2019

Demographics and anthropometrics impact benefits of health intervention: data from the Reduce Obesity and Diabetes Project.

L. Ostrowski

P. W. Speiser
Zucker School of Medicine at Hofstra/Northwell

S. Accacha

L. Altshuler

I. Fennoy

See next page for additional authors

ORIGINAL ARTICLE

Demographics and anthropometrics impact benefits of health intervention: data from the Reduce Obesity and Diabetes Project

L. Ostrowski[1], P. W. Speiser[2], S. Accacha[3], L. Altshuler[4], I. Fennoy[5], B. Lowell[7], R. Rapaport[6], W. Rosenfeld[3], S. P. Shelov[3,7], S. Ten[7], M. Rosenbaum[4] and the ROAD Group[†]

[1]Department of Neuroscience, Brown University, Providence, RI, USA; [2]Pediatrics, Cohen Children's Medical Center of NY, Hofstra Northwell School of Medicine, New Hyde Park, NY, USA; [3]Pediatrics, Winthrop University Hospital, Mineola, NY, USA; [4]Medicine, NYU Med Ctr, New York, NY, USA; [5]Pediatrics and Medicine, Columbia University College of Physicians and Surgeons, New York, NY, USA; [6]Pediatrics, Mt Sinai School of Medicine, New York, NY, USA; [7]Pediatrics, Maimonides Medical Center, Brooklyn, NY, USA.

Received 6 April 2018; revised 5 September 2018; accepted 22 September 2018

Address for correspondence: M Rosenbaum, MD, Naomi Berrie Diabetes Center Columbia University College of Physicians and Surgeons, New York, NY 10032, USA. E-mail: mr475@columbia.edu

[†]see Acknowledgements.

Summary

Objective

To determine the efficacy of a 4-month school-based health, nutrition and exercise intervention on body fatness and examine possible effects of demographic and anthropometric covariates.

Methods

Height, weight, waist circumference and body composition were measured in a diverse population of 644 NYC middle school students (mean ± SD age 12.7 ± 0.9 years; 46% male; 38% Hispanic, 17% East Asian, 15% South Asian, 13.5% African American, 8.5% Caucasian, 8% other) during the fall and spring semesters. Year 1 participants (n = 322) were controls. Experimental participants (year 2, n = 469) received a 12-session classroom-based health and nutrition educational programme with an optional exercise intervention.

Results

Groups were demographically and anthropometrically similar. The intervention resulted in significant reductions in indices of adiposity (ΔBMI z-scores [−0.035 ± 0.014; p = 0.01], Δ% body fat [−0.5 ± 0.2; $p < 0.0001$] and Δwaist circumference [−0.73 ± 0.30 cm; $p < 0.0001$]). Intervention effects were greater (p = 0.01) in men (ΔBMI z-score = −0.052 ± 0.015) versus women (0.022 ± 0.018), participants who were obese (ΔBMI z-score −0.083 ± 0.022 kg m^{-2}) versus lean (−0.0097 ± 0.020 kg m^{-2}) and South Asians (Δ% body fat −1.03 ± 0.35) versus total (−0.49 ± 0.20%) participants (p = 0.005).

Conclusion

A 4-month school-based health intervention was effective in decreasing measures of adiposity in middle school students, particularly in men, participants who were obese and South Asians.

Keywords: childhood obesity, demography, intervention, weight loss.

Introduction

Obesity in childhood is a major public health problem (1–3). The prevalence of obesity among 6- to 12- and 12- to 19-year olds has increased, respectively, from 7% and 5% in 1980 to over 18% and 21% in 2011–2014 (4). African–American, Hispanic/Latino, South Asian and Native American populations are disproportionately affected and also experience the highest prevalence of paediatric type 2 diabetes mellitus (5,6). The likelihood of obesity in childhood persisting into adulthood increases with age (7), and studies have suggested that therapies to reduce body fatness in children (8–10) are more likely to be successfully sustained over time than in adults (11–13).

School-based intervention (SBI) programmes have been advocated for improving the health of children and lessening the scope of overweight/obesity in childhood as well as the risk of development of obesity in adulthood

(14). The 'captive' nature of students in classrooms provides an opportune setting for health and nutrition education to direct children towards healthy behaviours (15–17). Previous studies of SBIs to reduce diabetes and obesity have often been targeted only at children who were already overweight or obese (15,18,19), i.e. towards treatment rather than prevention. Others have included complex interventions that are of scientific interest and desirable but not practical because of requirements for specialized facilities such as health clubs or extensive community and after school environmental changes such as counselling repeated clinic visits (20). Such interventions generally have little or no effect on body mass index (BMI) (21–23), even though other risk factors such as health knowledge (24–27), insulin resistance (28–30) and markers of inflammation (31) are reduced. In pilot studies by this group (32) and others (33), short-term additive effects of classroom-based intervention and exercise on adiposity and diabetes risk have been demonstrated. However, these effects do not seem to persist once the intervention stops (34).

The Reduce Obesity and Diabetes (ROAD) Project (16) examined the effects of a portable, inexpensive SBI on adiposity and risk factors for type 2 diabetes in a population of New York City Public School junior high school students irrespective of adiposity. Study design was based on a pilot study demonstrating significant beneficial effects on adiposity of a 12-week similar intervention in a population of predominantly Latino (Dominican) 8th graders in a single New York City Public School (32). The inclusion of a large multi-ethnic/racial population of students of varying adiposity and age and using an intervention previously shown to be effective in one age group and one ethnic/racial group provides insights into how intervention efficacy may be influenced by multiple demographic and anthropometric variables. The primary hypothesis of the present study was that such an intervention would be effective in decreasing adiposity and thereby the risk of adiposity-related comorbidities. The secondary hypothesis was that the efficacy of the intervention would be affected by such demographic factors as family history of obesity, ethnicity/race, gender, age and initial adiposity, i.e. the same factors correlated with obesity and comorbidity risk.

Methods

Overview

This is a before/after study of the effects of a SBI on adiposity and its comorbidies in which discrete subject groups (those receiving the intervention and those not receiving it) were studied late in the fall semester and late in the spring semester in separate consecutive years, i.e. the control group in year 1 and the experimental group in year 2 (18). Participants were recruited by investigators in the classroom as part of their general science curriculum with no incentives except a guaranteed 'A' on the homework assignment of completing the consent and assent forms regardless of whether or not they agreed to participate. All students in the intervention year (year 2, see succeeding text) received the classroom intervention regardless of whether or not they agreed to participate in the study. The intervention consisted of a 12-week health and nutrition educational programme plus voluntary physical exercise classes. The study was approved by the ethics boards of the NYC Department of Education, the New York City Board of Health, Institutional Review Boards at each institution (35) and individual principals and school boards. The protocol was consistent with guiding principles for research involving humans (36).

Control participants (no intervention) were all 6th, 7th and 8th graders studied in year 1 (Y1). Experimental participants were all 6th, 7th and 8th graders studied in year 2 (Y2). Students in the 6th and 7th grades in Y1 were also eligible to participate in the Y2 studies. All Y2 participants were naïve to all classroom and physical education-related aspects of this study because no intervention was offered in Y1. Classroom interventions varied by grade and targeted physical activity and diet within the home environment (6th graders), the school environment (7th graders) or the community environment (8th graders) (Table S1). Learning objectives included self-esteem, peer acceptance and identification of local needs and obstacles to optimal health-promoting lifestyle with respect to diet and exercise. None of the schools initially met the New York State health mandate of three sessions per week (37,38). All participants were offered an optional physical activity intervention consisting of aerobic exercise in the form of hip-hop dancing designed to meet this mandate (16).

