses to follow-up occurred due to relocation out of the community and child absence when measurement data were collected. All three communities were diverse in race/ethnicity. Over one-third of the children were either overweight or obese at YR1F. Table 2 describes family characteristics at baseline.

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Table 3 evaluates the impact of the intervention on change in BMIz in intervention and control communities from YR1F to YR2S. The average change in BMIz in the intervention community was −0.06 [95% confidence interval (CI) −0.08 to −0.04; p = 0.005] compared to the pooled control communities, after controlling for baseline covariates. The change in BMIz was −0.05 (95% CI: −0.13 to 0.02; p = 0.07)

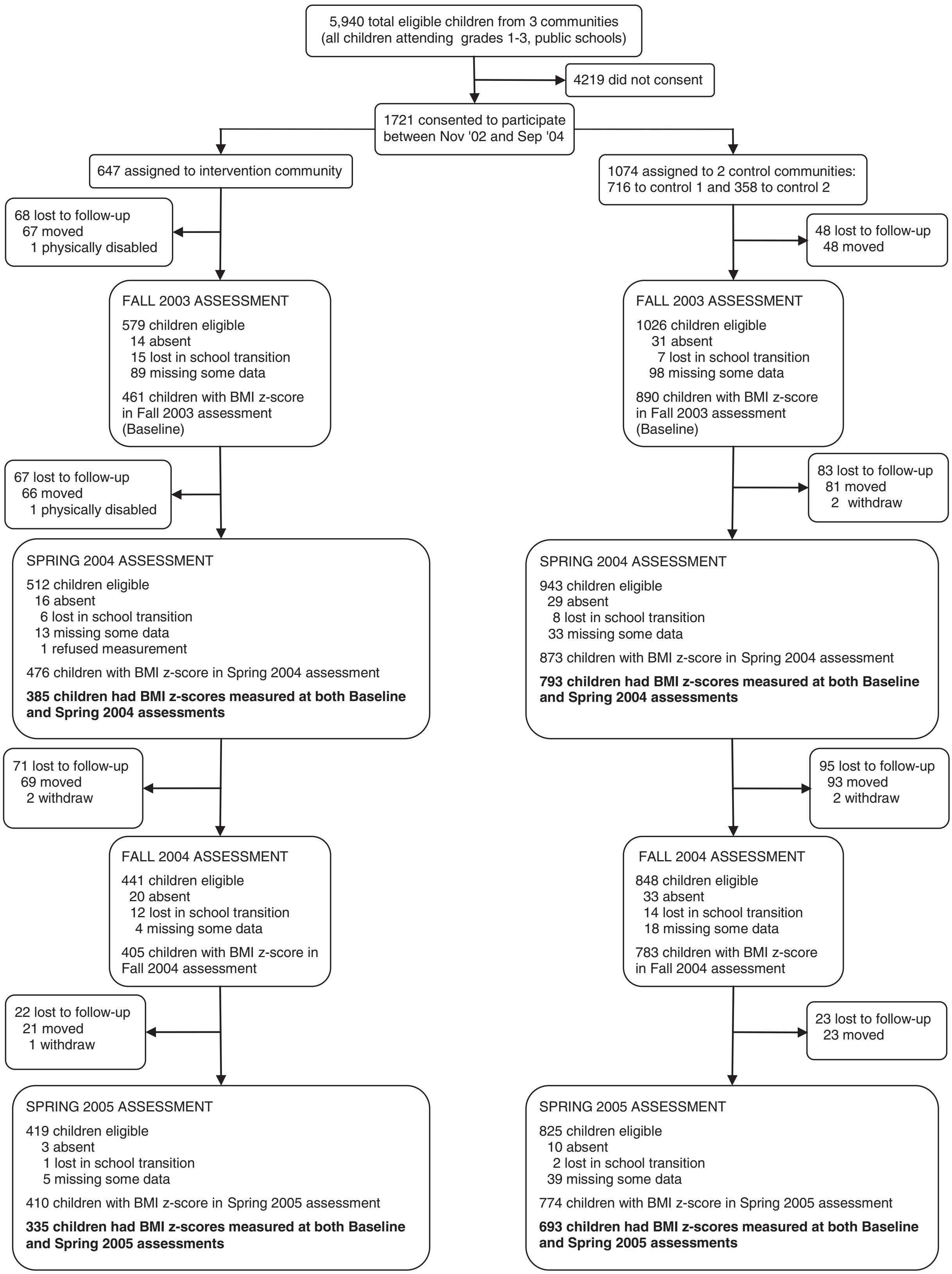

Fig. 1. Study flow chart over the two-year intervention study period.

