Relationships between the family environment and school-based obesity prevention efforts: can school programs help adolescents who are most in need?

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Abstract

Identifying factors that contribute to students' behavior and weight improvements during school-based obesity prevention interventions is critical for the development of effective programs. The current study aims to determine whether the support and resources that adolescent girls received from their families were associated with improvements in physical activity (PA), television use, dietary intake, body mass index (BMI) and body composition during participation in New Moves, a school-based intervention to prevent obesity and other weight-related problems. Adolescent girls in the intervention condition of New Moves ($n = 135$), and one parent of each girl, were included in the current analysis. At baseline, parents completed surveys assessing the family environment. At baseline and follow-up, 9–12 months later, girls' behaviors were self-reported, height and weight were measured by study staff and body fat was assessed using dual-energy X-ray absorptiometry. Results showed few associations between family environment factors and girls' likelihood of improving behavior, BMI or body composition. These findings suggest that in general, school-based interventions offer similar opportunities for adolescent girls to improve their PA, dietary intake, and weight, regardless of family support.

Introduction

Schools provide a unique opportunity for addressing behaviors that increase children's and adolescents' risk for obesity. Almost all youth spend a significant number of hours at school each day. Schools also have the facilities for classroom- and physical activity (PA)-based lessons, provide opportunities for policy or environmental changes, such as modifying cafeteria or vending machine food options, and employ personnel trained in education who are able to implement obesity prevention curricula. School-based interventions may also be particularly useful for accessing adolescents from lower socioeconomic status backgrounds or racial/ethnic groups, who are at particularly high risk for obesity [1]. Despite these numerous benefits of partnering with schools to provide obesity prevention programming, school-based interventions for adolescents have been less successful than anticipated at improving participants' weight status or participation in weight-related behaviors, such as PA and healthy dietary intake [2,3,4,5,6].

Recent research has identified several factors in the family environment that play a role in youth's weight-related behaviors and weight status. These family characteristics include parental modeling of and support for PA, the frequency of family meals and resources available in the home including healthy foods [7,8,9,10]. In light of the importance of the family environment in establishing and sustaining adolescents' weight-related behaviors, an

important question is whether interventions implemented in schools have the ability to improve the weight and weight-related behaviors of all adolescents, even those who do not receive support or resources for healthful behavior from their families.

To our knowledge, only one study has examined whether adolescents' family characteristics affect the likelihood that they can improve their weight-related behavior via participation in a school-based obesity prevention program. Martens *et al.* [11] examined associations between family environment factors including parenting style, parental food purchasing habits, family food rules, and home food availability and improvement in fruit and low-fat snack consumption among Dutch adolescents during their participation in a school-based dietary intervention [12]. No associations were observed between any of the family environment factors and students' change in fruit and snack consumption. The authors concluded that the lack of relationships between the family environment and adolescents' behavior change suggests that all adolescents who participate in school-based interventions have the potential to improve their behavior, regardless of whether their family environment supports healthful behavior.

To contribute to this body of research, the current study examines whether factors in adolescent girls' family environments were associated with changes in girls' weight and weight-related behaviors during participation in New Moves, a school-based intervention study designed to prevent weight-related problems via a girls-only physical education class and supplementary school-based activities. New Moves was effective in improving specific weight-related behaviors including decreasing the time girls spent engaging in sedentary behavior and decreasing girls' use of unhealthy weight control behaviors [13]. Findings from the current study can be used to inform future school-based interventions aimed at preventing obesity and other weight-related problems. If evidence suggests that youth whose families are not able to provide support for healthful behavior do not benefit from school-based obesity prevention programs, then novel strategies are needed to reach these youth. These strategies

may include revamping the methods currently used by school-based interventions, identifying alternative settings through which to access youth and implementing more broad-reaching policy and programmatic efforts that modify the food and PA environments of communities. In contrast, if school-based programs have similar impacts on youth from both more and less supportive families or have greater impact on those from less supportive families, there is strong justification for continuing to reach out to high-risk adolescents via school-based programs.

Methods

Study design

Subjects were high school girls (mean age = 15.7, SD = 1.1) who participated in the active intervention arm of New Moves, a school-based intervention aimed at preventing weight-related problems [13]. One parent of each girl was also invited to participate in the study. A total of 12 schools participated in the New Moves trial, with six schools randomly selected to offer the active intervention and six randomly selected to serve as comparison schools. Girls in the intervention and comparison schools were invited to register for an all-girls physical education class as an alternative to the regular coeducational class. Recruitment materials were designed to appeal to overweight, obese and/or inactive girls interested in healthy weight management. A description of the class was included in the schools' course catalogs and teachers and guidance counselors were encouraged to identify girls who would particularly benefit from the class. Additionally, posters and flyers about the class were displayed at schools. To assess predictors of change during participation in the intervention, 180 girls from the six schools that offered the active intervention were included in the current study. The majority (75%) of the 180 girls from the six intervention schools had a parent or guardian complete a survey about their family environment, resulting in an analytic sample of 135 parent/girl dyads. Girls and their parents completed a baseline assessment

before participation in the New Moves study. Girls participated in a follow-up assessment that occurred at the end of the school year in which they participated in New Moves, between 9 and 12 months after they completed baseline data collection. Most girls completed study measures at the University of Minnesota's General Clinical Research Center and a small number completed the study measures at their school if they were unable to leave during the school day. An invitation for parents to participate in the study coupled with a parent survey was mailed to the girls' homes after parents provided consent for their daughter's participation in New Moves. The study was approved by the University of Minnesota's Institutional Review Board and by each participating school district. Girls and parents provided consent/assent for their participation in the study.