Population and demographics

Participants (n = 644) were recruited from five New York City middle schools representing an ethnically and racially diverse population. Race has previously been used to characterize populations on the basis of biological characteristics such as genes, skin colour and other physical features, while ethnicity has been used to describe shared cultural characteristics such as language, religious traditions, dietary preferences and ancestry (6). Both of these constructs are known to influence health disparities, especially with respect to the prevalence of obesity and related comorbidities among non-White populations (39,40). The selected schools were chosen to ensure an ethnically and racially diverse subject population and were not chosen for any particular tendency of the students to have or develop obesity. This is in contrast to many previous SBIs to reduce diabetes and obesity, which have been targeted towards children who are overweight (15,41–43). The predominant ethnic/racial groups represented in the students recruited from these different middle schools were African American, Caucasian, East Asian (mainly Chinese, Japanese and Korean), Hispanic (mainly Dominican, Mexican and Puerto Rican) and South Asian (mainly Indian, Pakistani and Bangladeshi). Participants were grouped by racial/ethnic group based on self-identification.

Participants were excluded if they were on any medication known to affect appetite or energy expenditure, including thyroid medication, catecholaminergic agents, regular use of inhaled steroids or beta-adrenergic agonists, or had medical problems such as diabetes, severe asthma or an injury that would preclude their participation in exercise. Health histories were confirmed with parents both in the consent and by telephone.

Study design

The proposal was presented to the class in two pre-enrolment sessions that outlined the research questions and provided instruction to the students in the basics of study design. Students were then given the consent and assent forms and their 'homework assignment' was to return them either electing or declining to participate. Students received an 'A' on the homework regardless of the response as long as they returned the forms. The classroom intervention was offered to all students regardless of body fatness and consent status and was incorporated into the regular curriculum, providing inclusive nutritional education. The additional physical education intervention was offered only to those consenting and assenting to and participating in the study (16). Written informed assent and consent were obtained from all participants, who then completed a set of questionnaires. Demographic and historical information was verified by telephone contact with parents.

The health intervention consisted of a 12-session classroom-based enhanced health and nutrition education programme delivered over 4 months. Students received these classroom sessions targeting eating and exercise behaviours at home (6th graders), in school (7th graders) and in community (8th graders) environments (Table S1). This intervention was incorporated into the regular science curriculum at participating school classrooms, and as part of the curriculum that was presented to all students regardless of study enrolment status. Students also had the option to participate in an enhanced physical activity programme meeting the New York City mandate of three 45-min sessions per week. The programme provided aerobic exercise in the form of hip-hop dancing designed to raise heart rate to between 65% and 75% of maximum for at least 25 min per session (4,44,45). All classroom and physical activity sessions were taught by members of the ROAD team (mainly B. L. and G. R.).

Participants in the control group (Y1, 6th, 7th and 8th graders) received the initial discussion relevant to recruitment and the nature of the study but no other intervention between testing sessions. Participants in 6th or 7th grade in Y1 were told that they would be able to enrol in the intervention in the following year. Participants in the 8th grade in Y1 would be transferring to high school in the following year and so 8th grade classes (all students – regardless of whether or not they were enrolled in the Y1 control studies) received a condensed (4 weeks) version of the intervention after the second testing period in Y1 for enrolled students and prior to graduation as part of their regular science curricula. This was done to ascertain that all students received health intervention at one point while still enrolled in junior high school. No additional data was collected from graduating students in the control group after they received the intervention.

Recruitment at each site began in October. At each testing session, trained investigators measured weight without shoes or jackets and height without shoes were each measured twice using the school nurse's scale and a portable stadiometer that were calibrated prior to use. Waist circumference at the level of the umbilicus (46), BMI and body composition (single frequency bioelectrical impedance (47), [Bio-electrical Impedance Analysis (BIA), Omron HBF-300; Omron Health Care, Inc., Vernon Hills, IL]) assessments were made by investigators at each site also on the days of testing. Students were studied before and after a 4-month period, taking place at the same times of the year (early December for the first testing session and late April/early May for the second), in both the control year (Y1) and intervention year (Y2). By design, some (n = 146/322) of the participants were studied in the control group in Y1 (no intervention) and the experimental group in Y2 (intervention).

Statistical analyses

To account for those participants who were studied in both Y1 and Y2 in the analysis, Y2 data were analysed to compare participants studied in both years with participants only studied in Y2. No significant differences were observed, and participants studied only before and after receiving the intervention in Y2 and participants studied in Y1 as controls and then receiving the intervention in

Y2 were considered as a single intervention cohort. BMI *z*-score was designated as the primary outcome variable (18) to control for age-related (and puberty) and gender-related effects on body fatness even over the 4-month period between measurements as suggested in multiple meta-analyses of the effects of interventions of varying durations on childhood adiposity (48,49). In cross-sectional studies, BMI *z*-score is highly correlated with body composition by dual energy x-ray absorptiometry in children ($r = 0.83$), although not as highly correlated as Dual energy X-ray Absorptiometry (DXA) and BIA ($r = 0.87$) (50). BMI *z*-score was selected as the primary outcome variable in this cross-sectional (comparisons between groups at baseline and in response) and longitudinal (comparisons within participants over time) study for a number of reasons. First, it is a better reflection of the degree of shifts in weight, and indirectly body composition, in a longitudinal study than is actual weight, percent body fat, or BMI that are heavily influenced by age and gender. Second, it is easily calculated and can be used by other investigators. Finally, standard reference curves for large studies of BIA in U.S. children are not, as yet, readily available. BMI does not reflect body composition (51) with the same fidelity as BIA. For these reasons, fat mass and percent body fat, as well as waist circumference that is a measure of body fat distribution, were treated as secondary outcome variables that were examined if a significant effect on BMI *z*-score was noted. The primary hypothesis was that participation in the intervention would result in a significant decline in BMI *z*-score between testing periods. The secondary hypothesis was that the magnitude of the intervention effect would be significantly different between groups based on race/ethnicity, gender or initial adiposity.

The hypotheses relate to only two areas: intervention effects (primary) and ethnic/racial differences (secondary), and post hoc adjustments are not indicated (52–54). Statistical analyses were approached in a hierarchical manner. The first analysis was for a significant within-participants intervention effect on ΔBMI *z*-score. Once this was demonstrated (Table 2), it was then considered permissible to do subgroups analyses to determine whether the overall effect was significant across all groups (with or without significant between-group differences by gender, somatotype or racial/ethnic group) and whether the overall effect was because predominantly of changes in weight (which could reflect muscle) or fat mass/percent body fat.

Between-groups and within-groups analyses of BMI *z*-score or BMI *z*-score changes were significant across all groups before further analyses of other indices of body fatness between or within groups were analysed. Within groups analyses, to determine first whether statistically significant changes in adiposity occurred as a result of the intervention and next whether members within racial/ethnic and gender groups experienced changes in adiposity, were done by paired *t*-tests before and after the intervention as test parameters, and experimental and control groups (separated by gender and/or racial/ethnic group) as test groups. To gain a better understanding of the trends within the data set, the data were next analysed by analysis of covariance (ANCOVA) to statistically control for the effects of other continuous (e.g. initial adiposity and age) and discrete (e.g. gender, grade and site) variables as covariates, when analysing the dependent variable (e.g. change in adiposity). Between-group analyses, grouped by gender, initial adiposity, ethnicity/race and control/experimental group, were done by ANCOVA in which group was included as a dichotomous variable. Data regarding attendance in gym sessions were not included because of lack of reliable measures of actual attendance rather than enrolment from all sites. Statistical analyses were performed using the JMP 12.0 statistical package (SAS, Cary, NC, USA).

Data are presented as mean ± SD. Statistical significance was prospectively defined as $p\alpha < 0.05$; *p* values between 0.05 and 0.1 are also reported as ‘trends’ to suggest variables that may merit further study.

