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School gardens and physical activity: A randomized controlled trial of low-income elementary schools

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ABSTRACT

Objective: This study examines effects of a school garden intervention on elementary school children's physical activity (PA).

Method: Twelve schools in New York were randomly assigned to receive the school garden intervention (n = 6) or to the waitlist control group that later received gardens (n = 6). PA was measured by self-report survey (Girls Health Enrichment Multi-site Study Activity Questionnaire) (N = 227) and accelerometry (N = 124, 8 schools) at baseline (Fall 2011) and follow-up (Spring 2012, Fall 2012, Spring 2013). Direct observation (N = 117, 4 schools) was employed to compare indoor (classroom) and outdoor (garden) PA. Analysis was by general linear mixed models.

Results: Survey data indicate garden intervention children's reports of usual sedentary activity decreased from pre-garden baseline to post-garden more than the control group children's ($\Delta = -.19$, $p = .001$). Accelerometry data reveal that during the school day, children in the garden intervention showed a greater increase in percent of time spent in moderate and moderate-to-vigorous PA from baseline to follow-up than the control group children ($\Delta = +.58$, $p = .010$; $\Delta = +1.0$, $p = .044$). Direct observation within-group comparison of children at schools with gardens revealed that children move more and sit less during an outdoor garden-based lesson than during an indoor, classroom-based lesson.

Conclusion: School gardens show some promise to promote children's PA.

Clinical Trials Registration: clinicaltrials.gov # NCT02148315.

Introduction

Children and youths in the United States are not achieving recommended levels of physical activity (PA) (NASPE, 2004; Pate et al., 2002). Among 11 year olds in the U.S., only 24% of girls and 30% of boys achieve the recommended 1 h of moderate-to-vigorous PA (MVPA) daily (World Health Organization, 2012). In New York State, 34.1% of school-aged children engaged in at least 20 min of vigorous PA 4–6 days per week, compared to 37.8% of children nationwide. Additionally, only 24.6% of New York children engaged in vigorous PA everyday compared to 28.0% of children nationwide (National Survey of Children's Health). Physical inactivity has been linked both cross-sectionally and prospectively to obesity (Dietz and Gortmaker, 1985; Gortmaker et al., 1996; Hancox et al., 2004). Health benefits associated with PA throughout the life course are well-documented (Blair and Morris, 2009; Nocon et al., 2008; Woodcock et al., 2011). Strategies to reduce sedentary behavior and increase PA during childhood may help to curb the obesity epidemic and set youths on a more active, healthy life-course trajectory (Elder, 1998; Wethington, 2005; Wheaton and Gotlib, 1997).

School gardens have gained prominence as a potential contributor to public health (Christian et al., 2012; Ozer, 2007; Twiss et al., 2003). Gardens are unique in their potential to affect both sides of the energy balance equation: dietary intake and physical activity (Hill and Peters, 1998; Wells et al., 2007), and yet relatively few studies have examined the effects of gardens on children's health or health behaviors. Moreover, the extant research on the topic of gardens and children's health has focused almost exclusively on the potential for gardens to impact children's diet-related outcomes such as fruit and vegetable consumption or fruit and vegetable preference (Christian et al., 2012, 2014; Lineberger and Zajicek, 2000; Morris and Zidenberg-Cherr, 2002; Morris et al., 2001, 2002, Robinson-O'Brien et al., 2009), while studies of gardens' effects on children's PA are rare (Hermann et al., 2006; Phelps et al., 2010). For evidence-based garden interventions to be developed and implemented, there is a need for a clearer understanding of the potential for gardens to bolster children's PA and reduce sedentary behaviors.

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This study addresses the following three research questions:

1. Is there an effect of a school garden intervention on children's overall PA and sedentary activity, as measured by self-report survey?
2. Is there an effect of a school garden intervention on children's PA levels during the school day, as measured with accelerometry?
3. In a within-subjects comparison, does PA, measured by direct observation, differ during an indoor classroom lesson versus during an outdoor garden lesson?

Methods

Study design and procedure

In this longitudinal cluster randomized controlled trial, schools were randomly assigned to the garden intervention or to the waitlist control group that received gardens at the end of the study (Wells et al., in press). Baseline data were collected in Fall 2011 (wave 1). The garden intervention began in Spring 2012 and continued through Spring 2013. Three waves of post-garden implementation data were collected (wave 2: late Spring 2012, wave 3: Fall 2012, wave 4: late Spring 2013). All procedures were approved by the authors' University's Institutional Review Board. The study was deemed exempt and therefore did not require child assent or parental consent.