Study sample

The study sample was racially/ethnically diverse with 33% of girls reporting that they were white, 27% African-American/black, 11% Hispanic, 17% Asian and 12% of mixed race or another racial/ethnic group. There was also a diverse range of parents' educational attainment with 26% of parents having not completed high school, 22% having only a high school diploma, 31% having attended some college and 21% having completed college and/or have post-graduate training. About half (53%) of girls were normal weight [age- and gender-adjusted body mass index (BMI) <85th percentile], while 16% were overweight (85th $\geqslant$ BMI percentile <95th) and 32% were obese (BMI percentile $\geqslant$ 95th).

Description of New Moves intervention

The intervention was delivered primarily through a girls-only physical education class during which girls participated in PA lessons that focused on life-long activity within a non-competitive environment, nutrition education sessions that stressed a non-dieting healthy eating approach to healthy weight management and social support sessions that focused on enhancing self-esteem and body image. Additional components of New Moves that were designed to complement the skills gained

during the classroom components included individual counseling sessions and maintenance sessions where behavioral messages were reinforced after the completion of the physical education class. There were minimal parental outreach activities including postcards sent to the girls' homes with the intervention's behavioral messages and a single 2-hour parent/daughter event, which 21% of girls had a parent participate in. Girls reported very high satisfaction with the intervention, and the majority of girls participated in most or all intervention activities. In the comparison schools, girls participated in an all-girls physical education class without the supplementary activities [13].

Description of measures

Family environment measures

Survey items completed by parents to assess parental modeling of and support for girls' PA, television use, soft drink intake and fruit and vegetable intake, as well as home resources associated with these behaviors, are described in Table I. Selection of constructs to assess in the weight-related family environment was guided by Social Cognitive Theory [24, 25], as well as previous research that identified components of the family environment associated with youths' weight and weight-related behaviors. A thorough review of the literature was conducted to identify suitable tools that had been tested for psychometric properties. In cases in which suitable items were not located, they were developed for this study. When psychometric information was available from previous studies, it is included in Table I. Additionally, survey items were pilot tested during the current study for applicability and comprehension by 10 parents of adolescents resulting in slight modifications of some survey items to improve item comprehension.

In addition to the individual survey items/scales, a 'Healthy Family Environment' index score was created to summarize the supportive qualities of girls' family environments. The index was comprised of 15 family environment characteristics [parents' total PA and soft drinks available in the home were excluded because of their overlap with

Table I. *New Moves parent survey family environment constructs and measures*

Family environment constructs and psychometric information (when available)	Survey item	Descriptive statistics
PA-related family environment		
Home PA resources	Please indicate which items you have in your home, yard, or apartment complex that are available to your daughter: a. Stationary aerobic equipment (bicycle, treadmill, etc.) b. Bicycle c. Dog to walk d. Weight lifting equipment (free weights, Nautilus, etc.) e. Exercise workout videotapes or DVDs f. In-line, roller, or ice skates g. Sports equipment (balls, racquets, jump ropes, hula hoops) h. Skis or snowboard i. Stretching or yoga equipment Response options included 'Yes' and 'No' [14]	Mean = 3.5, items. SD = 2.2
Parental total PA and moderate-to-vigorous physical activity (MVPA), 2-week test–retest, $r = 0.48$–0.94	In the past week (7 days), how many HOURS did you spend doing the following activities? a. Strenuous exercise (heart beats rapidly) examples: biking fast, aerobic dancing, running, jogging, swimming laps, rollerblading, skating, tennis, cross-country skiing, soccer, basketball b. Moderate exercise (not exhausting) examples: walking quickly, dancing, baseball/softball, gymnastics, easy bicycling, volleyball, strength training c. Mild exercise (little effort) examples: walking slowly, bowling, yoga, stretching muscles, household chores Nine response options ranged from 'none' to '7 or more hours' [15]	Total PA: mean = 6.2 hours/week SD = 4.9 MVPA: mean = 3.2 hours/week, SD = 3.2
Family support for PA, Cronbach's $\alpha = 0.78$, 1-week test–retest, $r = 0.81$	During a typical week, how often have you or another member of your household: a. encouraged your daughter to do physical activities or play sports? b. done a PA or played sports with your daughter? c. provided transportation to a place where your daughter can do physical activities or play sports? d. watched your daughter participate in physical activities or sports? e. told your daughter that she was doing well in physical activities or sports Five response options ranged from 'Never' (coded as 1) to 'Every day' (coded as 5) [16]	Mean = 12.9, SD = 4.9