Results

Demographic and anthropometric characteristics (Table 1)

Participants were designated as having overweight if BMI ≥ 85th percentile (≥1.08 *z*-score) for age and gender and obesity if BMI ≥ 95th percentile (≥1.66 *z*-score). Participants with BMI < 85 percentile were designated as lean. There were no significant baseline demographic or anthropometric differences between the control and experimental groups. In contrast, significant baseline ethnic/racial group effects were observed in BMI *z*-score and so all groups were compared for observed and calculated indices of adiposity. Caucasian and Hispanic/Latino participants had the highest waist circumference, and Caucasian, Hispanic/Latino and African–American participants had higher proportions of both overweight and obesity. Although the participants were not selected on the basis of adiposity, the prevalence of overweight and obesity were greater in many racial/ethnic groups, and in the total subject population, than the national average for adolescents (55). Previous studies by this group have obtained height and weight data on the entire class and found no significant demographic or somatotype differences between participants who did or did not consent

Table 1 Mean (SD) demographic and anthropometric characteristics by ethnic group

Anthropometry	Hispanic	African American	Caucasian	East Asian	South Asian	Other/unsp.	All
N (male/female)	244 (105/139)	87 (43/44)	55 (29/26)	110 (56/54)	94 (38/56)	54 (26/22)†	644 (297/341)
Intervention group	176 (71/105)	61 (29/32)	39 (18/21)	87 (42/45)	70 (30/40)	36 (21/12)†	469 (211/255)
Control group	140 (65/75)	40 (19/21)	25 (15/10)	39 (22/17)	52 (19/33)	26 (8/13)†	322 (148/169)
Age (years)	12.7 (0.9)	12.8 (0.9)	13.0 (0.8)	12.6 (0.8)	12.8 (0.9)	12.7 (1.3)	12.7 (0.9)
Intervention group	12.9 (1.0)	12.9 (0.9)	12.9 (1.1)	12.6 (0.9)	12.8 (0.9)	12.6 (0.8)	12.8 (1.0)
Control group	12.7 (0.9)	12.8 (0.9)	12.9 (0.8)	12.6 (0.8)	12.9 (1.0)	12.7 (1.3)	12.7 (0.9)
Height (cm)	154.8^{b} (8.7)	160.6^{a} (8.1)	156.1^{a,b} (9.5)	155.8^{b} (8.1)	155.6^{b} (8.1)	155.2^{a,b} (12.1)	155.9 (8.9)
Intervention group	156.5^{b} (8.2)	159.4^{a} (9.4)	156.2^{a,b,c} (8.7)	154.2^{c} (8.9)	155.8^{b,c} (8.3)	154.9^{b,c} (7.2)	156.1 (8.6)
Control group	155.0^{b} (8.7)	160.3^{a} (7.9)	156.3^{a,b} (9.7)	156.4^{b} (7.6)	156.2^{b} (7.9)	154.9^{b} (12.0)	155.9 (8.9)
Weight (kg)	57.1^{a} (18.2)	61.3^{a} (18.3)	57.4^{a,b} (18.9)	54.5^{a,b} (15.5)	51.0^{b} (11.2)	52.7^{a,b} (16.5)	56.1 (17.0)
Intervention group	57.2^{a} (15.0)	60.2^{a} (16.3)	58.3^{a,b} (13.3)	49.0^{c} (13.3)	51.8^{b,c} (11.9)	50.2^{c} (12.0)	54.7 (14.6)
Control group	57.5^{a,b} (18.4)	61.2^{a} (18.5)	58.3^{a,b,c} (18.8)	55.1^{a,b,c} (15.2)	52.1^{c} (11.3)	52.2^{b,c} (16.3)	56.0 (17.0)
BMI (kg m^{-2})	23.6^{a} (6.3)	23.6^{a} (5.8)	23.1^{a,b} (5.4)	22.2^{a,b} (5.1)	21.0^{b} (3.7)	21.5^{a,b} (4.5)	22.8 (5.6)
Intervention group	23.2^{a} (5.1)	23.5^{a} (5.7)	23.6^{a} (4.9)	20.4^{b} (4.3)	21.2^{b} (3.7)	20.8^{b} (3.8)	22.3 (4.9)
Control group	23.7^{a} (6.3)	23.6^{a} (5.9)	23.4^{a,b} (5.3)	22.3^{a,b} (5.1)	21.3^{b} (3.8)	21.3^{a,b} (4.5)	22.8 (5.6)
BMI *z*-score	0.9^{a} (1.4)	1.0^{a,b} (1.0)	0.9^{a,b} (1.1)	0.8^{a,b} (1.1)	0.5^{b} (1.1)	0.6^{a,b} (1.1)	0.8 (1.2)
Intervention group	1.0^{a} (0.9)	0.9^{a,b} (1.1)	1.0^{a,b} (1.2)	0.4^{c} (1.0)	0.6^{b,c} (1.0)	0.5^{b,c} (0.9)	0.8 (1.0)
Control group	0.9^{a} (1.4)	1.0^{a,b} (1.0)	1.0^{a,b} (1.1)	0.8^{a,b} (1.1)	0.6^{b} (1.1)	0.6^{a,b} (1.1)	0.8 (1.2)
Waist (cm)	79.4^{a} (14.5)	76.7^{a,b} (11.2)	79.5^{a,b} (14.6)	75.5^{a,b} (13.6)	73.1^{b} (10.8)	74.1^{a,b} (12.2)	77.2 (13.5)
Intervention group	79.1^{a} (13.4)	77.5^{a,b} (13.1)	78.0^{a,b} (12.3)	70.9^{c} (10.1)	70.5^{c} (12.0)	72.1^{b,c} (14.1)	75.4 (13.0)
Control group	79.9^{a} (14.6)	76.6^{a,b} (11.4)	80.2^{a,b} (14.6)	75.9^{a,b} (13.5)	73.9^{b} (11.0)	74.0^{a,b} (11.9)	77.2 (13.4)
% Body fat	28.6^{a,b} (9.4)	26.1^{b} (9.5)	27.0^{a,b} (8.5)	26.3^{b} (7.5)	29.8^{a} (8.0)	28.4^{a,b} (6.2)	28.1 (8.8)
Intervention group	28.8^{a} (7.4)	28.8^{a} (9.0)	27.7^{a,b} (7.9)	25.9^{b} (6.6)	28.4^{a} (6.1)	28.2^{a,b} (7.5)	28.0 (7.4)
Control group	28.7^{a,b} (9.2)	26.1^{b} (9.6)	26.8^{a,b} (8.7)	26.4^{b} (7.6)	29.9^{a} (7.7)	28.8^{a,b} (6.3)	28.1 (8.8)
% with BMI ≥ 85th percentile	52.0^{a}	46.0^{a,b}	56.4^{a}	34.5^{b}	35.1^{b}	31.5^{b}	44.3
Intervention group (%)	50.6^{a}	42.6^{a,b}	46.2^{a,b}	29.9^{b}	35.7^{b}	27.8^{b}	43.7
Control group (%)	52.9^{a}	50.0^{a,b}	60.0^{a}	51.3^{a,b}	34.6^{b}	38.5^{a,b}	50.3
% with BMI ≥ 95th percentile	32.0^{a}	32.2^{a}	27.3^{a,b}	14.5^{b}	13.8^{b}	14.8^{b}	24.4
Intervention group (%)	30.5^{a}	32.8^{a}	30.8^{a,b}	9.2^{c}	15.7^{b,c}	16.7^{a,b,c}	23.7
Control group (%)	33.6^{a}	30.0^{a,b}	20.0^{a,b}	28.2^{a,b}	13.5^{b}	13.6^{a,b}	26.4

Initial anthropometric and subject characteristics by ethnic/racial group at baseline for the net group, the intervention group and the control group. Per row, racial/ethnic groups not sharing the same letter superscript are significantly different.
†Six participants not classified as male or female.
BMI, body mass index.

to participate in the study (32,56). Demographics of the cohorts in ROAD were similar to those of each school as reported by the New York City Department of Education (http://schools.nyc.gov/Accountability/data/default.htm.). Somatotype data for the schools were not available.

Subject participation

Full data sets were not available from 31/322 participants in Y1 (control studies) and 93/469 participants in Y2 (intervention studies) because of incomplete data collection, absenteeism on testing days, subject voluntary withdrawal from the study or relocation to other schools. Demographics and somatotype of those children who did not complete studies were not significantly different from the population as a whole.

