Effects of an after-school care-administered physical activity and nutrition protocol on body mass index, fitness levels, and targeted psychological factors in 5- to 8-year-olds

James J. Annesi, PhD, FAAHB, FTOS, FAPA,^{1,2} Alice E. Smith, MS, MBA,¹ Stephanie M. Walsh, MD, FAAP,^{3,4} Nicole Mareno, PhD, RN,² Kathleen R. Smith, MS³

¹YMCA of Metropolitan Atlanta, 100 Edgewood Avenue, NE, Suite 1100, Atlanta, GA 30303, USA

²Kennesaw State University, Kennesaw, USA

³Children's Healthcare of Atlanta, Atlanta, USA

⁴Emory University, Atlanta, USA

Correspondence to: J Annesi
jamesa@ymcaatlanta.org

Cite this as: TBM 2016;6:347–357
doi: 10.1007/s13142-015-0372-6

Abstract

Over one third of U.S. youth are overweight or obese. Treatments typically have had unreliable effects, inconsistently incorporating behavior-change theory. After-school care might be a viable setting for health behavior-change programs. We evaluated effects of two consecutive 12-week segments of a revised self-efficacy/social cognitive theory-based physical activity and nutrition treatment on fitness levels, body mass index (BMI), and targeted psychosocial factors in after-school care participants, ages 5–8 years. Changes in physiological measures, exercise self-efficacy (ESE), and physical self-concept over 9 months were contrasted in experimental ($n=72$) vs. typical-care ($n=42$) groups. Mediation of the group–BMI change relationship by the psychosocial factors was also assessed. Improvements in physiological measures and ESE were significantly greater in the experimental group. ESE change completely mediated the association of treatment type with BMI change. The experimental group demonstrated significantly greater improvements in the physiological measures, with its treatment's theoretical basis and application within after-school care supported.

Keywords

BMI, Physical activity, Psychological factors, Youth, Self-efficacy, Children

The prevalence of children being either overweight (body mass index (BMI; kg/m^2) $\geq 85\text{th}$ – $<95\text{th}$ sex- and age-adjusted percentile) or obese ($\geq 95\text{th}$ percentile) [1] is an increasing concern in industrialized nations [2]. A high weight at a young age predicts overweight, obesity, and increased health risks into and throughout adulthood [2–4]. U.S. government data indicate that approximately 35 % of White children of ages 6 through 11 years are either overweight or obese, with their African-American and Hispanic counterparts higher at an average of about 40 % [5]. Although adequate physical activity and a healthy diet will promote a healthy weight, children now consume a preponderance of unhealthy foods that are high in fat, sugar, and calories [6], and active free-play has been reduced through increased screen time and parents'

Implications

Practice: For young elementary school students, after-school care can, and should, provide moderate-to-vigorous physical activity and health information in a manner that increases feelings of accomplishment and mastery (self-efficacy) and serves to improve health and physical activity behaviors both in, and out of, school.

Research: Future research is warranted to further investigate psychosocial correlates of adequate physical activity and healthy nutrition and how self-regulatory skills might be incorporated to overcome naturally occurring barriers—especially in overweight/obese children whose environments might be especially challenging.

Policy: Resources and evidence-based methods should be directed at school-administered programs so that state-of-the-art behavioral science is best deployed to foster recommended amounts of physical activity, healthful nutritional choices, and other health promotion behaviors, especially when the naturally occurring setting makes them difficult to attain.

concerns for safety when unsupervised [7]. Although recess provided in elementary schools varies by state, schools have a clear opportunity to increase physical activity levels and improve nutrition in children of that age group [7, 8]. However, they have been either unwilling or unable to consistently provide healthy foods [6], and even when physical education (P.E.) time has not been reduced (as has been a trend [8]), moderate-to-vigorous physical activity during such classes has been minimal [9] with only 8 to 11 % of a child's daily physical activity provided by P.E. [10]. Accelerometer-measured data indicate that for U.S. children of ages 6 through 11 years, only about half the boys and one third of the girls attain the recommended amount of moderate or more intense physical activity of 60 min/day, 5 or more days per week [11].

In a recent meta-analysis of 64 obesity prevention programs for children and adolescents [12], 32 of those treatments focused on ages 5 through 10 years. Approximately 84 % were school based, and almost all targeted both increased physical activity and healthy eating. Some also attempted to reduce children's media use, and a few sought to improve theoretically derived psychosocial correlates of improved health behaviors such as self-concept and self-efficacy. Sixteen studies included samples from the general population and 16 assessed participants who possessed at least one risk factor for future overweight/obesity (e.g., present obesity). Overall, treatments averaged 50 h over 38 weeks. Only four (25 %) and three (19 %) treatments, respectively, demonstrated significant positive effects on either BMI or a more direct measurement of body composition. Based on suggested conversions across studies [13], overall effect sizes were very small at $ES=0.03$ and $ES=0.04$, respectively. Within that meta-analysis, the 5- to 10-year-old age range demonstrated the weakest intervention effects; however, benefits of including a parental component was the strongest [12].

Partly because of an increase in two working parents and single parenting, 10.2 million elementary school children participated in after-school care in 2014 [14]. This represents almost double the participant rate of 10 years ago [14]. Although support of academics is typically a key aspect of after-school care, it has also been suggested to be a worthwhile venue for the administration of physical activity and fostering knowledge in children that might lead to improved food/beverage choices and increased physical activity during out-of-school hours [14–16]. Although it has been posited that one third of a child's recommended moderate-to-vigorous physical activity could be attained through after-school care [17], research also suggests that considerable structure and instructor training might be required for that to occur because staff will rarely engage in physical activity promotion behaviors spontaneously [18]. Observation research indicated that when physical activities and games *were* incorporated, they typically discouraged moderate-to-vigorous physical activity by requiring long explanations, waiting in lines for one's turn, and eliminating most participants during games [18].