Table I. *Continued*

Family environment constructs and psychometric information (when available)	Survey item	Descriptive statistics
TV-related family environment Media resources	Please indicate which of the following you have in your home: a. Pay television (cable, satellite, etc.) b. Video/DVD player c. Electronic game (Nintendo, Playstation, etc.) d. Computer e. Internet access Response options included 'Yes' and 'No' [17]	Mean = 3.9 resources, SD = 1.2
Number of televisions in home 2-week test–retest, $r = 0.99$	How many televisions do you have in your home? Response options ranged from '0' to '4 or more' [17]	Mean = 2.9 televisions, SD = 1.0
Television in bedroom[a]	Do you have a television in the room where you sleep? Response options included 'Yes' and 'No' [18]	Mean = 44.8%, SD = 49.8%
Parental television use	On a typical weekday (Monday through Friday), how many hours do you spend doing the following? a. Watching TV/Videos/DVDs On a typical weekend day (Saturday and Sunday), how many hours do you spend doing the following? a. Watching TV/Videos/DVDs Seven response options ranged from '0 hour' to '5+ hour' [4]	Mean = 16.9 hours/week, SD = 10.8
Familial encouragement to limit television use	During a typical week, how often have you or another member of your household encouraged your daughter to watch less TV? Five response options ranged from 'Never' (coded as 1) to 'Every day' (coded as 5)	Mean = 3.04, SD = 1.4
Dietary intake-related family environment		
Healthy food available at home Cronbach's $\alpha = 0.632$-week test–retest, $r = 0.54–0.59$	In the past 7 days: a. vegetables were available in my home b. vegetables were served at meals in my home c. fruit was available in my home d. fruit was served at meals in my home Four response options ranged from 'Never' (coded as 1) to 'Always' (coded as 4) [19]	Mean = 11.8, SD = 2.7

Table I. *Continued*

Family environment constructs and psychometric information (when available)	Survey item	Descriptive statistics
Unhealthy food available at home including home soft drink availability Cronbach's α = 0.80 2-week test–retest, r = 0.55–0.72	In the past 7 days: a. regular soda pop or other sugar-sweetened drinks were available in my home b. regular soda pop or other sugar-sweetened drinks were served at meals in my home c. chips or other salty snacks were available in my home d. candy was available in my home Four response options ranged from 'Never' to 'Always' [19]	Mean = 9.14, SD = 2.6
Parental soft drink intake	Thinking back over the PAST WEEK, how often did you drink regular soda pop (not diet)? Seven response options ranged from 'None' to '5 or more servings'	Mean = 1.7 times/week, SD = 1.9
Parental fruit and vegetable intake	Thinking back over the PAST WEEK, how many servings of FRUIT did you USUALLY eat on a typical day? A serving would be a medium piece of fruit or ½ cup of fruit. Do not include fruit juice. Thinking back over the PAST WEEK, how many servings of VEGETABLES did you USUALLY eat on a typical day? A serving would be a ½ cup of cooked vegetables or 1 cup of raw vegetables. Do not include potatoes or French fries. Seven response options ranged from 'None' to '5 or more servings' [20]	Mean = 5.1 servings/day, SD = 2.8
Familial encouragement to eat healthy food, 2-week test–retest, r = 0.70	During a typical week, how often have you or another member of your household encouraged your daughter to eat healthy foods? Five response options ranged from 'Never' to 'Every day' [21]	Mean = 3.9, SD = 1.1
Family meal frequency, 2-week test–retest, r = 0.74	During the past 7 days, how many times did all, or most of your family living in your house eat a meal together? Nine response options ranged from '0 times' to 'More than 7 times' [22]	Mean = 4.6 meals/week, SD = 3.1
Fast food family meal frequency	During the past 7 days, how many times was a family meal purchased at a fast food restaurant (McDonalds, KFC, pizza, etc.) and eaten either at the restaurant or at home? Nine response options ranged from '0 times' to 'More than 7 times' [23]	Mean = 1.4 meals/week, SD = 1.5

[a]The question assessing the presence of a television in the adolescents' bedrooms was asked of the adolescent girls.

the moderate-to-vigorous physical activity (MVPA) and unhealthy home food availability measures] and families were given a point for each supportive family environment characteristic that they reported. Examples include parents participating in at least 2.5 hours of MVPA per week, girls not having a television in their bedroom and parents reporting that they 'usually' or 'always' had fruits and vegetables available in the home and served at meals. Possible scores ranged from 0 to 15. The mean score was 6.4 (SD = 2.3), with a minimum score of 0 and maximum score of 13.