The intervention

The intervention, developed as part of the *Healthy Gardens, Healthy Youth* pilot program, consisted of four components. (1) The garden was a 4′ × 8′ raised bed for each class. (2) Access to a curriculum of 20 lessons for children in grades 4–6; 11 lessons for year 1, and 9 for year 2. The curriculum toolkit was created based on a review of 17 extant garden curricula and focused on nutrition, horticulture, and plant science and included activities and snack suggestions. Aside from the lessons, educators led other activities in the garden such as planting, weeding, and harvesting. (3) Resources for the school included information about food safety in the garden and related topics. (4) The garden implementation guide provided guidance regarding planning, planting and maintaining the garden throughout the year; gardening during the summer; engaging volunteers; building community capacity; and sustaining the program.

Schools and classes

This study targeted low-income schools that did not already have school gardens used for teaching and learning and had at least 50% of students qualifying for free or reduced price meals (FRPM). A total of 12 schools in 5 regions of

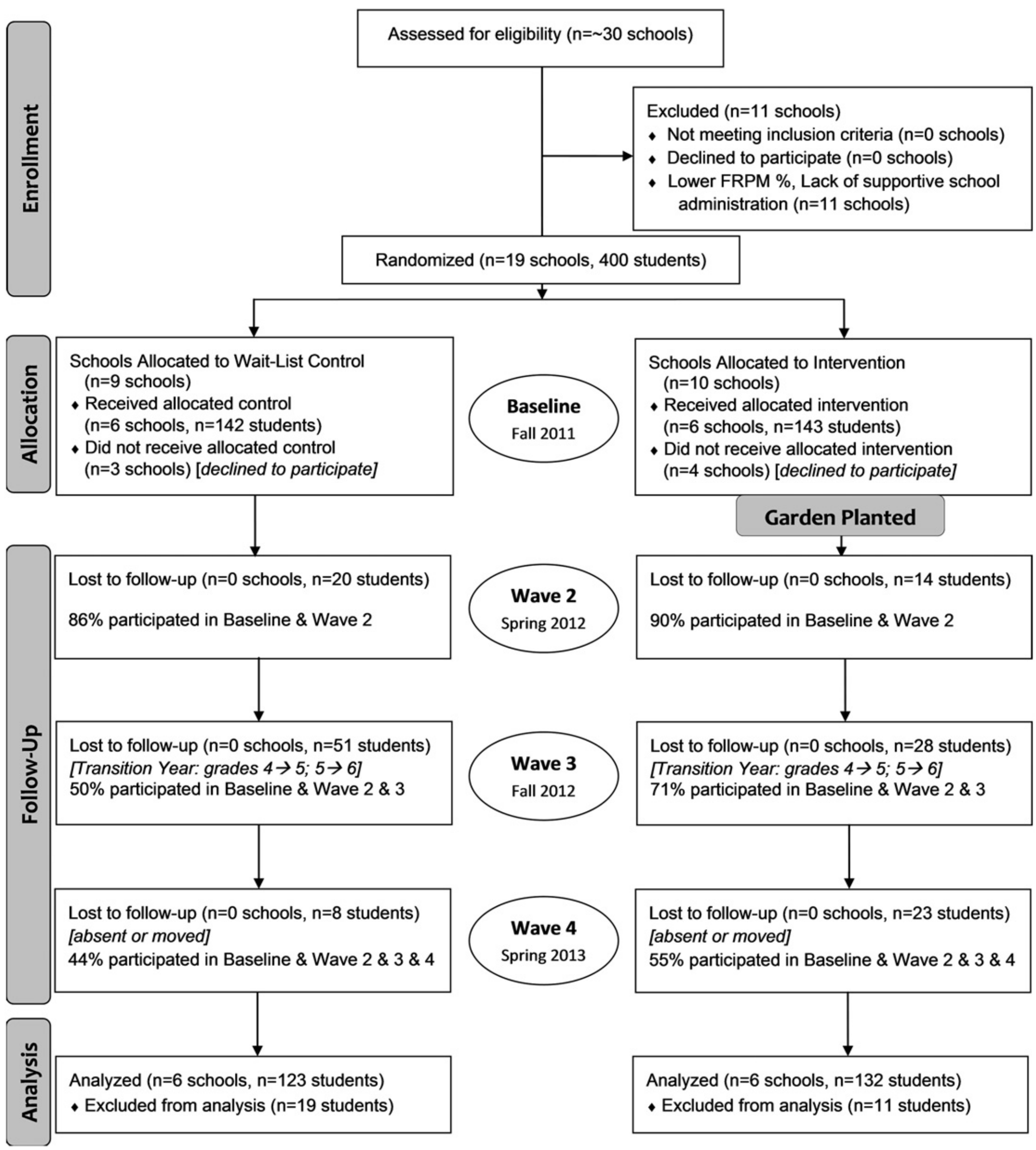

Fig. 1. Flow diagram for school gardens RCT.

New York State participated in this study. Fig. 1 shows the flow chart of the school recruitment procedure and corresponding sample sizes. Schools within each region (rural, suburban, and urban areas) were randomly assigned (by the first author, using random number generator) to intervention or waitlist control such that each region had an equal number of intervention and waitlist control schools. Nineteen schools were randomized and 7 subsequently left the study: 4 were lost because the Cooperative Extension staff person resigned; 3 schools dropped out due to personnel changes at the schools. The total number of classes evaluated within the 12 schools was 21, with most schools having 2 classes that participated in the intervention/evaluation (mean = 1.75). This study is part of a larger 4-state examination of the effects of school gardens on fruit and vegetable (FV) intake, FV preference, nutritional knowledge, and related outcomes.

Participants

The participants in this study were children in grades 4–5 (ages 8–12 years) at the start of the study.

Constructs and measures

The dependent variable, PA, was operationalized in 3 ways. For each of the 3 dependent variable measures, sample size varied. Trained Cooperative Extension educators and university student research assistant (RAs) carried out the data collection following standardized procedures to ensure consistent and unbiased administration.

GEMS Activity Questionnaire (GAQ)