The effects of 11 structured physical activity/fitness promotion treatments during after-school time were consolidated within another meta-analysis [19]. Nine studies assessed effect sizes for changes in body composition in children from ages 5 through 10 years, and six assessed effects on measures of fitness that could be related to body composition and health risks (e.g., cardiovascular endurance) [8]. Although seemingly important for assessing the dynamics of an intervention [20], only four of the studies suggested a theoretical foundation and/or reported change in a psychosocial predictor of a health behavior (e.g., self-efficacy for participation). In agreement with the aforementioned meta-analysis of *all* obesity prevention interventions meeting the inclusion criteria [12], the mean

effect size for body composition change was very small ($ES=0.04$), with only two (22 %) demonstrating a significant effect [21, 22]. Additionally, the mean effect size was small for both fitness changes ($ES=0.16$) and psychosocial predictors ($ES=0.08$). The one treatment that was associated with the largest increases in self-efficacy for both physical activity participation ($ES=1.23$) and healthy food choices ($ES=0.47$) incorporated social cognitive theory-based, cognitive-behavioral components such as modeling, goal-setting, contracting, behavioral skills training, and controlled reinforcement methods [23].

A 12-week, 3 days/week treatment entitled Youth Fit For Life was specifically designed for implementation during a 45-min segment of elementary after-school care by existing staff members. It translated tenets of social cognitive [24] and self-efficacy [25] theory into practical application by including age-appropriate adaptations of cognitive-behavioral skills such as cognitive restructuring, goal-setting, and self-reward along with mastery-based cardiovascular activities, use of resistance bands, and nutrition education. Youth Fit For Life was accepted into the Research-tested Intervention Programs of the National Institutes of Health/National Cancer Institute in 2006 [26]. A meta-analysis of 16 studies on the effects of the Youth Fit For Life treatment suggested its favorable effects on body composition that were lesser in ages 5 through 8 years ($ES=0.10$) than in ages 9 through 12 ($ES=0.16$) [27]. Additional research evaluated its effects on outputs of moderate-to-vigorous physical activity ($ES=0.33$) [28], fruit and vegetable intake ($ES_{Mean}=0.21$) [29, 30], strength ($ES_{Mean}=0.62$) [29, 30], cardiovascular, and endurance ($ES_{Mean}=0.17$) [29, 30] and, in ages 7 years and above, physical self-concept ($ES_{Mean}=0.26$) [29–34], mood ($ES_{Mean}=0.31$) [30, 31, 34–36], self-efficacy ($ES_{Mean}=0.19$) [29, 30, 32–35], and free-time physical activity ($ES_{Mean}=0.42$) [29, 33, 34] changes.

In efforts to improve on the significant effects on body composition, fitness, and psychosocial factors already found to be associated with Youth Fit For Life across after-school care sites, a new and substantially revised protocol was developed. Although this experimental treatment also translated behavioral concepts derived from social cognitive [24] and self-efficacy [25] theory, and used cognitive-behavioral skills to empower health-behavior improvements, revisions included the following: (a) separate age-tailored curricula for 5 through 8 years and 9 through 12 years; (b) an expanded duration of two, 12-week sessions of 4 days/week; (c) a greater emphasis on time in moderate-to-vigorous physical activity for all; (d) enhanced personal tracking of goal progress; (e) enhanced health education and behavioral skills training that better address a young child's social support system; (f) an easier-to-follow instructor manual and curriculum; and (g) planned communications to parents/guardians to encourage their support of the health behaviors being addressed at the time.

This study reports on data from the initial trial of this experimental treatment for children ages 5 through 8 within an after-school care setting. Hypotheses were as follows:

1. The experimental treatment will have significantly greater effects on measures of fitness, body composition, and targeted psychosocial factors than a control condition of typical after-school care.
2. Effect sizes will be greater than other related treatments and the previously validated Youth Fit For Life protocol.
3. Changes in measures of fitness will significantly predict change in body composition.
4. Changes in the targeted psychosocial factors will significantly mediate the relationship between treatment condition and change in body composition.

METHOD

Participants

Participants were registered users of YMCA-managed after-school care sites in the southeastern United States. Inclusion criteria were age between 5 and 8 years (inclusive) at baseline and attendance at a minimum of two of the three planned measurement sessions. Written informed consent by each participant's parent/legal guardian and verbal assent from each child participant was obtained. Randomization was by site, with five treatment sites and four "usual-care" control sites. Institutional review board approval was received. There was no significant difference between the control ($n=42$) and treatment ($n=72$) groups on age (overall $M=7.2$ years; $SD=1.1$), percentage of boys (overall 46.5 %), race/ethnicity (overall 11.4 % White, 75.4 % African-American, 11.4 % Hispanic, 1.8 % other), BMI (overall $M=17.6$ kg/m²; $SD=2.9$), and sex- and age-adjusted BMI percentile (overall $M=69.7$ %; $SD=24.6$). The control group had 15 (35.7 %) participants classified as overweight/obese (≥ 85 th percentile sex- and age-adjusted BMI), while the treatment group had 28 (38.9 %) classified as overweight/obese. Based on the location of participants' elementary schools, their median family income of US\$62,200 was moderate and also did not significantly differ by group.

Measures

We limited measurement of psychosocial variables to ages 7 and 8 years due to (a) the limited level of reading comprehension typically associated with ages below 7 years, (b) results from pilot and published research indicating unacceptably low instrument reliability for those ages [37], and (c) a desire to have participants complete the self-report surveys autonomously. We considered a Cronbach's α internal consistency minimum score of 0.60 to be acceptable, which was reduced from the typical requirement of 0.70. An

acceptable test-retest relationship remained at ≥ 0.70 [38].