Efficacy of intervention (Table 2; Figure 1A)

There was a significant decline in BMI *z*-score in experimental participants and so further analyses of inter-group differences in the effects of the intervention on multiple adiposity-related measures were performed. In the intervention group, BMI *z*-score decreased by 0.04 ± 0.01 (p = 0.01) and percent body fat decreased by 0.5 ± 0.2% (p = 0.017), while there were no significant changes to BMI *z*-score or percent body fat in the control group. Comparison of changes in BMI *z*-score between experimental control groups were not significantly different, although there was a trend towards greater declines in BMI *z*-score in the experimental group (p = 0.09).

The effect of the intervention was more pronounced in men (ΔBMI *z*-score = −0.05 ± 0.02, p = 0.015; Δ% body fat = 0.92 ± 0.35%, p = 0.01). In the male control group,

Table 2 Changes in adiposity among ethnic groups and genders by paired *t*-tests

	ΔBMIz		ΔFat mass (kg)		Δ% Body fat		ΔWaist circumference (cm)		ΔWeight (kg)		ΔHeight (cm)	
	Int.	Contr.	Int.	Contr.	Int.	Contr.	Int.	Contr.	Int.	Contr.	Int.	Contr.
Total	**−0.035***	−0.009	0.18	1.43	**−0.49***	−0.45	−0.16	−0.01	1.56	1.78	1.87	1.54
Male	**−0.052***	0.007	−0.031	−0.003	**−0.92***	**−1.24****	−0.12	0.02	2.06	2.29	2.74	1.93
Female	−0.02	−0.012	**0.34***	**0.36***	−0.15	0.24	−0.20	−0.008	1.16	1.04	1.18	1.21
African American	0.008	−0.04	**0.83***	−0.59	0.11	**−1.45***	0.63	1.04	2.05	1.45	1.56	2.0
Male	0.04	−0.02	**1.15***	−0.90	0.54	−2.38	0.69	0.50	2.56	1.98	1.98	1.82
Female	−0.02	−0.06	0.55	−0.13	−0.24	−0.22	0.57	1.64	1.59	0.7	1.20	2.23
Hispanic	−0.04	0.03	0.07	**0.80***	−0.27	0.28	−0.63	−0.30	1.17	2.44	1.44	1.37
Male	−0.05	0.04	−0.36	1.02	−0.97	−0.16	**−1.78***	0.40	1.8	2.41	2.25	1.86
Female	−0.04	0.02	0.36	**0.64***	0.19	0.64	0.12	−0.88	0.75	1.42	0.90	0.98
Caucasian	−0.12	0.006	0.06	−0.10	−0.66	−0.81	−0.23	−0.68	1.65	1.29	2.45	1.64
Male	−0.10	−0.009	0.47	−0.50	−0.49	−1.40	−1.26	−2.15	2.98	1.07	3.15	1.77
Female	−0.12	0.03	−0.28	0.49	−0.80	0.04	0.61	1.44	0.56	1.6	2.01	1.44
East Asian	−0.08	−0.08	0.21	−0.04	−0.39	−0.57	0.25	**1.97***	1.54	0.91	2.49	2.14
Male	**−0.12***	−0.04	0.15	−0.42	−0.32	−1.64	0.75	**2.34****	1.73	1.30	2.83	2.5
Female	−0.03	−0.14	0.26	0.51	−0.45	1.93	−0.28	1.43	1.45	0.4	1.38	1.67
South Asian	0.02	**−0.06***	0.04	−0.58	**−1.03****	**−3.01****	**−1.93***	−1.31	1.96	0.76	1.73	1.59
Male	−0.05	−0.06	−0.54	−0.47	**−1.91***	**−2.67***	**−2.55****	−1.77	2.02	1.0	2.3	1.88
Female	**0.40***	−0.06	0.41	−0.65	−0.49	−1.33	−1.57	−1.04	1.93	0.64	1.38	1.43

Changes in measurements of adiposity by race/ethnic group and gender were analysed by paired *t*-tests between intervention (Int.) and control (Contr.) groups following the intervention.
*$p < 0.05$ compared with zero.
**$p < 0.01$ compared with zero.
BMI, body mass index. Values with statistical significance highlighted are in bold.

there was no significant change in BMI *z*-score, but percent body fat declined by 1.2 ± 0.4% (p = 0.002). In contrast, fat mass was significantly increased in both the intervention (0.34 ± 0.15 kg, p = 0.024) and control (0.36 ± 0.22 kg, p = 0.014). In contrast to the overall tendency for female participants to increase fat mass, it was noted that women who were obese experienced a decrease in fat mass (0.46 ± 0.37 kg), although statistical significance was not reached. Within the control population, the South Asian male subgroup experienced a significant decrease in percent body fat of 2.7 ± 0.93% (p = 0.01) and African–American men experienced a trending decrease in percent body fat of 2.4 ± 0.81% (p = 0.10).

Intervention efficacy by somatotype (Figure 1B)

Based on the pre-intervention BMI *z*-scores, 19.9% of the participants were initially overweight and 24.4% of the participants were obese (Table 1). Using paired *t*-test analyses comparing intervention and control groups in classifying subgroups of 'lean', 'overweight'and 'obese', it became clear that the intervention was only significantly effective in reducing BMI *z*-score (−0.08 ± 0.02, p = 0.0004) in participants who were obese. Declines in BMI *z*-scores in the population of participants who were obese were significantly greater in the intervention group than the control group (p = 0.005).

Correlation between initial adiposity and effect of intervention (Table 3)

Further analyses by ANCOVA were performed to see the effects of demographics (gender, race/ethnicity and age) and anthropometrics (initial BMI *z*-score, percentage of body fat, amount of fat mass and waist circumference), on the observed changes in adiposity-related measures in the experimental group. After adjustments by ANCOVA using initial adiposity (same measure as the dependent variable), gender and age at pre-intervention testing as covariates, there were significant declines in percent body fat of −0.5 ± 2.8% ($p < 0.001$), waist circumference of −0.7 ± 5.3 ($p < 0.001$) cm and BMI *z*-score of −0.005 ± 0.034 (p = 0.007) in the intervention group. All three measures of initial adiposity were negatively correlated with change in adiposity, as reflected in ANCOVA-adjusted cell means. Having greater measures of adiposity at the beginning of the intervention corresponded with a likelihood of a negative change in adiposity during the intervention, except for the measure of fat mass, for which the analysis was not statistically significant.

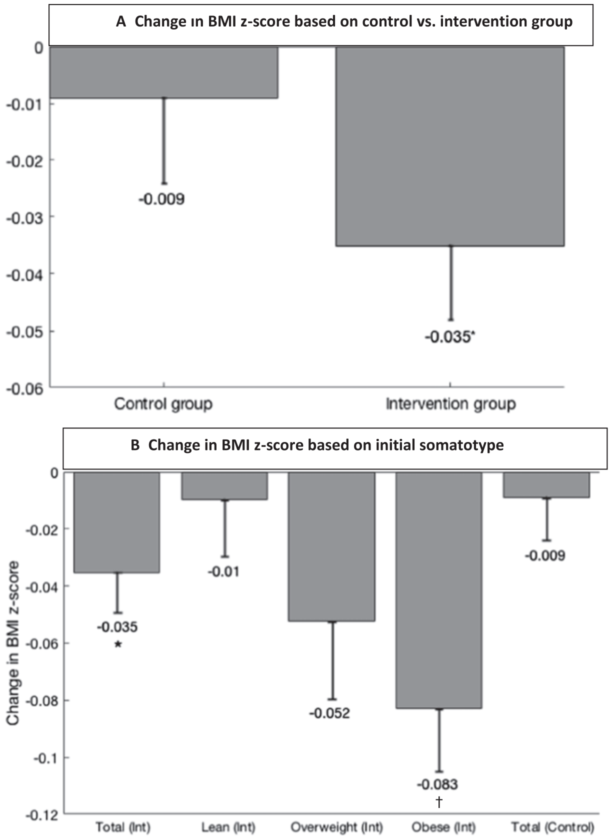

Figure 1 (A) The mean change in BMI *z*-score in the control group and the intervention group by ANOVA ($p = 0.09$). (B) Participants were divided into three subgroups: obese (those at or above the 95th BMI percentile) ($n = 89$), overweight (those at or above the 85th BMI percentile and below the 95th percentile) ($n = 74$) and lean (those below the 85th BMI percentile) ($n = 212$). The change in BMI *z*-scores over the duration of the intervention (Int) was compared among these groups as well as the total intervention population ($n = 376$) using paired *t*-tests.*Only the obese and total populations experienced statistically significant changes in BMI *z*-score (prob>|t| = 0.0004 and 0.01, respectively). The average changes in BMI *z*-scores of the other two intervention groups as well as the total control group are shown alongside these for the sake of comparison. $^{\dagger}p = 0.01$ compared with zero. ANOVA, analysis of variance; BMI, body mass index.

