

The MATCH Program: Long-Term Obesity Prevention Through a Middle School Based Intervention

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Abstract

Background: Motivating Adolescents with Technology to CHOOSE Health™ (MATCH) has been provided for eight years in North Carolina middle schools with high obesity prevalence.

Methods: Seventh grade teachers in two schools delivered MATCH lessons in 2009, with one control school. In 2013 students were remeasured and completed a health behavior survey. Outcomes include BMI, BMI z-score (zBMI), weight category, and self-reported behaviors. Comparisons used t tests (continuous measures), Fisher's exact test (categorical measures), and linear mixed models (trend between groups).

Results: Of original participants, 104/189 (55%) of MATCH and 117/173 (68%) of control were remeasured. In the control group, retained participants had lower baseline BMI and were higher percent white. Among all participants, zBMI decreased in MATCH (mean change -0.15 with $SD=0.60$) and increased in control (mean change 0.04 with $SD=0.52$); between groups $p=0.02$. In mixed models for the all overweight subgroup, MATCH had a downward trend in zBMI over time that was significantly different from control (slope MATCH -0.0036 versus control 0.0009 ; $p=0.01$). For shifts in weight category: incidence of obesity was lower in MATCH (13%) versus control (39%); remission of overweight to healthy weight was greater in MATCH (40%) versus control (26%). MATCH participants self-reported lower frequency of intake of sweetened beverages and snacks and hours of weekday TV time than control students.

Conclusions: MATCH participation can result in long-term prevention of obesity compared to control, with differences in self-reported health behavior changes to support an underlying mechanism for the observed BMI differences.

Introduction

Obesity remains an enormous health and economic threat worldwide, and trends show little to no improvement in prevalence in school-age children and adolescents.¹ Although it is generally agreed that schools should be an important part of the solution,²⁻⁴ the evidence for effectiveness is greater for younger children than adolescents, and there is no consensus yet about an optimal school-based intervention to promote sustained changes in health behaviors and BMI.^{5,6} However, several large studies have been completed with promising results.

In elementary schools the Coordinated Approach to Child Health (CATCH®) program addresses obesity through improvements in school environments and eating and physical activity behaviors.⁷ Three-year follow-up studies of the randomized controlled trial on which the

current program was originally based, the Child and Adolescent Trial for Cardiovascular Health,⁸ showed success in select health behaviors, but no persistent differences in BMI or physiologic measures.⁹ One- and two-year follow-up studies of adaptations of CATCH have been promising for reducing obesity in elementary grades.^{10,11} In middle schools, the Planet Health® intervention demonstrated some improvements in BMI in one subgroup of African American girls,¹² and a broader initiative that incorporated Planet Health as one component appeared to show schoolwide improvements in obesity and behavior measures.¹³ More recently, the intensive HEALTHY study intervention in middle schools failed to show improvements compared to control in weight category or BMI measures.¹⁴ Although there have been numerous studies of various sizes and approaches to intervention in this age group,¹⁵⁻¹⁸ no long-term studies of middle school interventions

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have been published, except for the early results of the Motivating Adolescents with Technology to CHOOSE Health™ (MATCH) program in one school.¹⁹

MATCH was created by a teacher and implemented in 2006 based on the underlying premise that an effective strategy embedded within the school curriculum at a receptive age can result in behavior change and improved outcomes. Published findings from the pilot study of a single school with high obesity prevalence demonstrate improved BMI measures in both short- and long-term results when compared to a national comparison group.^{19,20} Since inception, the MATCH program has been iteratively improved and expanded to additional schools. In the 2015–2016 school year MATCH is in 32 North and South Carolina schools (28 and 4 schools, respectively) and two Mississippi schools.

As reported previously in a paper that described the original study justification and methods, MATCH was first expanded in spring 2009, with modest short-term results compared to control.²¹ In this study we report the four-year follow-up results of this expansion of MATCH. Reported outcomes include BMI, BMI z-score (zBMI), and weight category changes after four years and cross-sectional health behaviors.

Methods

Study Design

The MATCH intervention is a combined educational-behavioral obesity intervention designed by a teacher and embedded in standard curriculum in the seventh grade.^{19,20} In 2009, MATCH was expanded using a quasi-experimental design. Details of the expansion and results have been described.²¹ In brief, there was a convenience sample of three schools with a high percentage of low socioeconomic status and minority students, two in MATCH and one serving as control. Students at intervention schools received MATCH activities as part of their regular classes; students in the control school received standard curriculum. All students had height and weight measurements done prior to and after the program. No additional intervention activities occurred after seventh grade. The East Carolina University Medical Center institutional review board approved the study (#07–0741). Student assent and parent consent for participation in the research study were obtained at baseline. In 2013, additional recruitment of control subjects was undertaken for long-term follow-up. Eleventh grade students were recruited if they attended the control site and were measured in seventh grade but did not originally enroll.