Muscular strength—The number of push-ups completed while maintaining a 3-s pace per repetition was the measure of muscular strength. Starting at an upright plank position, each participant was required to lower the body, using his/her arms until elbows were at a 90° angle. Arms were then straightened to raise the body, and the same physical sequence was then repeated as many times as possible. The required pace was indicated by a recording. When either the required form or pace was not maintained, the tester recorded the number of properly executed push-ups. So that improvements were not primarily due to an increased familiarity with the task, practice trials with sufficient recovery time prior to testing were facilitated. Test-retest reliability over 1 week was previously reported to be 0.90 to 0.91 in ages 7 to 11 years [39]. Validity had been demonstrated through correlations of ≥ 0.70 with combined bench press, latissimus pull-down, and arm-curl tasks, after controlling for the participant's weight [40].

Cardiovascular fitness—Running and/or walking for as long a distance as possible over a period of 3 min was the measure of cardiovascular fitness. To standardize conditions at the three planned measures times (that occurred at different seasons and associated weather conditions), available indoor areas such as basketball courts were used. Testers recorded distance covered in meters. For the 6-min run/walk test, test-retest reliability over 1 week averaged 0.72, and concurrent validity was suggested in children of ages 9 to 11 through reported correlations of 0.71 to 0.82 between distances recorded and $VO_{2\text{ max}}$ treadmill test results [30, 41]. Research suggested that there was considerable correspondence between runs of 12, 9, 6, and 3 min in the elementary school age group [41]. Pilot testing for children of ages 5 to 8 years indicated that the correlation of a previously used run/walk tests of 6 min [29, 30], and a 3-min version, was strong at 0.70, $p<0.001$. Thus, the 3-min version was used in this study because of its greater acceptability to the younger participants and easier administration in the limited spaces available.

Exercise barriers self-efficacy—The five-item version of the Exercise Barriers Self-Efficacy Scale for Children (ESE [37]) measured participants' perception of their ability to overcome environmental, personal, and social barriers to exercise and physical activity. Each item began with the stem, "I am sure I can exercise most days of the week even if ...". Examples of item endings were "exercise was not fun" and "I didn't like the activity." Response options ranged from 1 (not at all confident) to 5 (definitely confident) and were summed. The possible score range was 5 to 25, with a higher score indicating greater self-efficacy. Internal consistency for ages 7 to 8 years was reported to range from Cronbach's $\alpha=0.72$ to 0.77, and test-retest reliability over 1 week ranged from 0.75 to 0.78 [37]. For the present sample, Cronbach's $\alpha=0.78$.

Physical self-concept—The five designated “behavior” items of the Physical Self-Concept subscale (PSC) of the Tennessee Self-concept Scale: 2 Child Form [42] measured participants’ perceptions of their physical selves. Examples of items were “I feel good most of the time” and “I’m often clumsy.” Response options ranged from 1 (always false) to 5 (always true) and were summed after responses to negatively worded items were reversed (e.g., 5=1; 2=4). The possible score range was 5 to 25, with a higher score indicating a more positive perception of one’s physical self. Internal consistency for ages 7 to 8 years was reported to be Cronbach’s $\alpha=0.60$ [42]. In a study of ages 7 to 13 years, test-retest reliability over 1 week was reported to be 0.71 [42]. For the present sample, Cronbach’s $\alpha=0.71$.

Body composition—After removal of shoes and outer garments such as jackets, participants’ weight was obtained to the tenth of a kilogram using a Seca 876 flat medical scale (Seca, Hanover, MD). Height was obtained in centimeters using a Seca 213 portable stadiometer (Seca, Hanover, MD). The mean of two consecutive trials was recorded. BMI was then calculated as weight (kg)/height (m²). Conversion to age- (reported to the tenth of a year) and sex-adjusted percentiles was based on normative data for the U.S. [1]. For change scores, actual BMI score, rather than BMI *z*-score or BMI percentile, was used because it was found to be the most accurate measure for estimating change in children [43].

Procedure

Both experimental and control conditions were administered by previously hired after-school care counselors. In both conditions, the majority of after-school care time consisted of participants’ completion of homework, center-based activities (e.g., math, science, literacy), and receiving tutoring. However, state policy required at least 30 min for daily physical activity. This was scheduled near the start of after-school care to include participants who might leave early. After-school care counselors rarely had any formal training in physical education or health education methods beyond guidance for safety that was provided in their general job training. For both the experimental and control conditions, physical activities were conducted in either the elementary school’s gymnasium, all-purpose room, or outdoor play area. For both control and experimental conditions, there was a limit of 18 participants per one counselor. Both parents and participants were blinded to assignment to the experimental vs. control condition and goals of this research in an effort to minimize expectation effects [44].

Within the control condition, physical activity was administered in a variety of ways that were mostly left up to the discretion of the counselor. Sometimes only the children most interested in activity participated while others were mostly inactive. However, counselors sometimes encouraged all to participate in

supervised ball, tag, running games, or other physical activities in which all could be involved. Activities that were offered, and rates of participation, were varied and primarily driven by the volition of the counselors’ and participants’ interests in physical activity.

A 6-h training was required of those counselors administering the experimental treatment. Along with a goal of attaining at least 30 min/day of moderate-to-vigorous physical activity for all participants, it incorporated cognitive-behavioral methods throughout that emphasized the development and use of self-regulatory skills (e.g., cognitive restructuring, relapse prevention) to overcome barriers to being active and consuming healthy foods and beverages, the attainment of feelings of ability through progress relative to one’s previous accomplishments, and one’s physical competencies. Activities were intended to foster competition with one’s self, and participants were never intended to be sedentary due to a poor (or excellent) performance during a game or activity. The treatment protocol was highly structured and was supported by a 296-page manual that directed after-school care counselors’ actions for 24 weeks of 4 days/week (i.e., 96 individual lessons). The components of the daily sessions were similar and are indicated below:

- 5 min: active warm-up and focus upon a specific movement for the week (e.g., skipping)
- 10 min: the day’s assigned “high-intensity activity” (e.g., “galloping tag”)
- 10 min: alternate days of either a “behavioral topic” (e.g., “positive self-talk”) or “health topic” (e.g., “what is a grain?”)
- 10 min: “content reinforcement” activity where the day’s behavioral or health topic was bolstered by a structured physical activity (e.g., complete an assigned physical movement when a whole- vs. refined-grain food is named by a counselor)
- 10 min: “go-to game” consisting of a moderate- to high-intensity game selected by the counselor from an approved list.