Differences between racial/ethnic groups (Table 4, Figure 2)

For analysis of the effect of race/ethnicity on the efficacy of the intervention, an ANCOVA with the covariates gender, age and initial BMI *z*-score versus the dependent variable ΔBMI *z*-score was run prior to more detailed analyses of anthropometric variables. Upon observing a significant effect in ΔBMI *z*-score, other measures of adiposity and body composition were examined. ANCOVAs were performed analysing changes in four measures of

Table 3 Impact of initial adiposity on intervention outcomes

Measure of adiposity	% Body fat	Waist	BMIz
Correction by ANCOVA	−0.16	−1.02	−0.14
p value	<0.001	<0.001	<0.001

The impact of initial adiposity on intervention outcomes. N.B.: The units for the correction by ANCOVA are not normalized and therefore do not indicate which measure of adiposity had the greatest impact. The values for correction should not be compared between different measures of adiposity. The conclusion is simply that changes in % body fat, waist circumference and BMIz following the intervention were negatively correlated with initial adiposity measures. ANCOVA, analysis of covariance; BMI, body mass index.

adiposity: BMIz, percent body fat, fat mass and waist circumference. For each measure of adiposity, two different ANCOVAs were performed: one using gender, age and initial anthropometrics as covariates, and one using gender, age and the change in adiposity measures as covariates. As discussed in the succeeding text, the efficacy of the intervention differed between racial/ethnic groups (Figure 2 shows ANCOVA-adjusted cell means by racial/ethnic group). An ANCOVA including racial/ethnic group and experimental/control group as covariates showed a trending towards a greater decline in BMI *z*-scores in the experimental group ($p = 0.10$).

Response in African–American participants (Table 4, Figure 2)

In both ANCOVAs examining the change in percent body fat, African Americans were more likely to increase percent body fat during the intervention. A significant experimental/control group difference was observed in the ANCOVA with change in BMI *z*-score as a covariate ($p = 0.049$), as well as a trending experimental/control group difference in the ANCOVA with initial percent body fat as a covariate ($p = 0.09$). In fact, in all analyses but one (the change in BMI *z*-score with the change in fat mass as a covariate), being African American was correlated with a greater likelihood of gaining fat during the intervention. Specifically, African–American participants were significantly more likely to gain percent body fat over the course of the intervention than Hispanic participants ($p = 0.05$) and South Asian participants ($p = 0.006$). They were also significantly more likely to gain fat mass than East Asian participants ($p = 0.02$), Hispanic participants ($p = 0.01$) and South Asian participants ($p = 0.04$).

Response in South Asian participants (Table 4, Figure 2)

South Asian participants experienced greater decreases in percent body fat, fat mass and waist circumference

Table 4 Mean (SEM) adjusted cell means by ethnic/racial intervention group

Adjusted cell means	Covariates	Hispanic	African American	Caucasian	East Asian	South Asian	*p* values				
							Overall	Race/ ethn.	Age	Sex	Adiposity
Δ% Body fat (SE)	Age, sex, pre-% fat	−0.49 (0.24)	0.44 (0.41)	−0.63 (0.52)	−0.99 (0.35)	−1.20 (0.42)	<0.001	0.046	NS	<0.001	<0.001
	Age, sex, ΔBMIz	−0.54 (0.23)	0.44 (0.39)	−0.24 (0.52)	−0.60 (0.33)	−1.45 (0.40)	<0.001	0.019	NS	0.006	<0.001
ΔBMI *z*-score (SE)	Age, sex, pre-BMIz	−0.007 (0.038)	0.019 (0.026)	−0.021 (0.023)	−0.031 (0.023)	0.005 (0.027)	0.007	NS	NS	NS	<0.001
	Age, sex, Δ fat mass	−0.014 (0.036)	−0.008 (0.025)	−0.038 (0.036)	−0.012 (0.022)	0.028 (0.026)	<0.001	NS	NS	NS	<0.001
Δ Fat mass (SE)	Age, sex, pre-fat mass	−0.008 (0.18)	0.87 (0.31)	0.077 (0.40)	−0.088 (0.26)	−0.053 (0.32)	<0.001	0.004	0.017	0.044	NS
	Age, sex, ΔBMIz	0.006 (0.16)	0.70 (0.27)	0.41 (0.37)	0.13 (0.23)	−0.24 (0.29)	<0.001	0.003	0.005	NS	<0.001
ΔWaist circumference (SE)	Age, sex, pre-waist circumference	−0.53 (0.46)	0.56 (0.75)	−1.36 (1.03)	−0.48 (0.64)	−2.62 (0.80)	<0.001	NS	<0.001	NS	<0.001
	Age, sex, ΔBMIz	−0.95 (0.47)	0.29 (0.77)	−1.53 (1.11)	0.29 (0.65)	−2.09 (0.82)	<0.001	NS	<0.001	NS	<0.001

ANCOVA-adjusted cell means by ethnicity/race in intervention groups, with *p* values corresponding to the overall test and each covariate. ANCOVA, analysis of covariance; BMI, body mass index.

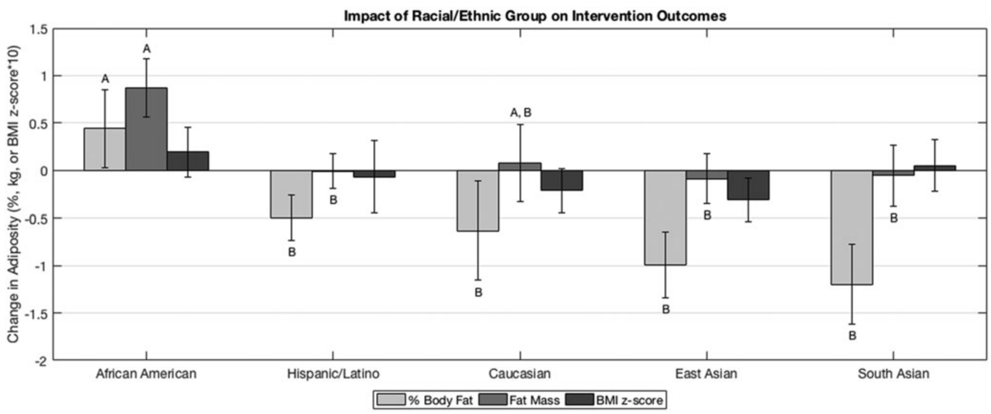

Figure 2 ANCOVA-adjusted cell means for different racial/ethnic intervention groups. The y-axis measures the average change in percentage or kilograms by group for percent body fat or fat mass, respectively. Covariates for each ANCOVA are age, gender and initial adiposity (the same measurement of adiposity as the dependent variable for each test). Bars labelled with different letters (A vs. B) within each adiposity metric (change in % body fat, fat mass or BMI *z*-score) are significantly different. Bars labelled with the same letters are not significantly different. There were no significant differences between groups in BMI *z*-score, and those bars are unlabelled. ANCOVA, analysis of covariance; BMI, body mass index.

than all other ethnic/racial groups. ANCOVA-adjusted cell means were significantly more negative than the same cell means for African–American participants in terms of the change in percent body fat (p = 0.006) and the change in fat mass (p = 0.009). ANCOVA-adjusted cell means for the change in waist circumference were significantly more negative than multiple other ethnic/racial groups (p = 0.004 compared with African–American participants; p = 0.03 compared with East Asian participants; p = 0.03 compared with Hispanic participants), possibly meaning that South Asians were more likely to lose abdominal girth, a surrogate measure for metabolically unhealthy visceral fat, with the intervention. Here, experimental/control group differences were observed in the ANCOVAs examining the change in fat mass. There was a significant group difference with initial fat mass as a covariate (p = 0.019), and a similar trend was observed with change in BMI *z*-score as a covariate (p = 0.082) both of which showed a significantly more negative change in fatness in the experimental group.