For the MATCH intervention, trained teachers provided the majority of lessons in science classes (with some lessons in other classes) in a sequenced manner over 14 weeks. Key concepts were repeated and applied to enhance skill development in making healthy eating and physical activity choices. Educational technology resources were used as part of lessons to illustrate key points, such as

students using web-based tools to plot their BMI and examine their nutritional intake and using spreadsheets and graphing software with their own data to view results for goal setting. At given intervals associated with lessons/goals, teachers provided pedometers and small, nonfood incentives (*e.g.*, pens, water bottles). All or part of 26 core lessons/activities were taught at both intervention schools, with a few supplemental lessons provided at either school for a total of 30 and 26 lessons/activities, respectively.²¹ Details of the intervention have been described previously.^{19–21} The MATCH program continued in subsequent years for seventh graders at the intervention schools and was implemented at the control school beginning in fall 2010.

Participant Recruitment: Intervention Participants

As previously described, prior to the start of the intervention in 2009 all seventh grade students in the intervention and control schools received letters inviting participation; 96% (189/196) of eligible seventh graders participated from the intervention schools and 95% (180/189) were measured postintervention.²¹ In 2013, the research team identified two high schools serving the majority of intervention participants. Given the four-year interval since the intervention, the team elected to inform prior participants of the plan for remeasure and provide the opportunity to opt out. The team partnered with school leaders to send letters inviting reassessment of student height and weight and completion of a health habits questionnaire to prior participants (then in 11th grade) and their parent/guardian(s); letters included student and parent opt-out forms. All students not opting out were provided the questionnaire and a time at school to have height/weight measured. Of the 138 students enrolled at the high schools in 2013 104 (75%) were remeasured (104/189, 54% of the original sample).

Control Participants

In 2009 the study participation rate at the control school was low (< 35%). In 2013, to increase participation in this follow-up study, the research team conducted additional recruitment. Two high schools enrolled the majority of students from the control school. After identifying students enrolled who had attended the control school, letters were distributed to these students with assent forms and opt-out parent consent forms. A small incentive item (student choice of item valued at approximately \$10) was offered to students completing the height/weight measures. For this study, control participants included all students who returned assent forms whose parent did not opt out and who completed height and weight measures, for a total of 68% (117/173) participation; due to administrative issues at one of the schools, only 90 of 117 completed the health habits survey. No power analysis was conducted to establish sample size, because the sample was predetermined by school enrollment.

Data Collection

Methods of data collection were reported previously.²¹ All students had height (to nearest quarter inch) and weight (with shoes off, wearing school uniform) measured privately, following procedures devised by trained research staff, using a stadiometer (Schorr Productions, Olney, MD); and calibrated scale at baseline (January 2009) and post-MATCH (April 2009); those participating in the follow-up study were remeasured in spring 2013. BMI was calculated from height and weight; sex-specific zBMI, BMI percentile, and weight category (underweight <5th percentile; healthy weight 5th percentile – <85th percentile; overweight 85th percentile – <95th percentile; obese ≥95th% percentile) were determined using current CDC parameters.²² Sex, ethnicity, and dates of birth were extracted from school records.

In addition to anthropometric measures, all follow-up participants were offered a 29-question Health Habits Questionnaire. This questionnaire included 19 questions adapted from the Beverage and Snack Questionnaire²³ and 10 from the 2010 Youth Risk Behavior Survey (YRBS).²⁴ The original Beverage and Snack Questionnaire was validated for use in middle school subjects to assess self-reported beverage and snack intake over a one-week period in home or school settings. The respondent reports “how often in the past week” they consumed specific types of drinks (nine), snack (eight), and fruit (one) and vegetable (one) servings. Possible responses include never/less than one per week, one per week, two to four per week, five to six per week, one per day, two to three per day, or four plus per day. The questionnaire does *not* quantify a serving size but queries only frequency consumed for each item. For this study the response format was modified to include *total* intake without distinction between school and home. The Health Habits Questionnaire also assessed physical activity and sedentary behaviors using 10 questions from the 2010 YRBS.²⁴

Statistical Analysis

All data analyses were conducted with statistical software SAS (SAS version 9.4; SAS Institute Inc., Cary, NC). Baseline characteristics were compared between groups and between those retained and lost to follow-up using Fisher’s exact test for categorical variables (sex, race, weight category) and two-sample t test for continuous variables (age, BMI, zBMI, BMI percentile). McNemar’s test was used to compare change in the proportion of each weight category between the two groups. We used multiple regression models to compare the changes in BMI measures between the two groups, controlling for effects of sex, race, school, and baseline BMI measures. Both race and school effects were found to be not significant for all BMI measures and were eventually excluded from all regression models. Linear mixed models were adopted to compare the overall trend over time in zBMI between the two groups. Potential sex, race, and school effects were

considered but then dropped from the model due to insignificance. A significance level of 0.05 was adopted for all statistical tests.