Posters supported the health topics, simple apparatus (e.g., cones, foam balls, hoops) supported the physical activities, and an “activity sheet” supported a participant-specific goal-setting process. In an effort to obtain further support for the physical activity and nutrition behaviors, brief letters explaining what was recently emphasized within the program, and how it might be supported outside of school, were sent to parents/guardians weekly. In the fifth day of the week, the time allocated to physical activity was left to the discretion of the after-school care counselor, similar to the control condition’s daily experience.

No more than 5 days prior to program start (time 1), at the end of a 12-week session just before the end-of-year holiday break (time 2), and at the end of the second 12-week session after resumption of school (time 3), trained wellness staff members completed assessments for both the control and experimental conditions in an identical manner. After-school care

counselors were not present for either physiological or self-report survey measurements nor could they inspect participants' performance scores so that social support or expectation effects were minimized [44]. Every attempt was made to avoid comparisons of results among participants, and participants' identification data were not retained. Structured fidelity checks were completed on approximately 10 % of sessions by trained wellness staff members not otherwise involved in the study. Minor violations with treatment protocols were typically corrected through their interactions with the counselors.

Data analyses

The expectation-maximization algorithm (EM [45]) was used to impute data for the 6 % of missing cases. A required criterion for the use of EM is data being missing at random. This was indicated here because participants who were missing any data did not significantly differ from the sample as a whole on any demographic or study measure. For the primary analysis of BMI change, to detect the expected small-moderate effect of $f^2=0.08$ at the statistical power of 0.80 ($\alpha=0.05$), a minimum of 98 total participants was required [46]. Analyses of the overweight/obese participants ($n=43$) was supplementary. Variance inflation factors of 1.01–1.02 indicated a low degree of multicollinearity. Both skewness and kurtosis values for all measures were acceptable at <2 SE. Consistent with previous suggestions for research within the present context, change scores were unadjusted for baseline values [47]. Statistical significance was set at $\alpha=0.05$ (two-tailed), throughout. Statistical analyses were conducted using SPSS Version 22 (Armonk, NY).

For each measure, general linear model mixed-model repeated measures ANOVAs were computed to determine if there was a significant between-group difference in score changes across the three measurement times. These were followed up by planned t tests to contrast group differences in score change between time 1 and time 2, and time 1 and time 3. For mixed-model repeated measures ANOVAs, effect sizes were expressed as partial eta-squared ($\eta^2_{\text{partial}} = \text{SS}_{\text{effect}} / [\text{SS}_{\text{effect}} + \text{SS}_{\text{error}}]$). To facilitate contrasts with a recent meta-analysis of after-school program impacts [19], the same effect size (ES) formula for independent groups suggested by Morris and DeShon [13],

$$ES = \left(\frac{[M_{\text{post:experimental}} - M_{\text{pre:experimental}}]}{SD_{\text{pre:experimental}}} \right) - \left(\frac{[M_{\text{post:control}} - M_{\text{pre:control}}]}{SD_{\text{pre:control}}} \right),$$

was used to calculate significant changes occurring from time 1 to time 3. By convention, small, moderate, and large effects were 0.01, 0.06, and 0.14 for η^2_{partial} and 0.20, 0.50, and 0.80 for ES, respectively.

Multiple mediation analyses incorporating 20,000 bootstrapped resamples [48] were then calculated on aggregated data to assess whether changes in ESE and PSC from time 1 to time 3 significantly mediated the

relationship of group (control group coded 0, treatment group coded 1) and BMI change. Within mediation analyses, path a represents the relationship between the predictor (here, the treatment type) and the mediator(s), path b represents the relationship between the mediator(s) and the outcome (here, change in BMI), and path c' represents the relationship between the predictor and outcome, after controlling for the mediators. Complete mediation is found when a significant path c (the bivariate relationship between the predictor and outcome) is no longer significant when a mediator or mediators are entered into the model (path c'). A mediator is statistically significant when its 95 % confidence interval (95 % CI) does not include zero. When significant mediation was found, it was followed up by simple (single) mediation models where the position of the mediator and outcome variables were reversed in paired equations. If mediation was significant in both of the paired equations, then a reciprocal, bi-directional relationship between the mediator and outcome variables had been detected [49, 50]. Each of the above analyses was completed separately for the overall sample and the overweight/obese subsample.

RESULTS

Treatment-related effects

Descriptive statistics of scores at times 1, 2, and 3, and score changes for the overall sample and the overweight/obese subsample are given in Table 1. There was no significant group difference at baseline on any variable, $p>0.30$. For the overall sample, there was a significant time $\times$ group interaction in favor of the treatment group on push-ups completed, $F(1, 112)=4.31$, $p=0.040$, $\eta^2_{\text{partial}}=0.04$; distance on the run/walk test, $F(1, 112)=11.79$, $p=0.001$, $\eta^2_{\text{partial}}=0.10$; ESE, $F(1, 61)=4.05$, $p=0.049$, $\eta^2_{\text{partial}}=0.06$; and BMI, $F(1, 112)=4.05$, $p=0.049$, $\eta^2_{\text{partial}}=0.06$. Planned follow-up contrasts indicated that the score increase from time 1 to time 2 was significantly greater in the treatment group on ESE, $t(61)=2.44$, $p=0.018$. From time 1 to time 3, the treatment group demonstrated significantly greater improvements on push-ups, $t(112)=2.08$, $p=0.026$, $ES=0.58$; run/walk, $t(112)=3.43$, $p=0.001$, $ES=0.61$; and ESE, $t(61)=2.00$, $p=0.050$, $ES=0.62$. BMI increase was significantly less from time 1 to time 3 for the treatment group, $t(112)=2.60$, $p=0.011$, $ES=0.15$. For the overall sample, mean BMI percentile in the control group increased from 71.29 to 72.67 % over the length of the study. For the treatment group, BMI percentile reduced from 68.79 to 65.14 %.