Effect of gender on response to intervention (Table 5)

Male participants, regardless of age, race/ethnicity or initial adiposity, were more likely than females to lose body fat during the intervention in two measures of adiposity: fat mass (p = 0.04) and percent body fat (p = 0.002). In all assessments of body fatness, female participants on average gained adiposity, whereas male participants on average lost adiposity. In the race/ethnicity-grouped ANCOVAs performed with percent body fat as the dependent variable, female participants were more likely to gain percent body fat or simply lose less percent body fat than their male counterparts during the study across all racial/ethnic groups and in both the experimental and control groups (p = 0.006).

Discussion

The major findings of this study are that the ROAD Project's school-based health intervention is beneficial to students but that there are numerous group-specific covariates that should be considered in designing and implementing such programmes, including initial adiposity, gender and ethnicity/race. Participants enrolled in a relatively straightforward SBI and were given the opportunity to meet school mandates for physical education experienced significant declines in fatness compared with their own baseline pre-intervention values, and a similar trend was seen when they were compared with a control group of participants who received no intervention. In initial paired t-tests as well as analyses by ANCOVA, participants with greater initial adiposity showed greater reductions for each of the adiposity measures as a result of the intervention compared with lean participants, i.e. the participants at highest risk for adult obesity and related comorbidities benefitted the most from the intervention. The decline in BMI z-score in the intervention group was comparable with those reported in meta-analyses of other studies (57), although most of these studies involved longer interventions (1–6 years). Longer intervention time has been reported to correlate with greater declines in BMI (49). This study is unusual in the large number of students within the peri-pubertal age group, the attention paid to intervention cost (none would be required to implement), intervention portability and the multivariate nature of the analyses.

Table 5 Impact of gender in intervention groups

Dependent variable	Gender	Average Δ (least sq mean)	Std error	p value
% Body fat	Female	0.02	0.23	0.002
	Male	−**1.17**	0.25	
Fat mass	Female	0.29	0.19	0.04
	Male	−**0.17**	0.19	
BMI z-score	Female	0.008	0.015	NS
	Male	−**0.02**	0.02	

The impact of gender on intervention outcomes. The ANCOVA-adjusted cell means for three measurements of adiposity are listed by gender. Covariates for each test are age, ethnicity/race and initial adiposity (the same measurement of adiposity as the dependent variable for each test). ANCOVA, analysis of covariance; BMI, body mass index. Values with statistical significance are highlighted in bold.

In both paired t-tests and ANCOVA, men were more likely to lose adiposity over the course of the intervention. There were no significant differences in the percentage of men and women who signed up for the exercise portion of the study (about 40% of each) nor were there significant differences between ethnic/racial groups or sites. (As noted previously, specific attendance data are not yet available.) Some of the observed gender differences may be because of increased variability in female entry into puberty and the expectation that a larger proportion of women would be in early to mid-puberty based on earlier entry into puberty than men as well as gain of relatively more body fat during puberty in women (58–60). This does not, however, account for the trend of male participants to decrease BMI z-score more than female participants, as BMI z-score is already 'corrected' for age.

South Asian participants were particularly likely to benefit from the intervention, while African–American participants were least likely to benefit for reasons that cannot be explained by available data. Fat mass and percent body fat in particular were significantly reduced in South Asian participants compared with African–American participants, and waist circumference was significantly reduced compared with African–American, East Asian and Hispanic participants. In African–American participants, percent body fat was significantly increased compared with Hispanic and South Asian participants, and fat mass was similarly significantly increased compared with Hispanic, East Asian and South Asian participants. Possible confounders include cultural/lifestyle differences, compliance differences or differences in pubertal status between ethnic/racial groups (African–American girls in particular tend to enter puberty earlier) (6,61,62). Caucasian, East Asian and Hispanic populations all tended to benefit from the intervention, although not as much as the South Asian participants.

There are few studies actually comparing the effects of the same intervention based on ethnicity or race. A recent pilot study by Karczewski *et al*. (63) found that African–American students experienced a gain in BMI% while

Hispanic students experienced a loss in BMI% over a 1-year intervention similar to this investigation. In contrast, in the Planet Health intervention for 6th and 7th graders, Gortmaker *et al*. found that the largest and only significant intervention effect was in African–American women (24) while Johnston *et al*. (64) found no differences in effect sizes based on ethnicity utilizing a health provider-based intervention. The variation in results indicates that ethnic/racial response differences are not because of any biological or sociological differences in response to weight loss interventions as a whole. Instead, they emphasize the need for investigation, definition and application of more culturally sensitive interventions, which based on the ethnic/racial backgrounds of habits of school catchment areas should increase effect sizes.

School-based interventions to reduce and prevent adiposity and its comorbidities have been criticized for their high cost, unreliable efficacy and lack of long-term benefit, and their difficulty in implementation, particularly after the resources of the initial efficacy study are reduced to a school's standard operating budget (14). These issues were addressed in the design of the ROAD Project (16) that offered a low-cost (no specialized personnel or equipment required for a curriculum easily placed within the ongoing science programmes and no additional expenses for gym classes other than to meet the NYC mandate for school exercise), portable intervention integrated into the students' regular health curriculum. The ROAD Project intervention was successful in reducing adiposity regardless of whether measured as changes in BMI *z*-score, percent body fat and fat mass in the total subject population and especially among students who were obese at enrolment. The study's scope included all students on the principle that a student should not be denied the benefits of a good health education and appropriate physical education programme because of normal body weight. Analyses of intervention effects on other adiposity-related comorbidity risk factors (lipids, cytokines and glucose homeostasis) based on gender, initial adiposity and so on are pending. Additionally, targeting the entire class rather than limiting the intervention to individuals who were overweight or obese minimized the potential social impact of publically identifying students as 'overweight'. The programme had success in a large, diverse population, and, considering the increased risk for obesity and related comorbidities in all men in later life, and particularly in select racial and ethnic groups, notably the South Asian population (5,6,65,66), the efficacy in these student subgroups is of particular interest. As discussed earlier, there are few studies looking at the effects of race/ethnicity on intervention efficacy. The demonstration of these interactions suggests that further refinement of SBIs, and probably other interventions designed to prevent adult obesity through early action, along more culturally sensitive lines could be more effective.

Study weaknesses include the brevity of the intervention that may have decreased the sensitivity of the study to detect beneficial effects of school adherence to physical education mandates over the full year and the effects of classroom teaching over time. These effects cannot be adequately partitioned because of the lack of available data on actual gym attendance. Follow-up studies are needed to determine long-term programme efficacy. Studies of intervention dose effectiveness and persistence of benefits over the summer break, as well as effects on adiposity-related comorbidity risk in these cohorts, are ongoing. Neither BMI *z*-score nor body composition determined by single frequency BIA are ideal measures of fatness, especially for individuals at the extremes of body weight. This issue should be explored further using more sensitive measures of body composition such as dual energy x-ray absorptiometry, multi-frequency bioimpedance spectroscopy or quantitative magnetic resonance spectroscopy (51).