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compared to Control 1 and −0.06 (95% CI: −0.10 to −0.03; p = 0.03) compared to Control 2, after controlling for baseline covariates (data not shown). In a sample of 711 subjects with complete parental education information, it was not a significant predictor of BMIz change. All covariates are the same in the reduced model as in the full model. Change in BMIz over the summer recess in the intervention community compared to controls over the summer interval was also negative, but non-significant.

In the analysis of 2-year changes in BMIz using imputed data for all 1361 subjects with baseline BMI z-score, the intervention effect was −0.08 ($p < 0.001$) after controlling for covariates. Similarly, in the analysis of 2-year changes in BMIz using imputed data for the 1545 subjects with BMI z-score data at any of the four time points, the adjusted intervention effect was −0.07 ($p < 0.001$). Fig. 2 shows the absolute BMIz values of subjects with all four measurement points (n = 916) over the entire intervention. The average unadjusted change in BMIz in the intervention community was −0.04 compared to an increase of 0.05 in the pooled control communities. The adjusted difference in BMIz change over this 2-year period in the sample of 916 was −0.07 when the multivariable regression model described above, with covariates, was applied, (95%CI: −0.10 to −0.05, $p < 0.01$).

The intervention had a significant impact on overall overweight/obesity prevalence (BMIz ≥85th percentile) (OR 0.71, 95% CI 0.56 to 0.90; p = 0.004) as well as remission of overweight/obesity (OR 2.29, 95% CI 1.14 to 4.62; p = 0.02) at study conclusion (Table 4). Due to the significant sex by intervention interaction, results are presented stratified by sex. Compared to controls, the prevalence of overweight/obesity decreased in males (OR = 0.61, p = 0.01) and females (OR = 0.78, p = 0.013). Although there was remission in both intervention and control groups, remission increased in males (OR 3.18, p = 0.033) and females (OR 1.93, p = 0.027) in the intervention group compared to controls (Table 4). Incidence of overweight/obesity in males or females did not differ by intervention group.

Discussion

This study demonstrated that a prolonged multi-component intervention targeting numerous environments, with involvement and ownership by the community, can lead to a decrease in BMIz in early elementary school children at high risk for obesity. In this study, a change in BMIz was observed between intervention and control communities over twenty months. The effect size is modest yet we observed twice the rate of overweight and obesity remission and an almost 30% lower prevalence of overweight and obesity in the intervention group. As previously reported, after one school year of intervention, BMIz decreased in children in the intervention compared to controls (Economos et al., 2007). During the subsequent summer, when the intervention was less intensive, BMIz change was not significantly different between intervention and controls.

More intense interventions, longer than one school year, appear necessary to effect sustained change (Kropski et al., 2008; Summerbell et al., 2005). Yet few childhood obesity prevention trials have intervened longer than 18 months and prevented weight gain or decreasing rates of overweight (Foster et al., 2008; Sanigorski et al., 2008; Taylor et al., 2007).

Shape Up Somerville used a CPBR approach to develop strategies for implementation that matched the community's wants, needs and strengths and interventions that could be built into existing “platforms” such as active transport, school curriculum, food service,

Table 1
Pre-intervention (YR1F) child demographic characteristics by community (n = 1028).

Demographic characteristic	Intervention (n = 335)	Control 1 (n = 486)	Control 2 (n = 207)
Age (years ± SD)	7.88 ± 1.079	**7.317 ± 0.9297**	7.824 ± 1.034
Grade (%)			
One	31.3	**48.1**	38.2
Two	32.2	**24.7**	27.1
Three	36.5	**27.2**	34.8
Race/ethnicity (%)			
Non-Hispanic White	51.0	**37.4**	51.7
Non-Hispanic Black	8.1	**25.7**	6.3
Hispanic	18.5	**9.7**	23.7
Asian	9.0	**2.3**	7.2
Other	13.4	**24.9**	11.1
Weight category (%)			
<85th percentile of weight	54.9	**65.2**	55.6
85th–95th percentile of weight	19.4	15.8	17.9
>95th percentile of weight	25.7	**18.9**	26.6
Non-English primary home language (%)	32.5	**14.8**	34.3

Bold numbers indicate differences from the intervention group that were significant at $p < 0.05$.

Table 2
Selected characteristics of parents at pre-intervention (YR1F) by community (n = 1028).