When considering only overweight/obese participants, there was a significant time $\times$ group interaction in favor of the treatment group on distance on the run/walk, $F(1, 41)=4.74$, $p=0.035$, $\eta^2_{\text{partial}}=0.10$; ESE, $F(1, 22)=7.16$, $p=0.014$, $\eta^2_{\text{partial}}=0.25$; and BMI, $F(1, 41)=4.11$, $p=0.049$, $\eta^2_{\text{partial}}=0.09$. Planned follow-up contrasts indicated that the score increase from time 1 to time 2 was significantly greater in the treatment

Table 1 | Descriptive statistics of study variables at three time points

	Time 1		Time 2		Difference		Time 3		Difference		
	<i>M</i>	SD	<i>M</i>	SD	Time 1–time 2		<i>M</i>	SD	Time 1–time 3		
					<i>M</i>	SD			<i>M</i>	SD	
Overall sample											
Control group											
Push-ups	1.42	2.54	1.71	2.12	0.29	2.05	1.79	2.60	0.36	2.20	
Run/walk (m)	490.27	78.30	494.79	79.16	4.52	72.27	465.85	75.96	−24.42	70.25	
ESE	18.76	4.34	16.80	3.71	−1.96	4.25	17.04	3.96	−1.48	4.34	
PSC	15.68	3.28	15.00	4.01	−0.68	4.20	14.36	3.41	−1.32	4.88	
BMI (kg/m ²)	17.78	2.85	17.98	3.08	0.19	0.71	18.34	3.07	0.56	0.81	
Treatment group											
Push-ups	1.14	2.08	1.82	2.43	0.68	1.93	2.64	3.55	1.50	3.14	
Run/walk (m)	475.33	77.20	486.14	75.31	10.80	72.33	498.23	70.54	22.90	71.38	
ESE	18.37	4.49	19.47	3.53	0.95	4.87	19.39	4.23	1.21	5.71	
PSC	15.95	2.66	16.18	2.86	0.24	3.60	14.61	3.97	−1.34	4.62	
BMI (kg/m ²)	17.51	2.92	17.58	2.98	0.07	0.52	17.64	3.15	0.13	0.88	
Overweight/obese participants											
Control group											
Push-ups	0.93	1.22	1.47	1.36	0.53	1.41	1.40	2.06	0.47	1.68	
Run/walk (m)	465.04	61.47	481.68	69.86	16.63	56.27	445.56	80.07	−24.42	70.25	
ESE	17.33	3.97	14.00	2.78	−3.33	4.44	13.67	3.39	−3.67	5.43	
PSC	14.67	3.61	12.22	3.27	−2.44	2.70	11.89	2.76	−2.78	5.02	
BMI (kg/m ²)	20.80	2.63	21.36	2.65	0.56	1.02	21.63	2.71	0.83	1.09	
Treatment group											
Push-ups	1.11	2.08	2.07	2.58	0.96	2.17	3.00	3.46	1.89	3.42	
Run/walk (m)	449.74	74.87	459.92	87.69	10.19	84.75	474.00	77.50	−19.49	67.47	
ESE	16.53	4.59	18.93	4.28	2.40	5.40	19.47	4.47	3.93	6.08	
PSC	17.07	2.09	16.40	3.70	−0.67	4.34	15.13	4.03	1.93	4.40	
BMI (kg/m ²)	20.10	3.05	20.18	2.97	0.08	0.55	20.13	3.58	0.03	1.30	

Time 1 baseline; Time 2 week 12; Time 3 week 24 of classes, which was 9 months after baseline; ESE Exercise Barriers Self-Efficacy Scale for Children, PSC Physical Self-Concept subscale

Time 1 baseline; Time 2 week 12; Time 3 week 24 of classes, which was 9 months after baseline; ESE Exercise Barriers Self-Efficacy Scale for Children, PSC Physical Self-Concept subscale

group on ESE, $t(22)=2.68$, $p=0.014$. From time 1 to time 3, the treatment group demonstrated significantly greater improvements on run/walk, $t(41)=2.18$, $p=0.035$, $ES=0.64$, and ESE, $t(22)=2.68$, $p=0.014$, $ES=2.33$. BMI increase was significantly less from both time 1 to time 2, $t(41)=2.03$, $p=0.049$, and time 1 to time 3, $t(41)=2.03$, $p=0.049$, $ES=0.31$. For the overweight/obese participants, mean BMI percentile in the control group changed minimally from 95.07 to 95.34 % over the length of the study. For the treatment group, BMI percentile reduced from 93.39 to 88.09 %.

For both the overall sample and the overweight/obese subsample, less gain in BMI over the course of the study was significantly associated with an increased distance completed on the run/walk measure, $r(112)=-0.22$, $p=0.021$, and $r(41)=-0.35$, $p=0.022$, respectively, but not an increased number of push-ups, $r(112)=-0.08$, $p=0.421$, and $r(41)=-0.10$, $p=0.539$, respectively.

Mediation of BMI change by changes in psychosocial variables

Multiple mediation analysis indicated that changes from time 1 to time 3 in ESE and PSC significantly mediated the relationship between treatment type and

BMI change for both the overall sample, $R^2=0.35$, $F(3, 59)=10.72$, $p<0.001$ (Fig. 1), and the subsample of overweight/obese participants, $R^2=0.59$, $F(3, 20)=9.68$, $p<0.001$ (Fig. 2). In both cases, there was complete mediation, and only change in ESE was a significant independent mediator (after controlling for the other psychosocial measure), 95 % CIs=−0.34, −0.02, and −1.07, −0.17, respectively.