The Girls Health Enrichment Multi-site Study (GEMS) Activity Questionnaire (GAQ) was developed by Treuth et al. (2004) based on the Self-Administered Physical Activity Checklist (SAPAC), that has been validated with heart rate ($r = .57$, $p < .001$) and accelerometry ($r = .30$, $p < .001$) with $n = 125$ 5th graders (Sallis et al., 1996). The GAQ obtains information about children's PA and sedentary activity “yesterday” and “usually” in 28 sports and physical activities (e.g. bicycling, volleyball, hiking, gymnastics) and 7 sedentary activities (e.g., watch TV, videos; computer games; play board games; listen to music). The GAQ is cost-effective for large numbers of participants, has been validated with 8–9-year-old girls (Treuth et al., 2004), and has been used with girls (Baranowski et al., 2003) and boys (Jago et al., 2007). The GAQ was administered at all 12 schools (n = 227 students at baseline and follow-up), in the classrooms. Activity scores[1] were weighted by intensity using the appropriate activity-specific MET values for children for each of the physical activities (Ridley et al., 2008). A MET-weighted mean was computed:

$$M_w(x_1, x_2, \ldots, x_k) = \frac{\sum_{i=1}^{k}(w_i \cdot x_i)}{\sum_{i=1}^{k}(w_i)},$$

where $w = \text{MET}_k$; $x =$ score; and k is the kth question in the GAQ.

Accelerometry

At each of the 4 waves of data collection, children at 8 schools (4 intervention and 4 control) wore Actigraph GT3X+ or GT1M accelerometers from the time they arrived at school in the morning until the end of the school day, for 3 days. On average, the children wore accelerometers for 355 min (5 h, 55 min) per day. Accelerometer data from children (collected with two accelerometer units simultaneously) are highly correlated with energy expenditure ($r = .86$ and $.87$), oxygen consumption ($r = .86, .87$), heart rate ($r = .77, .77$), and treadmill speed ($r = .90, .89$) (Trost et al., 1998; Freedson and Miller, 2000). Trained Cooperative Extension educators or university student RAs distributed the accelerometers to the children and recorded the belt numbers and time of day. Children were assisted with attaching the accelerometers to their waist with an elastic belt and plastic buckle and were instructed to follow their normal routine. Teachers were instructed on how to ensure that children properly wore the accelerometers. At the end of each day, classroom teachers collected the accelerometers and recorded the time collected. Due to a limited supply of costly accelerometers as well as the physical distance between sites, accelerometry data were collected from one class at 8 of the 12 schools (n = 124 at baseline and follow-up). On average, 21 children at each of the schools participated in accelerometry (range per school 15–25).