Results

Participant Characteristics

Baseline characteristics of MATCH intervention ($N=189$) versus control ($N=173$) participants were different in several ways (Table 1). Both groups had about equal participants of each sex; and the majority were black, overweight or obese, and from low-resource areas. Statistically significant differences between groups include that control participants had lower baseline BMI, were slightly younger, had greater variation in distribution of race (higher percentage black and lower percentage white), and

Table 1. Baseline Participant Characteristics, MATCH Intervention, and Control Groups

	MATCH intervention	Control	Test for difference
	N = 189 Mean (SD)	N = 173 Mean (SD)	t test p value
Age	13.28 (0.79)	13.08 (0.53)	0.01
BMI	24.82 (6.43)	23.42 (5.66)	0.03
BMI percentile	77.75 (25.84)	74.27 (25.84)	0.10
BMI z-score	1.10 (1.07)	0.92 (1.03)	0.20
	N (%)	N (%)	Fisher’s exact test p value
Sex			0.67
Female	88 (47)	85 (49)	
Male	101 (53)	88 (51)	
Race			<0.01
Black	120 (63)	127 (73)	
White	58 (31)	25 (15)	
Other	11 (6)	21 (12)	
Weight category			0.07
Underweight	1 (1)	1 (1)	
Healthy weight	76 (40)	92 (53)	
Overweight	43 (23)	29 (17)	
Obese	69 (36)	51 (30)	
School-level measure of % of students from low-resource families			
School % students receiving free/reduced price lunch 2008–2009	71%	96%	<0.01

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Table 2. Baseline Characteristics of Participants Lost to Follow-Up and Retained in MATCH Intervention and Control Groups

				Test for difference
		Lost to follow-up	Retained	p value
MATCH		N = 85 (45%)	N = 104 (55%)	
		Mean (SD)	Mean (SD)	
	Age	13.48 (0.93)	13.11 (0.62)	<0.01 ^a
	BMI	25.75 (7.21)	24.05 (5.64)	0.08 ^a
	BMI z-score	1.17 (1.11)	1.05 (1.04)	0.45 ^a
Control		N = 56 (32%)	N = 117 (68%)	
	Age	13.15 (0.56)	13.05 (0.52)	0.23 ^a
	BMI	22.32 (5.35)	23.95 (5.75)	0.07 ^a
	BMI z-score	0.65 (1.19)	1.05 (0.91)	0.03 ^a
		N (%)	N (%)	
MATCH	Sex			0.24 ^b
	Female	44 (51.8)	44 (42.3)	
	Male	41 (48.2)	60 (57.7)	
	Race			0.41 ^b
	Black	58 (68.2)	62 (59.6)	
	White	22 (25.9)	36 (34.6)	
	Other	5 (5.9)	6 (5.8)	
	Weight category			0.07 ^b
	Healthy weight	36 (42.4)	40 (38.5)	
	Obese	36 (42.4)	33 (31.7)	
	Overweight	13 (15.3)	30 (28.8)	
	Underweight	0 (0.0)	1 (1.0)	
Control	Sex			0.42 ^b
	Female	25 (44.6)	60 (51.3)	
	Male	31 (55.4)	57 (48.7)	
	Race			<0.01 ^b
	Black	46 (82.1)	81 (69.2)	
	White	10 (17.9)	15 (12.8)	
	Other	0 (0.0)	21 (18.0)	
	Weight category			0.15 ^b
	Healthy weight	34 (60.7)	58 (49.6)	
	Obese	15 (26.8)	36 (30.8)	
	Overweight	6 (10.7)	23 (19.7)	
	Underweight	1 (1.8)	0 (0.00)	

^aTwo-sample t test.^bFisher's exact test.

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greater proportion of low socioeconomic status. Although not significantly different, the weight status of the control group was overall healthier, with higher percentage of students at healthy weight and lower overweight/obese.

Comparison of Lost versus Retained Participants

Characteristics of participants lost to follow-up versus retained in both the MATCH (55% retained) and control (68% retained) groups are shown in Table 2. In MATCH there were no significant differences in BMI measures, sex, race, or weight category distribution, but retained participants were slightly younger. In control, there were no significant differences in age, sex, or weight category distribution, but the retained group had higher baseline BMI measures and slightly more white and fewer black participants.