For the overall sample, follow-up simple mediation analyses indicated that change in ESE significantly mediated the relationship between treatment and BMI change, 95 % CI=−0.36, −0.02; however change in BMI did not significantly mediate the relationship between treatment and ESE change, 95 % CI=−0.08, 3.52 (Fig. 3). For the subsample of overweight/obese participants, ESE change significantly mediated the relationship between treatment and BMI change, 95 % CI=−0.93, −0.19, and change in BMI significantly mediated the relationship between treatment and ESE change, 95 % CI=1.04, 9.19 (Fig. 4). Thus, a reciprocal, bi-directional relationship between changes in ESE and BMI was found in the overweight/obese subsample only. There was complete mediation in each of those paired models.

Fig. 1 | Mediation of the relationship between group (treatment/control) and change in BMI by changes in exercise self-efficacy and physical self-concept scores for the overall sample of ages 7 and 8 years ($n=63$)

DISCUSSION

Findings support the efficacy of the experimental treatment for improving measures of body composition, fitness, and self-efficacy to overcome environmental, personal, and social barriers to physical activity participation in children of ages 5 through 8 years. When contrasted with previous meta-analyses of obesity prevention treatments [12, 19], its significant effect size for BMI change ($ES=0.15$), while still small by conventional standards, was considerably larger than means for previous studies of similar age groups ($ES=0.03-0.04$). Only a small minority of the treatments within these meta-analyses demonstrated a significant effect. It has been noted that for variables found to be difficult to change (i.e., body composition), the difficulty of the manipulation should also be accounted for when evaluating effect sizes [51]. Also, the age group of 5 to 10 years has consistently demonstrated weaker intervention effects on body composition than older youths [12], and effect sizes are further reduced because approximately two thirds of participants are typically at a

healthy weight at baseline. Thus, maturation will be associated with a (desirable) weight gain in those participants. Consistent with this reasoning, it was found that for participants who initiated the treatment with a higher than normal BMI percentile, the effect size for BMI change was double that of the sample as a whole. Findings also supported the experimental treatment's improvement in body composition when contrasted with meta-analytic data on the Youth Fit For Life protocol ($ES=0.10$), which served as its foundation. For the measured fitness factors, the experimental treatment was associated with significant improvements in both muscular strength and cardiovascular endurance when contrasted with the control condition. The effect on cardiovascular endurance ($ES=0.61$) was also greater than findings associated with fitness changes found with after-school treatments ($ES=0.16$) and with the original Youth Fit For Life treatment ($ES=0.17$). Consistent with other research [52], improved cardiovascular endurance predicted improved body composition.

Fig. 2 | Mediation of the relationship between group (treatment/control) and change in BMI by changes in exercise self-efficacy and physical self-concept scores for the overweight/obese participants of ages 7 and 8 years ($n=43$)

Fig. 3 | Follow-up simple mediation analyses to assess reciprocity of relations between changes in BMI and exercise self-efficacy scores for the overall sample ($n=63$)

Unlike most of the related research, but congruent with strong recommendations [53], the experimental treatment was both translated from accepted behavioral theory and tested to evaluate if changes in corresponding psychological variables mediated outcomes. In support of tenets of social cognitive [24] and self-efficacy [25] theory, changes in ESE and PSC scores (together) completely mediated the relationship between treatment and change in BMI. However, only change in ESE was a significant, independent mediator. It was further demonstrated that for the overweight/obese subsample, there was a mutually reinforcing, bi-directional relationship between changes in ESE and BMI. Therefore, the importance of focusing on the ability to overcome external barriers, and highlighting small progress within the treatment [25], was affirmed. Although physical self-concept, as was measured here, was related to *task* self-efficacy (i.e., perceived physical competence [54]), it was neither improved nor a significant independent mediator within this study. Bandura [25] suggested that for complex tasks, scales on self-efficacy related to the physical domain require high specificity (e.g., self-efficacy for the endurance needed to complete a high-intensity game for 10 min). However, it is also possible that the physical challenges addressed within the PSC scale are not yet well-realized in ages 8 years and younger. Further research will be needed to identify the importance of physical self-concept for fostering healthy behaviors and weights in young children. Although survey-based psychological

measurement in an applied setting with very young children is challenging, it can yield important behavioral information that can help to shape and reshape interventions for added effectiveness.

Limitations within this study should be acknowledged. Although mediation analyses indicated the impact of psychosocial improvements, the path between changes in ESE and BMI (path *b*) was not comprehensively evaluated. For example, it would be beneficial to understand if increased feelings of competency to overcome barriers to completing physical activities induce more *free-time* physical activity and/or a generalization of learned self-regulatory skills to improved nutrition which, in turn, could foster a more healthy weight. To respond to such questions, an increased number of measurement instruments and a path analytic approach would be required. Also, the present research focused on the dynamic changes in both physiological and psychological measures. Although analyses of these changes were a strength of the study, multiple administrations of the same instrument unavoidably increase its measurement error [55]. This is of special concern for psychosocial surveys where their reliability is already challenged with young participants. Moreover, although the theoretical basis of the experimental treatment and its associated measures were consistent with social cognitive [24] and self-efficacy [25] theory, other theoretical approaches such as the theory of planned behavior or self-determination theory could, feasibly, yield more productive results and

Fig. 4 | Follow-up simple mediation analyses to assess reciprocity of relations between changes in BMI and exercise self-efficacy scores for the overweight/obese participants ($n=43$)

should be tested in the future. It remains highly desirable that when behavior change is a goal of a treatment, its architecture, measurement methods, and research questions/hypotheses emanate from a clear theoretical foundation [53], as was the case here. Without such bases and decompositions of findings, as has largely been the practice, researchers are left unaware of causal aspects of treatments and how they might be revised to improve their reliability and effects. Additionally, replications should evaluate the effects of sex, socioeconomic status, age, and race/ethnicity, especially because this sample was limited to ages 5 to 8 years and was three-fourths African-American. Longer term effects of the experimental treatment on physical activity, healthy eating, and self-regulatory skills usage also requires direct assessment. Future research should also evaluate protocol modifications for other venues such as day camps, P.E., and if the integrity of the protocol can be maintained with minimal fidelity checks. On a positive note, the present testing within an applied setting, using existing after-school care staff, maximized the treatment's generalizability [56]. Finally, although the curriculum sought to increase physical activity and healthy eating outside of school, methods for children to best impact parental facilitation of these, along with their direct measurement, will be needed in the future.