PA and television use

Girls' total daily PA, MVPA and television (TV) use were assessed using the 3-Day Physical Activity Recall (3DPAR). The 3DPAR has been shown to be a valid measure of MVPA as compared to accelerometry [26] and among adolescent girls had a 2-day test–retest reliability of $r = 0.71$ and $r = 0.77$ for MVPA and vigorous activity, respectively [27]. Total PA was defined as a per day average of number of blocks for which any PA was reported. MVPA was defined as the per day average of number of blocks for which physical activities with a metabolic equivalent value greater than or equal to 3 were recorded [26, 28]. TV use was determined by the average daily number of blocks during which subjects reported participating in 'Watching TV or movies' [29].

Soft drink intake

Girls' intake of soft drinks was assessed with the following item: 'Over the past month, how often did you drink regular soda pop (not diet)?' Response options included the following: 'Never', 'Less than once a week', '1–2 times per week', '3–4 times per week', '5–6 times per week', '1 time per day', '2 times per day', '3 times per day', '4 times per day' and '5 or more times per day'. These response options were adapted from existing beverage intake items in the literature [30].

Fruit and vegetable intake

Girls' fruit and vegetable intake was assessed using the question, 'Thinking back over the past week,

how many servings of fruit did you usually eat on a typical day? A serving would be a medium piece of fruit. Do not include juice.' and 'Thinking back over the past week, how many servings of vegetables did you usually eat on a typical day? A serving would ½ cup of cooked vegetables or 1 cup of raw vegetables. Do not include potatoes or French fries.' Response options for both questions included: 'None', 'Less than 1 serving', '1 serving', '2 servings', '3 servings', '4 servings' and '5 or more servings' [19, 31].

Body mass index

Trained study staff measured girl's body weight using a Tanita Body Composition Analyzer TBF-300A (Tanita Corporation of America, Arlington Heights, IL, USA) and height using a portable stadiometer. BMI was calculated using the formula: weight in kilograms divided by height in meters squared.

Percent body fat

Girls' total percent body fat was assessed using a Lunar Prodigy dual-energy X-ray absorptiometry (DXA) apparatus (Lunar Radiation Corp., Madison, WI) at the University of Minnesota's General Clinical Research Center. The software for adults was used as the high school-aged girls participating in New Moves were all menstruating and close to full physical maturity. DXA has been found to be a highly valid and reliable measure of body fat [32,33,34].

Socio-demographic information was also collected. Girls reported their race/ethnicity, parents reported their highest level of educational attainment and girls' ages were calculated from their birth date as recorded on their consent form to the date which they completed baseline data collection.

Statistical analysis

To examine relationships between family environment factors and girls' successful behavior, BMI and percent body fat change, outcome-specific baseline-to-follow up change scores were calculated and divided into quintiles. Girls were classified as being

successful in modifying their PA, MVPA and fruit and vegetable intake if they were in the upper two quintiles of change (greatest increase), while girls were classified as unsuccessful if their change score was in the lower two quintiles. Similarly, girls were classified as being successful in modifying their TV use, soft drink intake, BMI and percent body fat if their change score fell in the lower two quintiles (greatest decrease), while girls were classified as unsuccessful if their change score was in the upper two quintiles. Girls whose change score was in the middle quintile for a specific outcome were excluded from further analyses of that outcome in order to reduce misclassification bias and to increase the contrast of successful compared to unsuccessful outcomes. Hierarchical logistic regression models were then developed to examine the relationship between the outcome-specific family environment characteristics and the odds of being successful at improving. To aid comparison across family environment variables, each variable was standardized to a mean of 0 and a SD of 1. Regression models were adjusted for girls' race/ethnicity, age and parental education. Models also included girls' baseline level of the outcome variable to account for the fact that girls whose behavior was less healthy and BMI and percent body fat were higher at the beginning of the study would have greater opportunity to improve. School was also included in the models as a random effect to account for potential clustering of behaviors among girls who attended school together [35]. Adjusted associations between girls' Healthy Family Environment index score and girls' odds of successfully reducing their BMI and percent body fat were examined using the same method.

Results

For each of the outcomes, girls who were classified as successfully improving began the study with less healthful behavior, higher BMI and greater percent body fat (Table II). For example, among the 55 girls who were categorized as successfully decreasing their soft drink intake, girls reported drinking soft drinks 1.54 times per day at baseline and their mean

intake decreased by 1.02 times per day, with a range of decrease between 0.11 and 5.29 times per day. In contrast, girls who were characterized as unsuccessfully decreasing their soft drink intake reported drinking soft drinks 0.31 times per day at baseline and drank soft drinks 0.38 times more often per day at follow-up (range: 0–5 times per day). For the outcome of BMI, girls characterized as successful either decreased or maintained their BMI over the course of the study, with a mean change of -0.96 BMI units (range: 0.11 to -3.55) while girls characterized as unsuccessful increased their BMI on average by 1.51 U (range: 0.52–4.58).

Few associations were observed between family environment factors and the odds of girls successfully improving their PA, TV use or soft drink or fruit and vegetable intake (Table III). Thus, in general, girls had similar ability to improve their weight-related behavior over the course of the intervention regardless of the degree of family support for healthful behavior that they received. However, having a family environment that encourages television use, including girls having a television in their bedroom and parents watching higher amounts of television, was associated with girls being less likely to decrease their television use during the study [odds ratio (OR) = 0.56, P = 0.036 and OR = 0.53, P = 0.026, respectively].