Direct observation

To characterize children's movements and motions during a 1-hour garden lesson compared to a 1-hour classroom lesson, the Physical Activity Research & Assessment tool for Garden Observation (PARAGON) (Myers & Wells, in press) was employed. Direct observation was conducted by trained RAs during waves 2 and 4 (Spring 2012 and Spring 2013) at 4 intervention schools with N = 57 children (N = 117 within-subjects indoor–outdoor paired comparisons). PARAGON uses momentary time sampling with a trained observer repeatedly observing a focal child for 15 s and then recording behavior during a 15-second interval. Prior to data collection, each RA completed a five-phase, ~20-hour training protocol to memorize codes and ensure inter-rater reliability. PARAGON's overall test–retest reliability is .94. An Ebel of .97 (and percent agreement of 88%) indicates strong inter-rater reliability (Myers & Wells, in press). The five primary PA codes (lying, sitting, standing, walking, vigorous activity) used in PARAGON are based on Behaviors of Eating and Activity for Children's Health (BEACHES) PA coding and were previously validated using heart-rate monitors and accelerometers (Rowe et al., 2003; McKenzie et al., 1991) and by expected convergent validity with accelerometry (Kelkar et al., 2011).

Statistical analysis

Accelerometry data were scored using ActiLife6 software. Thirty-second epochs (Klesges et al., 1995) were converted into minutes and proportions of time spent in each level of PA: 1) sedentary, 2) light PA (LPA), 3) moderate PA (MPA), 4) vigorous PA (VPA); and MVPA using child-specific cut-points (Evenson et al., 2008). Preliminary analyses (i.e. χ^2 and t-tests) were conducted to assess demographic differences between intervention and control at the school and student levels.

The three PA outcomes have related structures of observations involving assessment over multiple waves but differ in whether there are observations on both controls and treatment, on more than one day, or more than one setting (i.e., indoors and outdoors). The model for the GAQ survey included treatment (control versus intervention), sex of child, and wave (1–4) as fixed classification factors; the interactions among these factors; and individuals and classrooms as levels of random classification factors. Ethnicity (white, African American, Hispanic, and Asian) was included as an additional fixed classification factor. Multi-racial, “other,”,and unknown-race children were excluded from the analysis because of small numbers. The model for accelerometry outcomes was the same as for GAQ but also included day of assessment (i.e., day 1, 2, or 3 of the 3 measurement days per wave) as an additional fixed classification factor. To take into account the variance in time spent in physical education (PE) and time spent in recess during the school day, we included PE and recess time as covariates (with higher-level regressions). We considered models with the dependent variable computed as an average over the 3 days but used the model with repeated measures on days to examine any differences by days and better account for individual variance in testing treatment differences. The model for direct observation included sex of child, ethnicity, wave (2 and 4), and setting (indoors versus outdoors) as fixed classification factors; and individuals and classrooms as levels of random classification factors. In deriving each model, we examined a number of mixed model specifications involving random classification factors for schools, classrooms, and children, with various assumptions about error structure. Models including all 3 of these random factors did not have stable estimation, despite attempts with a variety of iterative algorithms for estimation, starting points for the solution, and other tweaking of the estimation. We chose the model described here based on the larger variance associated with classrooms than with schools, model fit, and theoretical grounds that influences on the garden program were more likely to occur at the classroom level than the school level.

Analysis for all 3 PA outcomes was carried out in general linear mixed models. An unstructured error assumption was used, and denominator degrees of freedom were computed by first-order Kenward–Rogers method. The key test for evaluation of the GAQ and accelerometry outcomes is the test of the interaction of treatment by wave. We partitioned from this interaction key pre-specified contrasts of interest—specifically, the test of treatment by wave 1 versus waves 2, 3, and 4 (a 2 × 2 contrast). The tables show the means and probabilities for these contrasts.

Statistical analyses were carried out using SAS version 9.3.