In summary, the experimental treatment demonstrated promising results with 5- to 8-year-olds on measures of fitness, body composition, and its psychosocial mediators within an after-school care setting. The protocol appeared to be well accepted by both after-school care counselors and the young participants and represented an improvement over previous obesity prevention interventions, including a treatment that served as its foundation. The experimental treatment's theoretical basis was supported and highlighted salient areas for improvement, extensions, and further research. After sufficient replication, its large-scale application and dissemination across after-school care sites might reliably empower healthier eating, increased physical activity, and more healthy weights in young children and provide a useful supplement to an in-school P.E. environment that often places minimal emphasis on administering sufficient amounts of moderate-to-vigorous physical activity [9, 10, 57].

Acknowledgments: The authors acknowledge the participation of the after-school care sites that made this study possible. This research received no specific funding.

Compliance with ethical standards

Ethical standards: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation

(institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Informed consent: Informed consent was obtained from all participants and their parents/legal guardians included in the study.

Conflict of interest: The authors declare that they have no competing interests.

- US Department of Health and Human Services. 2000 CDC Growth Charts: United States. Available at http://www.cdc.gov/growthcharts/clinical_charts.htm. Accessibility verified Sep 3, 2015
- Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Prev Med*. 1993; 22: 167-177.
- Guo SS, Chumlea WC. Tracking of body mass index in children in relation to overweight in adulthood. *Am J Clin Nutr*. 1999; 70(suppl): 145S-148S.
- Magarey AM, Daniels LA, Boulton TJ, Cockington RA. Predicting obesity in early adulthood from childhood and parental obesity. *Int J Obes Relat Metab Disord*. 2003; 57: 505-513.
- Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in US children and adolescents, 2007–2008. *JAMA*. 2010; 303: 242-249.
- Brownell KD, Horgen KB. *Food fight*. New York: McGraw-Hill; 2004.
- Salmon J, Timperio A. Prevalence, trends and environmental influences on child and youth physical activity. *Med Sports Sci*. 2007; 50: 183-199.
- National Association for Sport and Physical Education. *Shape of the Nation Report: Status of Physical Education in the USA*. Reston, VA: American Alliance for Health, Physical Education, Recreation, and Dance; 2006.
- McKenzie TL, Feldman H, Woods SE, et al. Children's activity levels and lesson contexts during third-grade physical education. *Res Q Exerc Sport*. 1995; 66: 184-193.
- Tudor-Locke C, Lee SM, Morgan CF, Beighle A, Pangrazi RP. Children's pedometer-determined physical activity during the segmented school day. *Med Sci Sports Exerc*. 2006; 38: 1732-1738.
- Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008; 40: 181-188.
- Stice E, Shaw H, Marti CN. A meta-analytic review of obesity prevention programs for children and adolescents. *Psychol Bull*. 2006; 132: 667-691.
- Morris SB, DeShon RP. Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychol Methods*. 2002; 7: 105-125.
- Afterschool Alliance. *America after 3 pm: afterschool programs in Demand*. Washington, DC: Afterschool Alliance; 2014
- Story M, Kaphingst KM, French S. The role of child care settings in obesity prevention. *Futur Child*. 2006; 16(1): 143-168.
- Trudeau F, Shephard RJ. Physical education, school physical activity, school sports and academic performance. *Int J Behav Nutr Phys Act*. 2008; 5: 10.
- Trost SG, Rosenkranz RR, Dzwaltowski D. Physical activity levels among children attending afterschool programs. *Med Sci Sports Exerc*. 2008; 40: 622-629.
- Weaver RG, Beets MW, Huberty J, Freedman D, Turner-McGrievy G, Ward D. Physical activity opportunities in afterschool programs. *Health Promot Pract*. 2015; 16: 371-382.
- Beets MW, Huberty J, Beighle A. Physical activity of children attending afterschool programs: research- and practice-based implications. *Am J Prev Med*. 2012; 42: 180-184.
- Baranowski T, Anderson C, Carmack C. Mediating variable framework in physical activity. *Am J Prev Med*. 1998; 15: 266-297.
- Barbeau P, Johnson MH, Howe CA, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. *Obesity*. 2007; 15: 2077-2085.
- Vizcaino VM, Aguilar FS, Gutierrez RF, et al. Assessment of an after-school physical activity program to prevent obesity among 9- to 10-year-old children: a cluster randomized trial. *Int J Obes*. 2008; 32: 12-22.
- Kelder S, Hoelscher DM, Barrosa CS, Walker JL, Cribb P, Hu S. The CATCH Kids Club: a pilot after-school study for improving students' nutrition and physical activity. *Public Health Nutr*. 2005; 8(2): 133-140.
- Bandura A. *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall; 1986.
- Bandura A. *Self-efficacy: the exercise of control*. New York: Freeman; 1997.
- National Cancer Institute. *Research-tested Intervention Programs (RTIPs): Youth Fit For Life*. Available at <http://rtips.cancer.gov/rtips/programDetails.do?programId=293932>. Accessibility verified September 3, 2015.
- Annesi JJ, Marti CN, Stice E. A meta-analytic review of the Youth Fit For Life intervention for effects on body mass index in 5- to 12-year-old children. *Health Psychol Rev*. 2010; 4: 6-21.