The large majority of the family environment factors were not associated with girls' successful BMI or body composition change (Table IV). However, girls with more TVs in the home had a greater odds of decreasing their BMI (OR = 1.64, P = .039), and girls with more media resources such as DVD players and cable television had a greater odds of decreasing their percent body fat (OR = 1.83, P = 0.035). Cross-sectionally at baseline, there was a significant inverse association between girls' Healthy Family Environment index score and their BMI ($\beta = -0.71$, P = 0.013) and percent body fat ($\beta = -0.91$, P = 0.024) after adjustment for socio-demographic characteristics. However, girls' index score was not associated with their odds of successfully decreasing their BMI (OR = 0.95, P = 0.614) or body composition (OR = 0.97, P = 0.76) during the intervention. These findings

Table II. *Baseline means and distribution of change among New Moves participants who were classified as successful and unsuccessful[a] at improving weight-related behaviors, BMI and/or percent body fat*

Outcome	n	Mean baseline value	Mean (SD) change	Range of change (min, max)
Total PA (30 min blocks/day)				
Successful participants	53	3.08	4.59 (2.68)	1.67, 13.33
Unsuccessful participants	53	7.16	−4.43 (2.43)	−11.67, −1.33
MVPA (30 min blocks/day)				
Successful participants	54	1.40	2.76 (2.31)	0.33, 12.67
Unsuccessful participants	53	5.08	−3.37 (2.05)	−9.00, −1.00
TV use (30 min blocks/day)				
Successful participants	54	4.73	−3.07 (2.81)	−12.33, −0.33
Unsuccessful participants	53	1.60	2.41 (2.10)	0.33, 12.67
Soft drink intake (times/day)				
Successful participants	55	1.54	−1.02 (1.29)	−0.11, −5.29
Unsuccessful participants	70	0.31	0.38 (0.84)	0.00, 5.00
Fruit and vegetable intake (servings/day)				
Successful participants	60	3.61	3.48 (1.44)	2.00, 9.50
Unsuccessful participants	54	5.55	−1.83 (2.21)	0.50, −8.00
BMI				
Successful participants	52	27.74	−0.96 (1.03)	0.11, −3.55
Unsuccessful participants	52	25.82	1.51 (0.83)	0.52, 4.58
Percent body fat				
Successful participants	45	39.08	−2.33 (1.94)	−0.29, −10.11
Unsuccessful participants	45	36.57	2.87 (1.43)	1.07, 8.05

[a]Success was determined by calculating girls' baseline to follow-up change for each outcome and dividing this change score into quintiles. For the outcomes of total PA, MVPA and fruit and vegetable intake, girls were categorized as successful if their change score was in the upper two quintiles (greatest increase) and were categorized as unsuccessful if their change score was in the lower two quintiles (greatest decrease). For the outcomes of TV use, soft drink intake, BMI and percent body fat, girls were categorized as successful if their change score was in the lower two quintiles (greatest decrease) and were categorized as unsuccessful if their change score was in the upper two quintiles (greatest increase).

support those from the examination of individual family environment characteristics suggesting that girls' successful improvements in weight and body composition were predominantly independent of the support and resources for healthful behavior that their family provided.

Discussion

The purpose of this study was to explore whether girls' family environments were associated with girls' likelihood of improving their weight-related behaviors, decreasing or maintaining their BMI and decreasing their percent body fat during the New Moves intervention. Girls who were categorized as successfully improving during the intervention began the study with less healthful behaviors and

higher BMI and percent body fat. As New Moves targeted girls who were overweight, obese and/or interested in participating in healthful weight management behaviors, we expected that the majority of girls would demonstrate some improvement in their behavior. The finding that the girls with less healthful behavior and higher BMI and percent body fat were more likely to make the recommended changes suggests that the messages and structure of the New Moves intervention, including an emphasis on non-competitive physical activities, sustainable dietary improvements and avoiding fad diets, appealed to girls who have not been receptive to traditional efforts to improve their weight and weight-related behavior. Future interventions working to prevent obesity among underserved adolescents may benefit from incorporating these messages and methods.