Characteristic	Intervention (n = 335[a])	Control 1 (n = 486[b])	Control 2 (n = 207[c])
Marital status (%)			
Never married	13.8	**23.2**	14.3
Married	76.4	**61.3**	73.0
Separated/divorced	9.7	15.6	12.7
Parent birthplace (%)			
US born mother	55.1	**71.5**	56.3
US born father	50.8	**67.1**	53.7
Mother's education (%)			
Less than high school	14.8	**5.1**	14.6
High school or equivalent	35.7	**48.3**	**53.7**
Some or all college	34.7	41.6	27.6
Graduate school	14.8	**5.1**	**4.1**
Father's education (%)			
Less than high school	14.4	13.9	10.2
High school or equivalent	40.9	**57.3**	**68.6**
Some or all college	28.2	25.3	17.8
Graduate school	16.6	**3.6**	**3.4**

Bold numbers indicate values significantly different from intervention by chi square.
[a] Missing: 135–142 for marital status, parent birthplace and parental education.
[b] Missing: 178–182 for marital status, parent birthplace and parental education.
[c] Missing: 80–84 for marital status, parent birthplace and parental education.

Table 3
Estimates[a] for change in BMI z-score: Summer (YR1S to YR2F), two-year intervention (YR1F to YR2S).

Variables	Summer Control 1 + 2 n = 1115 Estimate (95% CI)	p-Value	Two-year intervention Control 1 + 2 n = 1028 Estimate (95% CI)	p-Value
Intervention (Somerville *vs.*)	−0.03194 (−0.16, 0.10)	0.3985	−0.05726 (−0.08, −0.04)	0.0054
Baseline BMI z-score	−0.09346 (−0.29, 0.11)	0.1836	−0.06207 (−0.08, −0.04)	0.0064
Sex	0.02813 (−0.04, 0.09)	0.2046	0.070394 (0.04, 0.10)	0.0081
Grade	0.02905 (−0.05, 0.10)	0.2339	−0.0033 (−0.12, 0.11)	0.9110
Age (in months)	−0.00126 (−0.01, 0.01)	0.4956	−0.002 (−0.01, 0.00)	0.1879
Race/ethnicity	0.01170 (−0.02, 0.04)	0.2194	−0.00538 (−0.03, 0.02)	0.4380
Primary language spoken at home	0.00388 (−0.04, 0.04)	0.7179	0.010486 (−0.02, 0.04)	0.2194
Constant	0.16429 (−0.19, 0.51)	0.1805	0.252367 (0.04, 0.47)	0.0368

[a] Estimates from linear mixed models regression. Models adjusted for all baseline variables shown above plus the clustering effect of community.

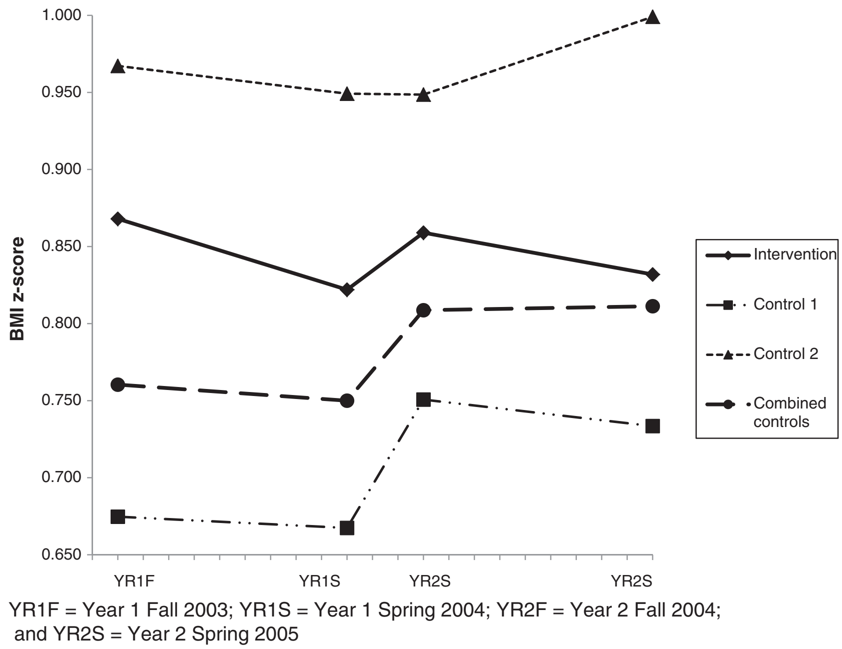

Fig. 2. Mean BMI z-score values (n = 916) at all measurement points, YR1F, YR1S, YR2F, YR2S. YR1F = Year 1 Fall 2003; YR1S = Year 1 Spring 2004; YR2F = Year 2 Fall 2004; and YR2S = Year 2 Spring 2005.

and after school programs, thereby ensuring sustainability into and beyond the second year of the intervention. This approach allowed researchers to plan sustainability efforts, together with the community, from the beginning (Economos and Curtatone, 2010). The favorable BMIz outcome, which was extended into year two, was likely due, at least in part, to increasing community involvement and the CBPR process. A CBPR approach to childhood obesity prevention intrinsically embodies a systems approach; it encompasses multidisciplinary, complex community systems, involving many factors and interrelationships (Economos and Tovar, 2012; Institute of Medicine, 2012).