In conclusion, these data demonstrate that a middle school-based intervention can be effective in improving adiposity among adolescents and is modulated by demographic and anthropometric factors for this intervention. The efficacy of SBI in this area remains inconclusive (14). The results of this study suggest that some of the variance in results may be because of the demography of the populations studied. Benefits in other paediatric obesity interventional studies have generally been shown to persist as long as the intervention is offered (67) although Savoye *et al*. (10) reported that weight gain was still diminished in participants 1 year after cessation of a broader-community and family-based intervention.

More research is necessary to gain meaningful insights into apparent demographic and anthropometric risk factors for obesity and its comorbidities and the development of a more 'precision medicine' oriented approach to disease prevention. Further analysis should include investigation as to how intervention efficacy could be improved to address those populations in which it was less effective. It is anticipated that such analyses will demonstrate the specific benefits of the exercise intervention, compared with the impact of the enhanced health and nutrition education. Finally, long-term follow-up would reveal whether there is a sustained effect from the intervention in later years.

Acknowledgements

We gratefully acknowledge the participation of the Department of Health and Department of Education of New

York City, in particular Drs. Henry Solomon and Roger Platt. We also would like to thank the local school boards, school principals, science teachers, physical education teachers, faculty and student participants at all participating schools. Most of all, we would like to thank all our collaborators in the ROAD Group without whom this work would never have been completed: Siham Accacha, Amrit Bhangoo, Claudia Boucher-Berry, Dennis E. Carey, Sharon Close, Deborah DeSantis D, Rushika Conroy, Yomery Espinal, Frankel D, Rishi Gupta, Abeer Hassoun, Stephen Holleran, Loretta Iazzetti, Alan Jacobson A, Fabien Jacques, Amy Jean, Michelle Klein, Audrey Koltun, Robert Levine, Lesley Michel, Kate Pavlovich K, Guy Rivera and Elisabeth Shamoon.

Funding

The development and implementation of this project was supported by AMDeC, the Hannah and Ryan Barry Memorial Foundation, the Naomi Berrie Diabetes Research Center, Columbia Diabetes and Endocrinology Research Center (DERC, NIH P30 DK63068), NIH UL1 RR024156, New York State, and the Starr Foundation.

Author contributions

L. O. was the primary author of the manuscript. P. W. S., S. A., L. A., I. F., W. R., R. R. and S. T. were site principal investigators and supervised all research at their respective sites. B. L. and L. A. developed the intervention and B. L. supervised its implementation. S. P. S. and M. R. were co-principal investigators on this project and M. R. supervised all specimen processing and data collection. Statistical analyses were performed by L. O. and M. R. and supervised by Dr. Stephen Holleran as described in the Acknowledgement section.

Conflict of interest statement

No conflict of interest was declared.

References

1. Cunningham S, Kramer M, Narayan K. Incidence of childhood obesity in the United States. *N Engl J Med* 2014; **370**: 403–411.
2. Kumar S, Kelly A. Review of childhood obesity: from epidemiology, etiology, and comorbidities to clinical assessment and treatment. *Mayo Clin Proc* 2017; **92**: 251–265.
3. Fennoy I. Metabolic and respiratory co-morbidities of childhood obesity. *Pediatr Ann* 2010; **39**: 140–106.
4. Epstein L, Goldfield G. Physical activity in the treatment of childhood overweight and obesity: current evidence and research issues. *Med Sci Sports Exerc* 1999; **31**: S553–S559.
5. Ogden C, Carroll M, Kit B, Flegal K. Prevalence of childhool and adult obesity in the United States, 2011-2012. *JAMA* 2014; **311**: 806–814.
6. Caprio S, Daniels S, Drewnowski A, et al. Influence of race, ethnicity, and cutlure on childhood obesity: implications for prevention and treatment. *Obesity* 2008; **16**: 2566–2577.
7. Whitaker R, Wright J, Pepe M, Seidel K, Dietz W. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 1997; **337**: 869–873.
8. Magarey A, Perry R, Baur L, et al. A parent-led family-focused treatment program for overweight children aged 5 to 9 years: the PEACH RCT. *Pediatrics* 2011; **127**: 214–222.
9. Reinehr T, Kleber M, Lass N, Toschke A. Body mass index patterns over 5 y in obese children motivated to participate in a 1-y lifestyle intervention: age as a predictor of long-term success. *Amer J Clin Nutr* 2010; **91**: 1156–1171.
10. Savoye M, Nowicka P, Shaw M, et al. Long-term results of an obesity program in an ethnically diverse pediatric population. *Pediatrics* 2011; **127**: 402–410.
11. Phelan S, Wing R. Prevalance of successful weight loss. *Arch Intern Med* 2005; **165**: 2430.
12. Wadden T, Neiberg R, Wing R, et al. Four-year weight losses in the Look AHEAD study: factors associated with long-term success. *Obesity* 2011; **19**: 1987–1998.
13. Unick J, Beavers D, Jakicic J, et al. Effectiveness of lifestyle interventions for individuals with severe obesity and type 2 diabetes: results from the Look AHEAD trial. *Diabetes Care* 2011; **34**: 2152–2157.
14. Durant N, Baskin M, Thomas O, Allison D. School-based obesity treatment and prevention programs: all in all, just another brick in the wall? *Int J Obes (Lond)* 2008; **32**: 1747–1751.
15. Johnston C, Tyler C, Fullerton G, et al. Effects of a school-based weight maintenance program for Mexican-American children: results at 2 years. *Obesity* 2010; **18**: 542–547.
16. Rosenbaum M, Accacha S, Altshuler L, et al. The Reduce Obesity and Diabetes (ROAD) project: design and methodological considerations. *Childhood Obes* 2011; **7**: 223–234.
17. Contento I. *Nutrition Education: Linking Research, Theory, and Practice*, 2nd edn. Jones and Bartlett: Sudbury, MA, 2011.
18. Pbert L, Druker S, Barton B, et al. A school-based program for overweight and obese adolescents: a randomized controlled trial. *J Sch Health* 2016; **86**: 699–708.
19. Freira S, Lemos M, Fonseca H, et al. Anthropometric outcomes of a motivational interviewing school-based randomized trial involving adolescents with overweight. *Eur J Pediatr* 2018; **15** https://doi.org/10.1007/s00431-00018-03158-00432. [Epub ahead of print].
20. Lubans D, Smith J, Plotnikoff R, et al. Assessing the sustained impact of a school-based obesity prevention program for adolescent boys: the ATLAS cluster randomized controlled trial. *Int J Behav Nutr Phys Act* 2016; **13**: 92.
21. Muller M, Danielzik L, Pust S. School- and family-based interventions to prevent overweight in children. *Proc Nutr Soc* 2005; **64**: 249–254.
22. Boon C, Clydesdale F. A review and childhood and adolescent obesity interventions. *Crit Rev Food Sci Nutr* 2005; **45**: 511–525.
23. Summerbell C, Waters E, Edmunds L, Kelly S, Brown T, Campbell K. Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2005; **20**: CD001871.
24. Gortmaker S, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med* 1999; **153**: 409–418.