Table III. *Associations between family environment factors and girls' odds of successful behavior change during the New Moves intervention[a]*

	OR	95% CI	*P*
Outcome: girls' successful increase in total PA			
Home PA resources	1.70	0.85–3.41	0.130
Parental total PA	1.31	0.76–2.27	0.329
Family support for PA	1.38	0.73–2.60	0.321
Outcome: girls' successful increase in MVPA			
Home PA resources	1.84	0.90–3.76	0.092
Parental MVPA	1.60	0.82–3.12	0.171
Family support for PA	0.79	0.43–1.46	0.441
Outcome: girls' successful decrease in TV use			
Media resources	1.06	0.65–1.72	0.825
Number of TVs in home	1.10	0.68–1.77	0.708
TV in bedroom	0.56	0.33–0.96	0.036
Parental TV use	0.53	0.30–0.92	0.026
Familial encouragement to limit TV use	0.89	0.55–1.44	0.634
Outcome: girls' successful decrease in soft drink intake			
Healthy food available at home	1.12	0.70–1.80	0.625
Home soft drink availability	1.64	0.97–2.79	0.066
Parental soft drink intake	0.89	0.55–1.44	0.635
Familial encouragement to eat healthy foods	1.26	0.80–1.98	0.314
Family meal frequency	1.04	0.67–1.61	0.858
Fast food family meal frequency	0.88	0.60–1.30	0.511
Outcome: Girls' successful increase in fruit and vegetable intake			
Home availability of fruits and vegetables	1.38	0.86–2.23	0.182
Home availability of unhealthy food	0.93	0.57–1.53	0.776
Parental fruit and vegetable intake	1.37	0.84–2.23	0.205
Parental encouragement to eat healthy food	1.27	0.82–1.96	0.282
Family meal frequency	1.45	0.91–2.29	0.116
Fast food family meal frequency	1.25	0.84–1.85	0.271

[a]Girls' age, race/ethnicity, parental education and baseline value of outcome included as covariates in regression models. School included as random effect.

The lack of significant associations between the girls' family environments and successful behavior change in the present study demonstrates that for most outcomes, the high school girls who participated in New Moves were equally able to improve their behavior regardless of their family environment. The ability for girls to improve their behavior and weight independent of their family may be attributable to increasing self-sufficiency during adolescence [36], including the ability to purchase food and participate in physical activities independent of their parents. However, girls whose family environments promoted television use were less likely to successfully decrease their television use during the intervention. A potential explanation for this finding is that while adolescents can modify PA and dietary intake behaviors during the school day or after school when with friends, the majority of television use occurs at home. As parental television use and having a television in the bedroom has been strongly linked to adolescents' television use [17, 18, 37], it is reasonable to believe that girls had a difficult time deviating from the norms of their family environment and actively choosing not to watch television.

While the majority of family environment characteristics and families' scores on the Healthy Family Environment index were unrelated to girls' decreases in BMI and percent body fat, girls with more TVs in the home had greater odds of

Table IV. *Associations between family environment factors and girls' odds of successful BMI and body composition change during the New Moves intervention*[a]

	Outcome: girls' successful decrease in BMI			Outcome: girls' successful decrease in percent body fat		
	OR	95% CI	P	OR	95% CI	P
PA-related family environment						
Home PA resources	1.19	0.71–2.00	0.504	0.92	0.53–1.60	0.760
Parental total PA	1.24	0.81–1.89	0.323	1.43	0.93–2.20	0.106
Parental MVPA	1.12	0.73–1.72	0.587	1.45	0.94–2.24	0.095
Family support for PA	1.34	0.83–2.16	0.233	1.49	0.89–2.47	0.126
TV-related family environment						
Media resources	1.19	0.75–1.88	0.452	1.83	1.04–3.21	0.035
Number of TVs in home	1.64	1.03–2.62	0.039	1.36	0.82–2.27	0.223
Television in bedroom	1.30	0.83–2.05	0.250	1.64	0.97–2.77	0.066
Parental television use	1.39	0.89–2.16	0.148	1.16	0.74–1.84	0.514
Familial encouragement to limit television use	1.05	0.69–1.59	0.835	1.50	0.93–2.42	0.094
Dietary intake-related family Environment						
Healthy food available at home	1.02	0.63–1.65	0.947	0.85	0.52–1.41	0.533
Home availability of unhealthy food	1.13	0.68–1.90	0.632	1.20	0.71–2.03	0.486
Home soft drink availability	1.32	0.79–2.21	0.283	1.19	0.73–1.93	0.481
Parental soft drink intake	1.14	0.73–1.79	0.561	0.95	0.58–1.57	0.851
Parental fruit and vegetable intake	1.41	0.90–2.21	0.132	0.91	0.58–1.42	0.668
Familial encouragement to eat healthy food	1.08	0.68–1.72	0.730	1.24	0.75–2.03	0.382
Family meal frequency	0.82	0.52–1.28	0.381	0.79	0.48–1.28	0.329
Fast food family meal frequency	0.78	0.52–1.18	0.240	1.03	0.65–1.64	0.897

[a]Girls' age, race/ethnicity, parental education and baseline value of outcome included as covariates in regression models. School included as random effect.

successfully decreasing their BMI and girls with more media resources had greater odds of successfully decreasing their percent body fat. As these family environment factors were not associated with changes in girls' television use, the relationships between media resources/televisions in the home and BMI and body composition change were not mediated by girls' television use. Further exploration as to how having televisions and other media resources in the home may influence adolescents' changes in weight and body composition is warranted. A possible explanation for the finding is that these qualities of the family environment may be a proxy for a family environment characteristic not assessed in the current study.