Changes in BMI Measures

In looking at both groups four years after the intervention, the MATCH group showed a significantly lower increase in BMI on average (mean change MATCH 2.66 versus control 4.03; $p=0.01$) and a significant decrease in zBMI compared to control (mean change MATCH -0.15 versus control 0.04; $p=0.02$) (Table 3). All subgroups showed significant increases in mean BMI, as would be expected when growing through adolescence. However, the MATCH group trended towards lower increases for every subgroup and demonstrated significantly lower increase in mean BMI in the all overweight (combined overweight + obese) subgroup (mean change MATCH 2.82 versus control 4.89; $p=0.03$). MATCH also showed significantly lower increase in the male subgroup, with a

Table 3. Changes at Four-Year Follow-Up in BMI and BMI Z-Score (for Age and Gender), MATCH Intervention, and Control Groups

Group		MATCH intervention			Control			Between groups p value ^b
		N	Δ Mean (SD)	p value ^a	N	Δ Mean (SD)	p value ^a	
All	BMI	104	2.66 (3.60)	<0.01	117	4.03 (3.61)	<0.01	0.01
	BMI z-score	103	-0.15 (0.60)	0.01	117	0.04 (0.52)	0.43	0.02
Weight category								
Healthy weight	BMI	40	2.40 (1.95)	<0.01	58	3.16 (2.39)	<0.01	0.10
	BMI z-score	40	-0.13 (0.56)	0.15	58	0.05 (0.60)	0.51	0.11
Overweight	BMI	30	2.57 (4.71)	0.01	23	4.31 (3.53)	<0.01	0.08
	BMI z-score	30	-0.28 (0.76)	0.05	23	0.06 (0.54)	0.60	0.03
Obese	BMI	33	3.05 (4.08)	<0.01	36	5.26 (4.81)	<0.01	0.20
	BMI z-score	32	-0.06 (0.44)	0.45	36	0.001 (0.36)	0.99	0.75
All overweight	BMI	63	2.82 (4.36)	<0.01	59	4.89 (4.35)	<0.01	0.03
	BMI z-score	62	-0.17 (0.62)	0.04	59	0.06 (0.54)	0.67	0.12
Sex								
Male	BMI	60	2.13 (3.02)	<0.01	57	3.32 (2.93)	<0.01	0.04
	BMI z-score	60	-0.18 (0.66)	0.04	57	-0.002 (0.55)	0.97	0.13
Female	BMI	44	3.37 (4.19)	<0.01	60	4.71 (4.06)	<0.01	0.17
	BMI z-score	43	-0.10 (0.50)	0.20	60	0.08 (0.49)	0.23	0.08
Race/ethnicity								
White	BMI	36	1.63 (2.89)	<0.01	15	3.19 (2.52)	<0.01	0.08
	BMI z-score	36	-0.26 (0.71)	0.04	15	-0.05 (0.52)	0.74	0.30
Black	BMI	62	3.32 (3.93)	<0.01	81	4.04 (3.30)	<0.01	0.17
	BMI z-score	61	-0.07 (0.52)	0.28	81	0.04 (0.51)	0.45	0.18
Other	BMI	6	1.92 (2.33)	0.10	21	4.59 (5.15)	<0.01	0.39
	BMI z-score	6	-0.23 (0.53)	0.34	21	0.08 (0.55)	0.53	0.23

^aMatched pairs t test for significance of changes.

^bBased on multiple regression controlling for the baseline values and sex effect (comparisons by sex controlled for baseline values only).

IQR, interquartile range; MATCH, Motivating Adolescents with Technology to CHOOSE Health.

Table 4. Comparisons of Overall Trend in BMI Z-Score between MATCH and Control Schools^a

Weight category	MATCH		Control		MATCH vs. control p value
	Slope ^b (standard error)	p value ^c	Slope ^d (standard error)	p value ^c	
All	-0.0029 (0.0011)	0.01	0.0009 (0.0010)	0.38	0.01 ^d
Healthy weight	-0.0023 (0.0019)	0.21	0.0009 (0.0016)	0.55	0.18
Overweight	-0.0062 (0.0025)	0.01	0.0017 (0.0029)	0.55	0.04 ^c
Obese	-0.0016 (0.0014)	0.23	0.0002 (0.0013)	0.90	0.34
All overweight	-0.0036 (0.0013)	0.01	0.0009 (0.0013)	0.46	0.01 ^c

^aEstimated using linear mixed models based on data from pre-intervention, postintervention, and four-year follow-up.

^bThe slope can be interpreted as average change per month.