25. Teufel N, Ritenbaugh C. Development of a primary prevention program: insight gained in the Zuni Diabetes Prevention Program. *Clin Pediatr* 1998; **37**: 131–141.
26. Holcomb J, Lira J, Kingery P, Smith D, Lane D, Goodway J. Evaluation of Jump Into Action: a program to reduce the risk of non-insulin dependent diabetes mellitus in school children on the Texas-Mexico border. *J Sch Health* 1998; **68**: 282–288.
27. Grey M, Berry D, Davidson M, Galasso P, Gustafson E, Melkus G. Preliminary testing of a program to prevent type 2 diabetes among high-risk youth. *J Sch Health* 2004; **74**: 10–15.
28. Reinehr T, Kiess W, Kapellen T, Andler W. Insulin sensitivity among obese children and adolescents, according to degree of weight loss. *Pediatrics* 2004; **114**: 1569–1573.
29. Nassis G, Papantakou K, Skenderi K, et al. Aerobic exercise training improves insulin sensitivity without changes in body weight, body fat, adiponectin, and inflammatory markers in overweight and obese girls. *Metabolism* 2005; **54**: 1472–1479.
30. Ritenbaugh C, Reufel-Shone N, Aickin M, et al. A lifestyle intervention improves plasma insulin levels among Native American high school youth. *Prev Med* 2003; **36**: 309–319.
31. Balagopal P, George D, Patton N, et al. Lifestyle-only intervention attenuates the inflammatory state associated with obesity: a randomized controlled study in adolescents. *J Pediatr* 2005; **146**: 342–348.
32. Rosenbaum M, Nonas C, Weil R, et al. School-based intervention acutely improves insulin sensitivity and decreases inflammatory markers in early adolescence. *J Clin Endocrinol Metab* 2007; **92**: 504–508.
33. Cox K, Burke V, Morton A, Belin L, Puddey I. Independent and additive effects of energy restriction and exercise on glucose and insulin concentrations in sedentary overweight men. *Am J Clin Nutr* 2004; **80**: 308–316.
34. Paradis G, Levesque L, Macaulay A, et al. Impact of a diabetes prevention program on body size, physical activity, and diet among Kanien'keha:ka (Mohawk) children 6 to 11 years old: 8-year results from the Kahnawake schools diabetes prevention project. *Pediatrics* 2005; **115**: 333–339.
35. Accacha S, Michel L, Rosenfeld W, et al. Plasma advanced glycation end products (AGE's), receptors for AGEs, and their correlation with inflammatory markers in middle school age children. *Horm Res Paediatr* 2013; **80**: 318–327.
36. American Physiological Society. Guiding principles for research involving animals and human beings. *Am J Physiol Regul Integr Comp Physiol* 2002; **283**: R281–R283.
37. The New York City department of education wellness policies on physical activity and nutrition; 2006.
38. Stiefel J, Elbel B, Pflugh Prescott M, Aneja S, Schwartz A. School wellness programs: magnitude and distribution in New York City Public schools. *J Sch Health* 2017; **87**: 3–11.
39. Burchard E, Ziv E, Coyle N, et al. The importance of race and ethnic background in biochemical research and clinical practice. *N Engl J Med* 2003; **348**: 1170–1175.
40. Williams D. Race and health: basic questions, emerging directions. *Ann Epidemiol* 1997; **7**: 322–333.
41. Tuomilehto J, Lindstrom J, Eriksson J, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001; **344**: 1343–1350.
42. Collins C, Okely A, Morgan P, et al. Parent diet modificaiton, child activity, or both in obese children: an RCT. *Pediatrics* 2011; **127**: 619–627.
43. Sacher P, Kolourou M, Chadwick P, et al. Randomized controlled trial of the MEND program: a family-based commity intervention for childhood obesity. *Obesity* 2010; **18**: S62–S68.
44. Epstein L, Valoski A, Vara L, et al. Effects of decreasing sedentary behavior and increasing activity on weight change in obese children. *Health Psychol* 1995; **14**: 109–115.
45. Epstein L, Wing R, Penner B, Kress M, Koeske R. The effect of controlled exercise on weight loss in obese children. *J Pediatr* 1985; **107**: 358–361.
46. Fernandez J, Redden D, Pietrobelli A, Allison D. Waist circumference percentiles in national representative samples of African-American, European-American, and Mexican-American children and adolescents. *J Pediatr* 2004; **45**: 439–444.
47. Segal K, Gutin B, Presta E, Wang J, Itallie TV. Estimation of body composition by electrical impedance methods: a comparative study. *J Appl Physiol* 1985; **58**: 1565–1571.
48. da Silveira J, Taddie J, Guerra O, Nobre M. The effect of participation in school-based nutrition education interventions on body mass index: a meta-analysis of randomized controlled community trials. *Prev Med* 2013; **56**: 237–243.
49. Lavelle H, Mackay D, Pell J. Systematic review and meta-analysis of school-based interventions to reduce body mass index. *J Public Health* 2012; **34**: 360–369.
50. Boeke C, Oken E, Kleinman K, Rifas-Shiman S, Taveras E, Gillman M. Correlations among adiposity measures in school-aged children. *BMC Pediatr* 2013; **13** https://doi.org/10.1186/1471-2431-1113-1199.
51. Rosenbaum M, Agurs-Collins T, Bray M, et al. The Accumulating Data to Optimally Predict Obesity Treatment (ADOPT): recommendations from the bological domain. *Obesity* 2018; **26**: S25–S34.
52. Perneger T. What's wrong with Bonferroni adjustments. *BMJ* 1998; **316**: 1236–1238.
53. Rothman K. No adjustments are needed for multiple comparisons. *Epidemiology* 1990; **1**: 43–46.
54. Thomas D, Siemiatycki J, Dewar R, Robins J, Goldberg M, Armstrong B. The problem of multiple inference in studies designed to generate hypotheses. *Am J Epidemiol* 1985; **122**: 1080–1095.
55. Ogden C, Carroll M, Kit B, Flegal K. Prevalence of obesity and trends in body mass index among US children and adolescents 1999-2010. *JAMA* 2012; **307**: 483–490.
56. Rosenbaum M, Nonas C, Horlick M, et al. Beta-cell function and insulin sensitivity in early adolescence: association with body fatness and family history of type 2 diabetes mellitus. *J Clin Endocrinol Metab* 2004; **89**: 5469–5476.
57. Wang Y, Cai L, Wu Y, et al. What childhood obesity prevention programmes work? A systematic review and meta-analysis. *Obes Rev* 2015; **16**: 547–565.
58. Villamor E, Jansen E. Nutritional determinants of the timing of puberty. *Annu Rev Public Health* 2016; **37**: 33–46.
59. Ahmed M, Ong K, Dunger D. Childhood obesity and the timing of puberty. *Trends Endocrinol Metab* 2013; **20**: 237–242.
60. Staiano A, Katzmarzyk P. Ethnic and sex difference in body fat and visceral and subcaneous adiposity in children and adolescents. *Int J Obes (Lond)* 2012; **36**: 1261–1269.
61. Freedman D, Wang J, Thornton J, et al. Classification of body fatness by body mass index-for-age categories among children. *Arch Pediatr Adolesc Med* 2009; **163**: 805–811.
62. Sisson S, Katzmarzyk P, Srinivasan S, et al. Ethnic differences in subacutaneous adiposity and waist girth in children and adolescents. *Obesity* 2009; **17**: 2075–2081.

63. Karczewski S, Carter J, DeCator D. The role of ethnicity in school-based obesity intervention for school-aged children: a pilot evaluation. *J Sch Health* 2018; **86**: 778–786.
64. Johnston C, Moreno J, El-Mubasher A, Gallagher M, Tyler C, Woehler D. Impact of a school-based pediatric obeisity prevention program facilitated by health professionals. *J Sch Health* 2013; **83**: 171–181.
65. D'Adamo E, Santoro N, Caprio S. Metabolic syndrome in pediatrics: old concepts revised, new concepts discussed. *Pediatr Clin N Amer* 2011; **58**: 1241–1255.
66. Weiss R, Caprio S. The metabolic consequences of childhood obesity. *Best Pract Res Clin Endocrinol Metab* 2005; **19**: 405–419.
67. Vos M, Welsh J. Childhood obesity: update on predisposing factors and prevention strategies. *Curr Gastroenterol Rep* 2010; **12**: 280–287.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. The ROAD Project: Curriculum Progression. Each grade focused on a different theme and a larger/final project (the "Action Project") aimed at changing the target environment. Each unit is 4 weeks/sessions long. The bullet points identify the topics of each of the 4 sessions in each unit.