Of particular note was the increase in BMIz following the summer months, parallel in intervention and control communities. This trend in weight gain, above what is expected with growth, has been reported in other studies (Carrel et al., 2007; von Hippel et al., 2007). During the summer, Somerville children did not receive any SUS-related intervention activities implemented through the school and may not have received any community components if they were away or had limited community interactions. In addition, we have observed that children may have less access to physical activity opportunities and healthy eating during the summer, particularly if they spend time in unstructured environments (Tovar et al., 2010), which may have led to a lower intervention "dose" during the summer months. Taken together, evidence suggests the need for broader, year-round, community-based efforts to address energy balance (Kobayashi and Kobayashi, 2006; Tovar et al., 2010; von Hippel et al., 2007).

A number of limitations and strengths of this study are noteworthy. This study was controlled, but not randomized. CBPR research requires a strong established relationship to initiate an intervention, making randomization particularly difficult. The intervention did not include a consistent summer dose. We were only able to measure and follow a subset of the entire eligible population of children. Given the ethnic diversity, different languages spoken, unfamiliarity with research, and the age of the children, we were unable to gain consent for many eligible children in the three communities. Despite these difficulties, we recruited and retained an impressive sample of ethnically and racially diverse, high-risk children. As in most community-based studies, there was attrition, albeit modest, as children moved. Our imputed data set provided

Table 4
Prevalence, incidence and remission of overweight and obesity (BMI z-score ≥ 85th percentile over the two-year intervention (YR1F to YR2S) (n = 1028)).

Measure			Sample (n)	Baseline (n, %)	Follow-up (n, %)	Unadjusted change	Adjusted odds	p
Male (n = 497)								
Overweight or obese[a]	Prevalence	Control	326	130 (39.9)	153 (46.9)	+7	1.00	0.01
		Intervention	171	80 (46.8)	86 (50.3)	+3.5	0.61	
	Incidence	Control	196	–	27 (13.8)	–	1.00	0.15
		Intervention	91	–	11 (12.1)	–	0.72	
	Remission	Control	130	–	4 (3.1)	–	1.00	0.03
		Intervention	80	–	5 (6.3)	–	3.18	
Female (n = 531)								
Overweight or obese[a]	Prevalence	Control	367	130 (35.4)	143 (39)	+3.6	1.00	0.01
		Intervention	164	71 (43.3)	70 (42.7)	−0.6	0.78	
	Incidence	Control	237	–	23 (9.7)	–	1.00	0.10
		Intervention	93	–	10 (10.8)	–	1.11	
	Remission	Control	130	–	10 (7.7)	–	1.00	0.03
		Intervention	71	–	11 (15.5)	–	1.93	

[a] Estimates from multivariate logistic regression, adjusting for baseline covariates and clustering by community. Odds ratios are adjusted for sex, age, grade, primary language spoken, race/ethnicity and clustering on community.

comparable results suggesting the validity of our intent-to-treat sample. These limitations were counterbalanced by the unwavering support and involvement of the community.

An effective response to the childhood obesity crisis will require change at multiple levels engaging many sectors. Involving children and families, schools, business leaders, healthcare practitioners, health insurers, policy makers, and community organizers to improve the food and physical activity environments throughout communities has been called for in many obesity prevention reports (Coleman et al., 2005; Economos et al., 2007; Institute of Medicine, 2010, 2012; Sanigorski et al., 2008; Taylor et al., 2007). Our study results emphasize that innovative community programs, supported as local action, can be relevant, successful and sustainable. In the context of other obesity prevention trials, these results are instructive and point to challenges inherent in community-centered population-based research.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

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Each author listed on the paper has seen and approved the submission of this version of the manuscript and takes full responsibility for its preparation. Dr. Economos was the principal investigator who oversaw every aspect of the study, from beginning to end, and led the development and writing of the manuscript. Drs. Nelson, Must, Naumova, and Goldberg worked with Dr. Economos as co-investigators and Ms. Collins worked as the project manager. Throughout the study, these individuals assisted with decisions regarding study design, implementation, and interpretation. Ms. Kuder managed the data and conducted statistical analyses under the direction of Dr. Hyatt, with assistance from Drs. Naumova and Must. All authors read drafts of the manuscript, provided comments, edits and feedback, and approved the final version.

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Dr. Economos, the principal investigator, is independent of any commercial funder and had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. No authors report a conflict of interest and all of the research conducted and presented in this manuscript was independent of the funders' interests or influence. Dr. Economos certifies that all persons named in the Acknowledgement have provided her with written permission to be named.

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