[1] Activity items are scored 0, 1, 10: 0 = none; 1 = <15 min; 10 = 15 min or more. Sedentary items are scored 0, .25, .75, 1.5, 2.5: 0 = none; .25 = <30 min; .75 = 30 min–1 h; 1.5 = 1–3 h; 2.5 = more than 3 h.

Table 1
Elementary school and town/city characteristics at baseline: school year 2011–2012, New York (school n = 12).

	Intervention schools							Control schools						
	1	2[a,b]	3[a,b]	4	5[a,b]	6[a,b]	Mean (sd)	7[a]	8	9[a]	10	11[a]	12[a]	Mean (sd)
Demographic														
School type	pK-5	pK-12	K-6	K-6	K-6	pK-7		pK-12	K-6	pK-8	K-6	3–5	3–5	
# students enrolled	284	286	367	317	280	612	358 (129)	425	436	527	459	496	449	465 (39)
% minority students	6%	4%	69%	72%	71%	95%	53% (38%)	26%	94%	82%	60%	99%	23%	64% (33%)
% free and reduced meals	51%	71%	89%	67%	66%	97%	74% (17%)	55%	61%	82%	68%	63%	56%	64% (10%)
Rural/suburban/ urban[c]	R	R	U	U	S	U		R	S	U	U	S	R	
Town and city characteristics														
Total Population	1712	617	66,135	66,135	33,506	210,565	63,112 (77,862)	596	32,082	66,135	66,135	11,647	9145	30,957 (29,143)
% families living in poverty[d]	13%	15%	18%	18%	13%	28%	18% (6%)	7%	20%	18%	18%	11%	11%	14% (5%)
Median household income[e]	$38,922	$44,038	$37,436	$37,436	$38,922	$30,367	$37,854 ($4403)	$41,375	$48,386	$37,436	$37,436	$54,527	$44,306	$43,911 ($6680)

[a] Schools in accelerometry study (n = 8).
[b] Schools in direct observation (n = 4).
[c] Classification based on 'locale codes' describing school locations as city, suburb, town, or rural (Common Core of Data, National Center for Education Statistics, and Census Bureau).
[d] New York state % families living in poverty average (2007–2011) = 14.5% (Census, 2010).
[e] New York state median household income average (2007–2011) = 56,951 (Census, 2010).

Results

Characteristics of the 12 participating schools and their communities are summarized in Table 1. On average, the 12 schools had 412 students enrolled (range 280–612 students). The percent of students who were ethnic minority varied across the 12 schools from 4% to 99% of the school population; with an average of 58% ethnic minority. All 12 schools were low-income, with an average of 69% of children participating in FRPM (range 51% to 97%). Town and city characteristics were derived from Census 2010 data.[2] Five of the schools were urban, 3 suburban, and 4, rural. On average, across the towns and cities, 16% of families were living in poverty, and median household income was, on average, $40,882. Overall, the intervention schools were smaller than the controls (359 v. 465 mean enrollment); had a higher percentage of children qualifying for FRPM (74% v. 64%) and had a lower percentage of minority children than the control schools (53% v. 64%); however these differences were not statistically significant.

Table 2 summarizes the participant characteristics at baseline, Fall 2011 (n = 227). The participating children were 204 4th graders (89.9%) and 23 5th graders (10.1%); 44% were boys. The average age of children in the intervention schools was 9.5 years and in the control schools, 9.0 years. Across all 12 schools, the majority of participating children were ethnic minorities (30.0% African American; 8.8% Hispanic; and 9.7% Asian); 51.5% were White. Comparing the intervention and control participants, a higher percentage of participating students at intervention schools were White (67%) compared to that in control schools (36%).

Overall physical activity and sedentary activity

Survey (GAQ) results indicate that children in the school garden intervention group showed a greater decrease in usual sedentary activity from wave 1 to waves 2, 3, and 4 than did children in the control group (p = .001). See Table 3.

Physical activity during the school day: accelerometry

Table 3 also presents the accelerometry findings. Children in the garden intervention group showed a greater increase in percentage of time spent in moderate PA (MPA) (+.45%; +1.6 min) from wave 1 (baseline) to waves 2, 3, and 4 than did the control group children (−.13%; −28 sec (p = .010). Similarly, intervention children showed a greater increase in percentage of time spent in MVPA (+1.68%; +5.96 min) from wave 1 (baseline) to waves 2, 3, and 4 than the control group children (+.68%; +2.42 min) (p = .044). No significant differences were found for changes in percentage of time spent in sedentary (p = .144); LPA (p = .492); or VPA (p = .213).