^cFor testing whether the slope is significantly different from 0.

^dStatistically significant difference in slopes between the two groups.

mean increase of 2.13 (SD=3.02) compared to 3.32 (SD=2.93) in control; $p=0.04$. In looking at zBMI changes, the MATCH group showed significant or near significant decreases in the overweight, all overweight, male, and white subgroups; while the control groups had no significant changes and trended towards increases in zBMI in nearly all subgroups. Using multiple regression models controlling for baseline zBMI and sex, the between-group difference between the MATCH and control groups in mean changes in zBMI was statistically significant for the overweight subgroup.

Rates of Change in BMI Z-Score

Although normal growth and changes in zBMI over time occur in nonlinear fashion, particularly during adolescence, when looking at repeated measures over time, overall trends can be assessed by linear mixed models. For this analysis we included measures at the pre-, immediately post-, and after-four-year time points to compare overall trends between groups. A comparison of the overall trend over time in zBMI between MATCH and control groups by weight category and using linear mixed models is shown in Table 4. For all weight categories, the MATCH group had decreasing trends, with significant decreases in the all, overweight, and all overweight groups. Although not statistically significant, the control groups had increasing trends in these groups. Due to these differences, the control group as a whole was statistically different from the MATCH group. As an example, in the overweight subgroup, in MATCH, the zBMI decreased by a mean (standard error) rate per month of 0.0062 (0.0025), $p=0.01$; while it showed no significant change in control: 0.0017 (0.0029), $p=0.55$; between-groups $p=0.04$.

Weight Categories

The percentage of participants in each weight category changed significantly after four years in the MATCH group

(Fig. 1), with the percentage healthy weight increasing (40.2% to 45.6%), overweight decreasing (22.8% to 18.5%), and obese also decreasing (36.5% to 31.1%), all with $p<0.01$. In comparison, in the control group the percent healthy weight decreased (53.2% to 47.9%, $p<0.01$), and there was no significant change in either overweight or obese. Looking at shifts between weight categories from baseline to follow-up (Table 5) provides the underlying detail to understand the changes seen in Fig 1. Using these numbers, the incidence of obesity in the MATCH group was 13% (5/30) compared to 39% (9/23) in control; and remission of overweight to healthy weight was 40% (12/30) in MATCH versus 26% (6/23) in control. Of those participants who were obese at baseline, the two groups were similar, remaining obese after four year, 81% (26/32) in MATCH and 81% (29/36) in control.

Self-Reported Health Habits

The Health Habits Questionnaire was completed by the majority of participants in both groups, 95% (98/104) MATCH and 77% (90/117) control (Table 6). There were no significant differences between the groups in the food/drink frequency consumed or hours per year for the following behaviors: sugar-free drinks, milk, physical activity, computer time (total or weekend), or TV time on the weekend. The MATCH group reported significantly fewer sweet drinks, snacks, and weekday TV time, however, compared to the control group. If the differences between groups are converted into per week quantities, the MATCH group consumed sweet drinks and snacks at a frequency below that of control: 8.8 fewer for sweet drinks and 9.5 fewer per week for snacks, and watched 1.9 fewer hours weekday TV per week.

Discussion

Despite prior studies of school-based interventions in adolescents showing mixed results for BMI changes and no