Findings from the current study regarding the role of the family environment in girls' improvements in television use but not other study outcomes highlight the need for obesity prevention interventions to explicitly link their behavioral targets with specific intervention strategies. Since among the girls participating in New Moves excessive television use by parents and having a television in their bedrooms presented barriers to girls' decreasing their television use, future interventions aiming to reduce television among adolescents

would likely benefit from developing family-focused intervention activities that include specific suggestions on how parents can reduce their own television use and the importance of removing televisions from adolescents' bedrooms. This clear focus on a limited number of goals for families allows for the creation of intensive intervention activities that can be less of a burden than previous family-focused activities that addressed a number of family environment characteristics and/or required an extensive time commitment by parents [2,38,39,40].

Strengths of the current study include the use of a longitudinal study design, expanding the findings of previous cross-sectional studies to examine temporal associations between the family environment and changes in adolescents' behavior and weight. Additionally, the study population was racially/ethnically and socio-economically diverse, and girls were either currently overweight or obese or at high risk for obesity due to a sedentary lifestyle. Understanding how to design interventions to improve the risk for obesity and other weight-related problems of girls such as these is essential. A limitation of this study is that the intervention and corresponding evaluations were conducted over one school year. A longer follow-up period would be informative to determine whether girls were able to sustain the improvements that they made while participating in the intervention and whether the family environment plays a role in adolescents' maintenance of improvements in health behavior. Additionally, as the family environment was assessed at baseline, changes in girls' family environments during the course of the year were not captured. However, in light of the minimal parent outreach during New Moves, and previous school-based studies' limited success in modifying adolescents' family environments [41], significant changes in the family environment due to girls' participation in the intervention are unlikely.

Physical inactivity, poor dietary intake and overweight and obesity among adolescent girls are major public health concerns [42]. Thus far, few interventions have been successful at improving healthful behavior and reducing the prevalence of obesity among this population [2]. In light of the limited

resources to implement health promotion programming, identifying social, environmental and personal characteristics that contribute to successful behavior change is essential. Results from the current study provide preliminary evidence that adolescent girls are equally capable of improving their PA, dietary intake and weight during participation in school-based interventions, regardless of their family environment. Thus, interventions that access adolescents via their school have the potential to provide the resources and support that girls may not receive from their families in order to reduce their risk of obesity and other weight-related problems.

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Conflict of interest statement

None declared.

References

1. Ogden CL, Carroll MD, Curtin LR *et al*. Prevalence of high body mass index in US children and adolescents, 2007–2008. *JAMA* 2010; **303**: 242–9.

2. Thomas H. Obesity prevention programs for children and youth: why are their results so modest? *Health Educ Res* 2006; **21**: 783–95.

3. Boon CS, Clydesdale FM. A review of childhood and adolescent obesity interventions. *Crit Rev Food Sci Nutr* 2005; **45**: 511–25.

4. 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**: 409–18.

5. Kropski JA, Keckley PH, Jensen GL. School-based obesity prevention programs: an evidence-based review. *Obesity (Silver Spring)* 2008; **16**: 1009–18.

6. Neumark-Sztainer D, Story M, Hannan PJ *et al*. New Moves: a school-based obesity prevention program for adolescent girls. *Prev Med* 2003; **37**: 41–51.

7. Ferreira I, van der Horst K, Wendel-Vos W *et al*. Environmental correlates of physical activity in youth - a review and update. *Obes Rev* 2007; **8**: 129–54.

8. van der Horst K, Oenema A, Ferreira I *et al*. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. *Health Educ Res* 2006; **22**: 203–26.

9. Pearson N, Biddle SJ, Gorely T. Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. *Public Health Nutr* 2009; **12**: 267–83.

10. Norman GJ, Schmid BA, Sallis JF *et al*. Psychosocial and environmental correlates of adolescent sedentary behaviors. *Pediatrics* 2005; **116**: 908–16.

11. Martens M, van Assema P, Knibbe R *et al*. Family environmental factors do not explain differences in the behavioral effect of a healthy diet promotion program in lower vocational schools among 12- to 14-year-old adolescents. *Am J Health Promot* 2010; **24**: 182–5.

12. Martens MK, Van Assema P, Paulussen TG *et al*. Krachtvoer: effect evaluation of a Dutch healthful diet promotion curriculum for lower vocational schools. *Public Health Nutr* 2008; **11**: 271–8.

13. 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**: 421–32.

14. Sallis JF, Johnson MF, Calfas KJ *et al*. Assessing perceived physical environmental variables that may influence physical activity. *Res Q Exer Sport* 1997; **68**: 345–51.

15. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci* 1985; **10**: 141–6.

16. Trost SG, Sallis JF, Pate RR *et al*. Evaluating a model of parental influence on youth physical activity. *Am J Prev Med* 2003; **25**: 277–82.

17. Salmon J, Timperio A, Telford A *et al*. Association of family environment with children's television viewing and with low level of physical activity. *Obes Res* 2005; **13**: 1939–51.