Physical activity in garden v. classroom: direct observation

Table 4 summarizes the percentage of time children spent across the 7 PA intensities (lying, sitting, kneeling, standing, squatting, walking, and very active) for both outdoor and indoor lessons. Findings indicate significant differences for outdoor versus indoor comparisons for 6 of the 7 PA intensity categories (lying was not significant, p = .108). During the outdoor garden lessons, children spent significantly more time walking (14% ~8.4/60 min) compared to an indoor lesson (3% ~1.8/60 min) (p < .0001). On average, during outdoor lessons, children sat 14% of their time, compared to 84% (~50.4/60 min) of indoor class time (p < .0001). The only VPA children obtained was during outdoor garden lessons (2%, ~1.2/60 min) versus indoor lesson time (0%) (p < .0001). During outdoor garden lessons, children spent the majority

Table 2
Participant characteristics, New York, 2011 (n = 227).

	Intervention n = 115	Control n = 112	Total n = 227	Significant difference I and C
Mean age (at baseline)	9.5 (.7)	9.0 (.5)	9.3 (.7)	.000[**a]
	n (%)	n (%)	n (%)	
Gender				.967[b]
Girl	65 (56.5)	63 (56.3)	128 (56.4)	
Ethnicity[c]				.000[**b]
White	77 (67.0)	40 (35.7)	117 (51.5)	
African American	25 (21.7)	43 (38.4)	68 (30.0)	
Hispanic	10 (8.7)	10 (8.9)	20 (8.8)	
Asian	3 (2.6)	19 (17.0)	22 (9.7)	

[a] *t*-Test analyses were used to compare the differences between intervention and control groups.
[b] Chi-square analyses were used to compare the differences between intervention and control groups.
[c] Children with missing race (N = 15), "other" (N = 12), and "multi-racial" (N = 1) not in analyses due to small Ns and lack of information.
** p < .01.

[2] Common Core of Data (CCD), National Center for Education Statistics and Census Bureau (nces.ed.gov/ccd/rural_locales.asp).

Table 3
Physical activity (GAQ & accelerometry) data, by treatment and pre-garden (wave 1) to post-garden (waves 2, 3, & 4); New York 2011–2013.

	Intervention		Control			
	Pre (W1)	Post (W2–W4)	Pre (W1)	Post (W2–W4)	Mean difference	
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	(Interv–cont)	*p*-Value
GAQ Survey (n = 227)						
Activity — yesterday	2.91 (0.19)	2.48 (0.20)	2.74 (0.17)	2.51 (0.19)	−.20	.312
Activity — usually	3.78 (0.18)	3.43 (0.19)	3.61 (0.16)	3.63 (0.18)	−.37	.083
Sedentary — yesterday	0.63 (0.04)	0.51 (0.04)	0.57 (0.04)	0.54 (0.04)	−.09	.064
Sedentary — usually	0.78 (0.05)	0.68 (0.05)	0.68 (0.04)	0.77 (.05)	−.19	.001**
	Mean % (SE), min	Mean % (SE), min	Mean % (SE), min	Mean % (SE), min	(Interv–cont)	*p*-Value
Accelerometry (n = 124)						
Sedentary	55.23 (1.71), 196.07	55.00 (1.73), 195.25	54.75 (1.59), 194.36	56.11 (1.60), 199.19	−1.59	.144
Light PA	34.62 (1.00), 122.90	33.17 (1.02), 117.75	35.09 (0.92), 124.57	33.07 (0.93), 117.40	+.57	.492
Moderate PA	5.17 (0.54), 18.35	5.62 (0.54), 19.95	5.41 (0.50), 19.21	5.28 (0.50), 18.74	+.58	.010*
Vigorous PA	5.01 (0.58), 17.79	6.24 (0.59), 22.15	4.99 (0.54), 17.71	5.78 (0.54), 20.52	+.44	.213
MVPA	10.14 (1.03), 36.00	11.82 (1.04), 41.96	10.35 (0.95), 36.74	11.03 (0.95), 39.16	+1.00	.044*