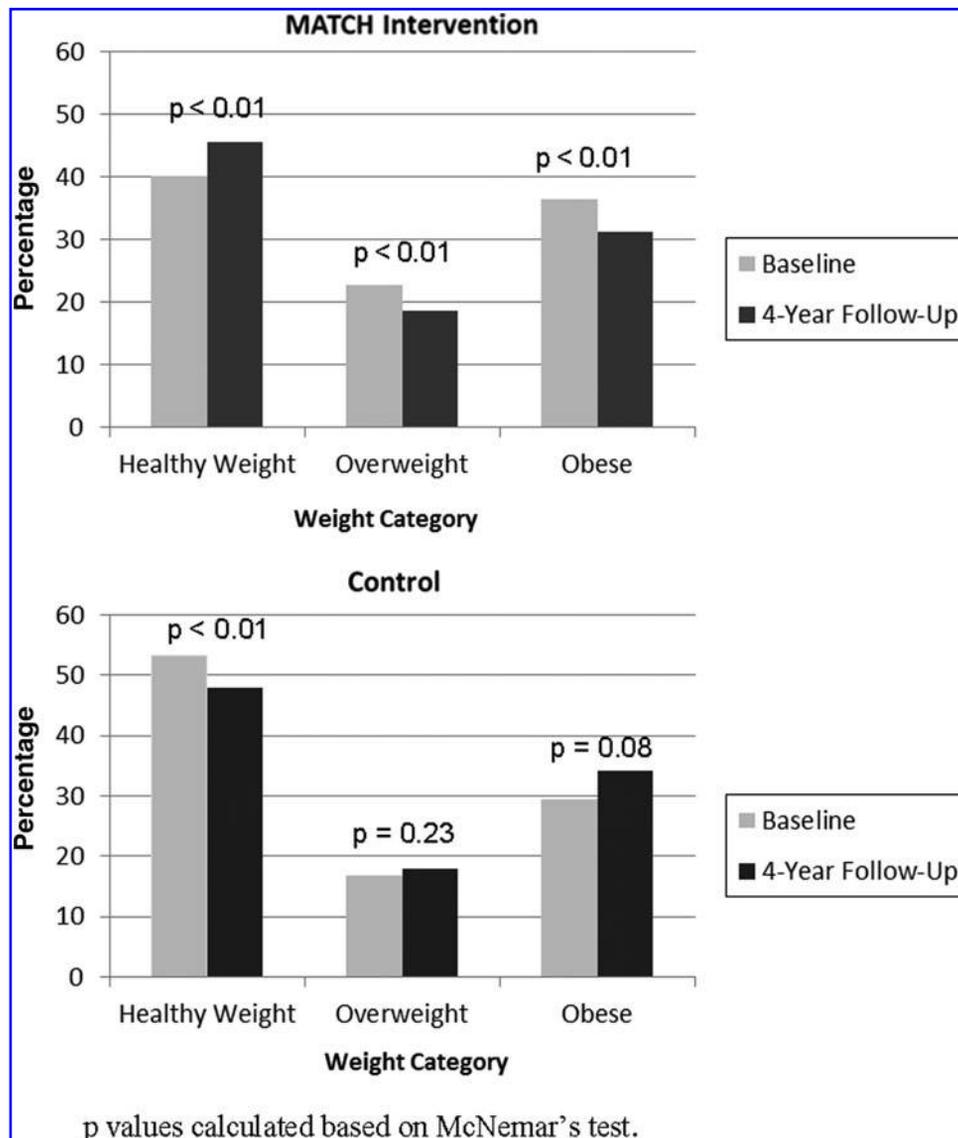


Figure 1. Percentage of all participants in each weight category at baseline and those remeasured at four-year follow-up; MATCH intervention and control groups.

prior studies reporting long-term results, this study of the MATCH intervention offers promising evidence that adolescents at high risk for obesity can change to a healthier weight trajectory *four years* after a time-limited, targeted intervention in seventh grade. The findings of the cross-sectional assessment of self-reported health behaviors in 11th grade comparing MATCH participants to control support the BMI results, in that the specific behaviors with significant differences between groups are behaviors targeted in the MATCH curriculum. No prior school-based intervention has demonstrated sustained success in prevention of overweight and obesity. Of note, the study is set in rural eastern North Carolina, a region without other targeted obesity prevention efforts during this time that could explain the results. Although North Carolina has ongoing statewide obesity prevention efforts, there were no efforts during this period for adolescents in the involved region or schools, and the chance that these results oc-

curred from population-level behavioral trends is extremely unlikely in this geographical region. In addition, although both involved school districts were gradually enacting changes in the school nutritional environment and offerings (such as changes to vending and snack availability) beginning during the study period, no changes were enacted to a greater extent in intervention schools than in control schools that could have explained results.

Although it is not possible in this small study to determine which intervention components led to the observed results, there are several aspects of MATCH that are unique and likely have contributed to its success. These characteristics are that the intervention is intensive, individualized, targeted, and embedded within the curriculum.

Intensive. MATCH teachers taught 20+ lessons over a 16-week period in seventh grade in contrast to Planet Health which was spread over three years, or the HEALTHY study

Table 5. Shifts in Weight Categories (Frequency and Percentage) at Baseline and Four-Year Follow-Up, MATCH versus Control Groups

	Baseline	Four-Year Follow-Up N (%)				
	Weight category ^a	Underweight	Healthy weight	Overweight	Obese	Total
MATCH intervention	Underweight	1 (100)	0 (0)	0 (0)	0 (0)	1
	Healthy weight	3 (8)	33 (83)	3 (8)	1 (3)	40
	Overweight	1 (3)	12 (40)	12 (40)	5 (13)	30
	Obese	0 (0)	2 (6)	4 (13)	26 (81)	32
	Total	5	47	19	32	103
Control	Underweight	0 -	0 -	0 -	0 -	0
	Healthy weight	0	49 (85)	7 (12)	2 (3)	58
	Overweight	0	6 (26)	8 (35)	9 (39)	23
	Obese	0	1 (3)	6 (17)	29 (81)	36
	Total	0	56	21	30	117

^aWeight category determined by CDC definitions based on BMI percentile for age and sex: underweight < fifth percentile; healthy weight 5 – < 85th percentile; overweight 85 – < 95th percentile; obese ≥95th percentile.