- Annesi JJ, Vaughn LL. Evidence-based referral: effects of the revised "Youth Fit 4 Life" protocol on physical activity outputs. *Perma J*. 2015; 19(3): 48-53.
- Annesi JJ, Tennant G, Westcott WL, Faigenbaum AD, Smith AE. Effects of the Youth Fit For Life protocol on physiological, psychological, and behavioral factors at YMCA Calgary after-school care sites. *Psychol Rep*. 2009; 104: 879-895.
- Annesi JJ, Faigenbaum AD, Westcott WL, Smith AE, Dixon GM. Effects of the Youth Fit For Life protocol on physiological factors, mood, self-appraisal, voluntary physical activity, and fruit and vegetable consumption in children enrolled in YMCA after-school care. *J Soc Behav Health Sci*. 2007; 1: 164-197.
- Annesi JJ. Improvements in self-concept associated with reductions in negative mood in preadolescents enrolled in an after-school physical activity program. *Psychol Rep*. 2005; 97: 400-404.
- Annesi JJ. Relations of age with changes in self-efficacy and physical self-concept in preadolescents participating in an afterschool care physical activity intervention. *Percept Mot Skills*. 2007; 105: 221-226.
- Annesi JJ. Relations of physical self-concept and self-efficacy with frequency of voluntary physical activity in preadolescents: implications for after-school care programming. *J Psychosom Res*. 2006; 61: 515-520.
- Annesi JJ, Faigenbaum AD, Westcott WL, Smith AE, Unruh JL, Hamilton FG. Effects of the Youth Fit For Life protocol on physiological, mood, self-appraisal, and voluntary physical activity changes in African American preadolescents: contrasting after-school care and physical education formats. *Int J Clin Health Psychol*. 2007; 7: 641-659.
- Annesi JJ. Relationship between self-efficacy and changes in rated tension and depression for 9- to 12-year-old children enrolled in a 12-wk. after-school physical activity program. *Percept Mot Skills*. 2004; 99: 191-194.
- Annesi JJ. Correlations of depression and total mood disturbance with physical activity and self-concept in preadolescents enrolled in an after-school exercise program. *Psychol Rep*. 2005; 96: 891-898.
- Annesi JJ, Westcott WL, Faigenbaum A, Unruh JL. Effects of a 12-week physical activity protocol delivered by YMCA after-school counselors (Youth Fit For Life) on fitness and self-efficacy changes in 5-12-year-old boys and girls. *Res Q Exerc Sport*. 2005; 76: 468-476.
- De Vellis R. *Scale development: theory and applications*. Thousand Oaks, CA: Sage; 2003.
- McManis BG, Wuest DA. Stability reliability of the modified push-up in children [abstract]. *Res Q Exerc Sport*. 1994; 65(suppl): A58-A59.
- Rutherford WJ, Corbin CB. Measuring upper body strength and endurance: which test is best? *Ky AHPERD J*. 1993; 29(2): 20-24.
- Jackson AS, Coleman E. Validation of distance run tests for elementary school children. *Res Q Exerc Sport*. 1976; 47: 86-94.
- Fitts WH, Warren WL. *Tennessee Self-Concept Scale*. 2nd ed. Los Angeles, CA: Western Psychological Services; 2003.
- Cole TJ, Faith MS, Pietrobelli A, Heo M. What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score, or BMI centile? *Eur J Clin Nutr*. 2005; 59: 419-425.
- Morgan WP. Methodological considerations. In: Morgan WP, ed. *Physical activity and mental health*. Washington, DC: Taylor & Francis; 1997: 3-32.
- Schafer JL, Graham JW. Missing data: our view of the state of the art. *Psychol Methods*. 2002; 7: 147-177.
- Cohen J, Cohen P, West SG, Aiken LS. *Applied multiple regression/correlation analysis for the behavioral sciences*. 3rd ed. Mahwah, NJ: Lawrence Erlbaum; 2003.
- Glymour MM, Weuve J, Berkman LF, Kawachi I, Robins JM. When is baseline adjustment useful in analyses of change? An example with education and cognitive change. *Am J Epidemiol*. 2005; 162: 267-278.
- Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav Res Methods*. 2008; 40: 879-891.
- Palmeira AL, Markland DA, Silva MN, et al. Reciprocal effects among changes in weight, body image, and other psychological factors during behavioral obesity treatment: a mediation analysis. *Int J Behav Nutr Phys Act*. 2009; 6: 9.
- Annesi JJ, Porter KJ. Reciprocal effects of changes in mood and self-regulation for controlled eating associated with differing nutritional treatments in severely obese women. *Clin Health Promot*. 2013; 3: 35-41.
- Prentice DA, Miller DT. When small effects are impressive. *Psychol Bull*. 1992; 112: 160-164.
- Gutin B, Barbeau P, Owens S, et al. Effects of exercise intensity on cardiovascular fitness, total body composition,

- and visceral adiposity of obese adolescents. *Am J Clin Nutr.* 2002; 75: 160-164.
53. Baranowski T, Lin LS, Wetter DW, Resnicow K, Hearn MD. Theory as mediating variables: why aren't community interventions working as desired? *Ann Epidemiol.* 1997; 7(suppl): S89-S95.
 54. McAuley E, Peña MM, Jerome GJ. Self-efficacy as a determinant and an outcome of exercise. In: Roberts G, ed. *Advances in motivation in sport and exercise.* Champaign, IL: Human Kinetics; 2001: 235-261.
 55. Nunally JC, Bernstein IH. *Psychometric theory.* 2nd ed. New York: McGraw-Hill; 1994.
 56. Glasgow RE, Emmons KM. How can we increase translation of research into practice? Types of evidence needed. *Ann Rev Public Health.* 2007; 28: 413-433.
 57. U.S. Department of Health and Human Services. *Strategies to Improve the Quality of Physical Education.* Available at http://www.cdc.gov/healthyyouth/physicalactivity/pdf/quality_pe.pdf. Accessibility verified Sep 10, 2015.