18. Barr-Anderson DJ, van den Berg P, Neumark-Sztainer D *et al*. Characteristics associated with older adolescents who have a television in their bedrooms. *Pediatrics* 2008; **121**: 718–24.

19. Hanson NI, Neumark-Sztainer D, Eisenberg ME *et al*. Associations between parental report of the home food environment and adolescent intakes of fruits, vegetables, and dairy foods. *Public Health Nutr* 2005; **8**: 77–85.

20. Boutelle KN, Birnbaum AS, Lytle LA *et al*. Associations between perceived family meal environment and parent intake of fruit, vegetables, and fat. *J Nutr Educ Behav* 2003; **35**: 24–9.

21. Neumark-Sztainer D, Wall M, Perry C *et al*. Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. *Prev Med* 2003; **37**: 198–208.

22. Neumark-Sztainer D, Hannan PJ, Story M *et al*. Family meal patterns: associations with sociodemographic characteristics and improved dietary intake among adolescents. *J Am Diet Assoc* 2003; **103**: 317–22.

23. Boutelle KN, Fulkerson JA, Neumark-Sztainer D *et al*. Fast food for family meals: relationships with parent and adolescent food intake, home food availability and weight status. *Public Health Nutr* 2007; **10**: 16–23.

24. Bandura A. Social Cognitive Theory. In: Vasta R, (ed). Annals of Child Development Six Vol. 6. theories of child development.. Greenwich, CT: JAI Press, 1989, 1–60.

25. Baranowski T, Perry C, Parcel G. How individuals, environments, and health behavior interact: social Cognitive Theory. In: Glanz K, Rimer B, Lewis F (eds). Health Behavior and Health Education: Theory, Research and Practice, 3rd edn. SanFrancisco, CA: Jossey-Bass, 2002, 165–84.

26. Pate RR, Ross R, Dowda M *et al*. Validation of a 3-day physical activity recall instrument in female youth. *Pediatr Exer Sci* 2003; **15**: 257.

27. McMurray RG, Ring KB, Treuth MS *et al*. Comparison of two approaches to structured physical activity surveys for adolescents. *Med Sci Sports Exerc* 2004; **36**: 2135–43.

28. Dowda M, Pfeiffer KA, Dishman RK *et al*. Associations among physical activity, health indicators, and employment in 12th grade girls. *J Womens Health (Larchmt)* 2007; **16**: 1331–9.

29. Dowda M, Pate RR, Felton GM *et al*. Physical activities and sedentary pursuits in African American and Caucasian girls. *Res Q Exerc Sport* 2004; **75**: 352–60.

30. Thompson FE, Subar AF, Smith AF *et al*. Fruit and vegetable assessment: performance of 2 new short instruments and a food frequency questionnaire. *J Am Diet Assoc* 2002; **102**: 1764–72.

31. Perry CL, Bishop DB, Taylor G *et al*. Changing fruit and vegetable consumption among children: the 5-a-day power plus program in St. Paul, Minnesota. *Am J Public Health* 1998; **88**: 603–9.

32. Laskey MA. Dual-energy X-ray absorptiometry and body composition. *Nutrition* 1996; **12**: 45–51.

33. Jensen MD, Kanaley JA, Roust LR *et al*. Assessment of body composition with use of dual-energy x-ray absorptiometry: evaluation and comparison with other methods. *Mayo Clin Proc* 1993; **68**: 867–73.

34. Russell-Aulet M, Wang J, Thornton J *et al*. Comparison of dual-photon absorptiometry systems for total-body bone and soft tissue measurements: dual-energy X-rays versus gadolinium 153. *J Bone Miner Res* 1991; **6**: 411–5.

35. Murray DM. *Design and Analysis of Group-Randomized Trials*. New York: Oxford University Press, 1998.

36. Perkins DF. Adolescence: developmental tasks. University of Florida, Institute of Food and Agricultural Sciences, 2007. FCS 2118.

37. Saelens BE, Sallis JF, Nader PR *et al*. Home environmental influences on children's television watching from early to middle childhood. *J Dev Behav Pediatr* 2002; **23**: 127–32.

38. Summerbell C, Waters E, Edmunds L *et al.* Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2005;3).

39. Neumark-Sztainer D, Haines J, Robinson-O'Brien R *et al.* 'Ready. Set. ACTION!' A theater-based obesity prevention program for children: a feasibility study. *Health Educ Res* 2009; **24**: 407–20.

40. Spoth R, Goldberg C, Redmond C. Engaging families in longitudinal preventive intervention research: discrete-time survival analysis of socioeconomic and social-emotional risk factors. *J Consult Clin Psychol* 1999; **67**: 157–63.

41. Lytle LA, Kubik MY, Perry C *et al.* Influencing healthful food choices in school and home environments: results from the TEENS study. *Prev Med* 2006; **43**: 8–13.

42. Brownell KD, Schwartz MB, Puhl RM *et al.* The need for bold action to prevent adolescent obesity. *J Adolesc Health* 2009; **45**: S8–S17.