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that involved school environmental changes and efforts led by students and nonschool personnel, which took place over one year.^{12,14}

Individualized. MATCH lessons are individualized by using the student's data (BMI that is plotted and weight category determined by the student, fitness test results, and health behaviors) to set goals and create action plans, and behaviors are reassessed and goals adjusted over time.

Targeted. Lessons cover broad health and nutrition content, but behavior changes specifically targeted are those that are most likely to be within the adolescent's

control, including beverage choice (e.g., sugar-free beverage taste test lab); restaurant meal selection (e.g., comparison of nutritional content of student's selected meals); and leisure activities (e.g., tracking of sedentary activities after school).

Embedded. By embedding all lessons and activities within the curriculum, teachers must teach the lessons in order to meet state or national objectives, so there is greater incentive to complete program components. In addition, the natural accountability of the school setting with the expectation of learning, role modeling by school staff, and

Table 6. Health Behavior Summary Responses at Follow-Up in 2013 from a Modified Beverage and Snack Questionnaire: MATCH Intervention versus Control Groups, Mean Frequency Consumed or Hours per Year

Health behavior	MATCH intervention n = 98	Control n = 90	p value
	Mean (SD) frequency consumed or hours per year		
Total sweet drinks	1004 (1119)	1460 (1321)	0.003
Total sugar-free drinks	268 (560)	289 (486)	0.550
Milk	303 (405)	306 (553)	0.240
Total snacks	1284 (1539)	1777 (2002)	0.010
Physical activity hours	154 (120)	167 (130)	0.530
TV hours weekdays	592 (371)	693 (365)	0.040
Total computer hours	443 (387)	498 (404)	0.290
TV hours weekend	277 (167)	275 (161)	0.860
Computer hours weekend	221 (158)	199 (169)	0.240

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test/assignment/grade components all act to promote student engagement and increased learning; and positive peer pressure can result. While we believe these aspects of MATCH are what make it unique and likely contribute to its success, future large controlled studies are needed to confirm effectiveness and explore key factors most important for effect and replication.

Limitations and Strengths

The study has several limitations. The study is small, with only three schools from rural, low-resource areas; thus results should be interpreted with caution and may not be generalizable to other regions or groups. Group assignment was not random, which could result in some undetected underlying biases or confounding factors contributing to the observed results.

Specifically, there were significant baseline differences between groups, with the control group from a school comprised of substantially more students of low socioeconomic status. And at follow-up in the control group, retained participants represented more white students and those with a lower baseline BMI. The overall retention rate was relatively low for a cohort study, and lower in the MATCH group than control (55% in MATCH and 68% in control; however, 75% of MATCH participants still enrolled in school were retained). The greater participation in control likely resulted from our offering a small incentive for measurement which was not provided for the MATCH group. Overall retention was good, and there are no identifiable reasons to believe the dropouts would result in systematic bias, although it is possible that MATCH participants would have been less likely to participate in follow-up measures if they perceived themselves as unsuccessful; and participants may have overreported “desired” behaviors. However, the MATCH and control groups had similar baseline weight status for those retained, which makes the two groups more comparable. Finally, although the inclusion of health behavior results supports the study’s findings, the use of a cross-sectional and self-reported assessment four years post-intervention is not as strong as an optimal objective pre- / postassessment with tools designed to assess individual behavior change. Additionally, the specific instrument used to assess health behaviors did not specify or quantify servings of foods queried, and so results should be interpreted for general trends and cannot be used for conclusions about intake in more detail. Finally, although we are unaware of other factors, we did not assess for factors that could have affected BMI in the participating schools or otherwise confounded our results.

The study also has notable strengths. The MATCH intervention was designed to fit within existing curricula and require limited additional resources, making it practical and feasible for replication. The study design with long-term follow-up to age 17 years in a high-risk cohort is unprecedented in prior school-based interventions. The use of appropriate analytical techniques to control for group differences increases the validity of the observed changes

in BMI measures and differences between groups. Finally, the inclusion of an assessment of health behaviors offers additional evidence to support the greater improvements in weight status demonstrated in the MATCH group. The identified differences in health behaviors in the MATCH group represent specific behaviors targeted by the MATCH curricula and offer a potential underlying mechanism for the observed BMI changes.