GAQ survey:
Mean activity: yesterday $t(570) = 1.01$; usually $t(569) = 1.74$; mean sedentary: yesterday $t(542) = 1.85$; usually $t(536) = 3.46$.
Accelerometry:
% sedentary: $t(1169) = 1.46$; % light PA: $t(1169) = -0.69$; % moderate PA: $t(1169) = -2.57$; % vigorous PA: $t(1169) = -1.25$; % MVPA: $t(1169) = -2.02$.
* $p < .05$.
** $p < .01$.

of the time standing (53%, ~31.8/60 min); while 9% (~5.4/60 min) of indoor time was spent standing ($p < .0001$).

Discussion

This school-based cluster randomized controlled trial examines the effects of a school garden intervention on children's PA. Results suggest that school gardens help to promote children's PA and reduce sedentary activity. Results indicate that compared to children at schools without gardens, over the course of 2-years, children at garden intervention schools report a greater reduction in their usual daily sedentary activity. During the school day specifically, children at schools with gardens exhibited a greater increase in MPA and MVPA than did children in the no-garden control schools, as measured by accelerometry. In addition, within-group comparison revealed that outdoor, garden-based lessons were associated with more varied postures and movements and less sitting than indoor, classroom-based lessons. Though there is little prior research examining the effects of school gardens on PA, our findings are consistent with a pre–post study (n = 43) that found, based on a 1-item self-report measure of PA, that more children were "physically active every day" following garden participation (Hermann et al., 2006).

Table 4
Percentage of time spent in each physical activity category, during 1-hour indoor v. outdoor, direct observation (PARAGON); New York, 2012–2013 (n = 117 indoor & outdoor paired observations).

PARAGON activity category	Outdoor		Indoor		Mean Difference	p-Value
	Mean	(SE)	Mean	(SE)	(Outdoor − indoor)	
Lying	0.73	0.50	0.05	0.50	+0.68	.108
Sitting	14.06	3.68	84.38	3.68	-70.32	.000***
Kneeling	9.90	2.28	0.89	2.28	+9.01	.000***
Standing	52.80	2.67	9.44	2.67	+43.36	.000***
Squatting	6.51	1.46	1.01	1.46	+5.50	.000***
Walking	14.09	2.12	3.10	2.12	+10.99	.000***
Very active	2.28	0.71	0.11	0.71	+2.17	.000***

Direct observation: % lying: $t(129) = 1.62$; % sitting: $t(129) = -28.93$; % kneeling: $t(129) = 5.66$; % standing: $t(129) = 17.51$; % squatting: $t(129) = 5.52$; % walking: $t(129) = 9.11$; % very active: $t(129) = 4.00$.
*** $p < .0001$.

Interpretation

It is unsurprising that findings from the GAQ did not reveal statistically significant effects on children's survey responses regarding PA "usually" and PA "yesterday." Although we might hope that school gardens would activate children to bicycle, do push-ups, play basketball, go hiking, or do yoga, it seems unlikely, particularly within the relatively short two-year time frame of this study. And, although no effect of school gardens is found on sedentary activities "yesterday," the significant effect of school gardens on sedentary activities "usually" suggests that school gardens may indeed compete with "screen time" (e.g., TV, computers, and on-screen games) and other sedentary endeavors to contribute to a reduction of time spent engaged in sedentary behaviors even beyond the school environment. Both longitudinal and secular trends contribute to an increase in sedentary behavior (Nelson et al., 2006) which has been linked both cross-sectionally and prospectively to obesity (Gortmaker et al., 1996; Dietz and Gortmaker, 1985; Hancox et al., 2004). Reduction of sedentary behaviors is an important objective and is associated with decreases in percentage overweight and body fat as well as with increased physical fitness (Epstein et al., 2000).