Conclusions

Given today’s pervasive obesogenic environment, it is critical that adolescents learn the knowledge and skills necessary to make healthy choices within their environment. Despite prior school-based efforts having mixed BMI results, results of the MATCH program offer convincing evidence that young adolescents at high risk for obesity can change their weight trajectory with an intensive, targeted program provided in the school setting. Given its design is practical and feasible, the MATCH approach warrants further study as a promising approach to preventing obesity in adolescents.

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Author Disclosure Statement

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References

1. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA* 2014;311:806–814.
2. Institute of Medicine Committee on Accelerating Progress in Obesity Prevention; Glickman D. Accelerating progress in obesity prevention: Solving the weight of the nation. National Academies Press, 2012.
3. Kumanyika SK, Parker L, Sim LJ. Bridging the evidence gap in obesity prevention: A framework to inform decision making. Institute of Medicine, 2010.

4. Waters E, de Silva Sanigorski A, Hall BJ, et al. Interventions for preventing obesity in children. *Cochrane Database* 2011;1–224.
5. Guerra PH, Nobre MR, da Silveria JA, et al. School-based physical activity and nutritional education interventions on body mass index: A meta-analysis of randomised community trials — Project PANE. *Prev Med* 2014;61:81–89.
6. Sobol-Goldberg S, Rabinowitz J, Gross R. School-based obesity prevention programs: A meta-analysis of randomized controlled trials. *Obesity* 2013;21:2422–2428.
7. Coordinated Approach to Child Health. catchusa.org/index.html Last accessed October 27, 2014.
8. Luepker RV, Perry CL, McKinlay SM, et al. Outcomes of a field trial to improve children's dietary patterns and physical activity. Child and Adolescent Trial for Cardiovascular Health. CATCH collaborative group. *JAMA* 1996;275:768–776.
9. Nader PR, Stone EJ, Lytle LA, et al. Three-year maintenance of improved diet and physical activity: The CATCH cohort. Child and Adolescent Trial for Cardiovascular Health. *Arch Pediatr Adolesc Med* 1999;153:695–704.
10. Coleman KJ, Sanchez MA, et al. Prevention of the epidemic increase in child risk of overweight in low-income schools: The El Paso coordinated approach to child health. *Arch Pediatr Adolesc Med* 2005;159:217–222.
11. Hoelscher DM, Ranjit N, et al. Reductions in child obesity among disadvantaged school children with community involvement: The Travis County CATCH Trial. *Obesity* 2010;18:S36–S44.
12. Gortmaker SL, 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.
13. Peterson GJ, Greaney ML, Austin SB, et al. Three-year improvements in weight status and weight-related behaviors in middle school students: The Healthy Choices study. *PLoS ONE* 2015;10:e0134470.
14. HEALTHY Study Group; Foster GD, Linder B, et al. A school-based intervention for diabetes risk reduction. *N Engl J Med* 2010;363:443–453.
15. Webber LS, Catellier DJ, Lytle LA, et al. Promoting physical activity in middle school girls: Trial of activity for adolescent girls. *Am J Prev Med* 2008;34:173–184.
16. Flores R. Dance for health: Improving fitness in African American and Hispanic adolescents. *Public Health Rep* 1995;110:189–193.
17. Neumark-Sztainer DR, Friend SE, Flattum CF, et al. New moves: Preventing weight-related problems in adolescent girls: A group-randomized study. *Am J Prev Med* 2010;39:421–432.
18. Contento IR, Koch PA, Lee H, et al. Adolescents demonstrate improvement in obesity risk behaviors after completion of choice, control & change: A curriculum addressing personal agency and autonomous motivation. *J Am Diet Assoc* 2010;110:1830–1839.
19. Lazorick S, Crawford Y, Gilbird A, et al. Long term obesity prevention and the Motivating Adolescents with Technology to CHOOSE Health™ (MATCH) program. *Child Obes* 2014;10:25–33.
20. Lazorick S, Hardison GT, Esserman DA, et al. Sustained body mass index changes one and two years post MATCH: A school-based wellness intervention in adolescents. *Child Obes* 2011;7:372–378.
21. Lazorick S, Fang X, Crawford Y, et al. Improved body mass index measures following a middle school-based obesity intervention: The MATCH program. *J Sch Health* 2014;85:680–687.
22. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC Growth Charts: United States. Hyattsville, MD: National Center for Health Statistics, 2000.
23. Neuhauser ML, Lilley S, Lund A, et al. Development and validation of a beverage and snack questionnaire for use in evaluation of school nutrition policies. *J Am Diet Assoc* 2009;109:1587–1592.
24. CDC: Youth Risk Behavior Survey Fact Sheets. CDC, 2011. www.cdc.gov/healthyyouth/yrbs/factsheets/index.htm#2. Last accessed May 26, 2014.

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