While the approximately 6-minute increase in MVPA and nearly 2-minute increase in MPA during the school day among garden intervention children were modest, they do contribute to daily MVPA and they may help to counteract the tendency toward greater inactivity with age (Sallis et al., 1999; Trost et al., 2002; Trost et al., 1996; Whitt-Glover et al., 2009). Moreover if schools embrace gardens as a pedagogical tool and as a health intervention strategy, more time will be spent gardening and engaging in garden-based lessons, likely yielding a stronger effect. In this study, the intervention varied somewhat from one class to another, with students, on average, spending only an hour or less in the garden weekly. Thus, our findings are likely conservative. Changes in other accelerometry-measured levels of PA during the school day (sedentary, LPA, VPA) were in the predicted direction though not statistically significant. Given the nature of gardening tasks, the effect on MVPA and MPA, but not VPA is expected. In fact, the significant effects on MVPA were primarily driven by the changes in MPA. Schools have been identified as a promising context for the promotion of youth PA and other health behaviors (Story et al., 2009; Centers for Disease Control and Prevention, 2011; Tuckerman, 2013). Thus, if gardens can be integrated more thoroughly with school curriculum throughout the day, school gardens may be one component of a school's health promotion intervention strategy, helping to nudge more children toward achieving the recommended 60 min of daily MVPA, which currently is only achieved by 42% of children ages 6–11 (Troiano et al., 2008).

In addition to school gardens contributing to a reduction in usual sedentary activities and nudging children's at-school MVPA a bit higher, our results suggest that while participating in a garden-based lesson, children engage in more diverse physical movements and postures than when participating in a classroom-based lesson. Indoors, children spend most (84%) of their time being sedentary (sitting) and engage in few other postures. Outdoors, while gardening, children mostly stand (53% of time) but also engage in a variety of physical movements, such as kneeling, squatting, walking, sitting, lying down, and running. Allowing children more opportunity to move their bodies during the school day may play a role in children's gross-motor development and strengthen muscles and bones. The direct observation data provide insight regarding what occurs during garden lessons and activities.

Study strengths

To our knowledge, this is the first randomized controlled trial to examine the effects of gardening on children's PA. The research design—including both pre- and post-measures as well as control and intervention groups—ensures strong internal validity and provides greater understanding of the effects of school gardens on children's PA. Second, use of multiple measures of PA—all with established reliability and validity—is an additional virtue of this study. Third, this study focuses on the population of children at greatest risk for physical inactivity and obesity: those from under-resourced communities and predominantly ethnic minority youth (Centers for Disease Control and Prevention, 2010; Ogden et al., 2010).

Study limitations

This study is not without its limitations. The focus on New York State youths in under-resourced communities limits the external validity of the study, hindering generalizability to other contexts and groups. In addition, the garden intervention was examined holistically, without distinguishing the individual components of the intervention. Thus, findings do not elucidate what aspects of the garden intervention are particularly potent to increase children PA. Moreover, this article does not examine the fidelity of the garden intervention, which is likely to differ from one school to another. With respect to the indoor classroom and the outdoor garden PA paired comparison, it was not possible to exactly match the curriculum delivered in the two settings. In addition, despite randomization of schools to intervention or waitlist control, there were significant differences in ethnicity and age between the two groups.

Future research

Future studies might aim to ascertain the dose–response relation between school gardens and children's PA. Specifically, how many square feet of garden space per child, how many hours of garden time, and which and how many garden-based lessons are necessary to increase children's PA. Also, the garden–PA relation might be examined in tandem with children's learning outcomes and with a focus on how garden activities affect children's attention once they return to the classroom. The school garden movement will continue to gain traction if educational effectiveness is established along with beneficial effects on health behaviors. Future research comparing PA levels during an indoor classroom-based and an outdoor garden-based lesson might more precisely match indoor and outdoor lesson content to enhance comparability of the two activities.

A school garden study from a life-course perspective might examine, over a longer time frame, whether introducing children to gardening is indeed a turning point that shifts them from a life-course trajectory of sedentary activities toward a trajectory of gardening and healthy habits. Empirical evidence suggests that life-long habits and patterns, including those related to PA and diet (DiNubile, 1993), are established early in life (Elder, 1998; Wethington, 2005; Wheaton and Gotlib, 1997; Wells and Lekies, 2006). The facts that gardening is one of the most popular home-based leisure activities in the United States (Ashton-Shaeffer and Constant, 2006) and the second most common leisure activity, after walking, among adults over age 65 years (Yusuf et al., 1996) suggest that, once begun, gardening has great potential as a life-long habit.

Conclusion

This randomized controlled trial of school gardens at under-resourced New York State schools suggests that school gardens may contribute to children's levels of PA at school and help to reduce time spent in sedentary activity. Evidence from this study suggests that gardening programs may merit school districts' allocation of resources.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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