# Multicomponent intervention for schoolchildren with asthma: Pilot cluster randomized controlled trial

Marina Reznik, MD, MS,[a] Florinda Islamovic, MD,[a] Jill S. Halterman, MD, MPH,[b] Cheng-Shiun Leu, PhD,[c] Jiaqing Zhang, PhD,[d] and Philip O. Ozuah, MD, PhD[e] *Bronx, New York, and Rochester, NY; and Waltham, Mass*

**Background: Physical activity (PA) is an important factor in asthma management. However, studies report low PA in children with asthma living in underserved communities.**
**Objective: We assessed preliminary effectiveness of a pilot multicomponent asthma intervention that includes classroom-based PA, asthma education to increase knowledge and reduce stigma, and care coordination to facilitate guideline-based care, on PA and symptom-free days (SFD) in urban, historically marginalized children with asthma.**
**Methods: Children aged 7-10 years with asthma and their caregivers were recruited from 4 Bronx, NY, schools. We randomly assigned 2 schools as intervention and 2 as control sites. Child PA (primary outcome) was measured by accelerometers at 4 time points, and caregivers completed surveys on asthma symptoms. Analyses used generalized linear mixed models with generalized estimating equation adjusting for clustering. Clinical Trial Registration: ClinicalTrials.gov NCT01873755.**
**Results: We included 107 children (53% male participants, 82% Hispanic, mean [standard deviation] age 9.0 [1.0] years, 76% with persistent or uncontrolled asthma). Children in the intervention group had a significantly greater increase in total moderate-to-vigorous PA and step counts at 12 months after intervention in the entire sample ($\beta = 6.05$, $P < .0001$; $\beta = 579.11$, $P = .008$, respectively) and in those with persistent or uncontrolled asthma compared to controls ($\beta = 6.20$, $P < .001$; $\beta = 639.08$, $P = .004$, respectively). Similar beneficial intervention effects were found in improvement in SFD over 2 weeks in the entire sample ($\beta = 1.38$, $P = .018$) and in children with persistent or uncontrolled asthma ($\beta = 1.82$, $P = .011$) compared to controls.**
**Conclusion: A pilot intervention addressing multiple barriers to PA, including stigma, teacher confidence in asthma management, access to PA, and in-school medication, improved PA levels and SFD in students with asthma. (J Allergy Clin Immunol Global 2025;4:100418.)**

***Key words:*** *Physical activity, urban youth, asthma, intervention, pilot RCT, school-based*

Asthma is the most prevalent chronic respiratory disease in children, affecting approximately 8.1% of children in the United States.[1] Asthma rates are higher among low-income, underrepresented children.[2,3] In the Bronx, New York, approximately 20% to 25% of school-age children have asthma.[4] National asthma guidelines recommend regular physical activity (PA) for children with asthma as an important factor for both asthma management and overall health.[5] PA has been associated with improved asthma control, reduced school absenteeism, increased exercise capacity, and improved quality of life.[6-9] Despite this, children with asthma have lower levels of PA, fitness, and sports participation than children without asthma.[10-13]

PA levels have been declining in US children, with some studies indicating lower PA in urban communities.[14-17] Decline in PA has been attributed to factors including increased screen time and lack of PA facilities.[18-20] There are additional barriers to PA for children with asthma at the level of the child, caregiver, and school. These include caregiver and child illness beliefs, fear of exercise-induced asthma attacks, stigma, and lack of teacher knowledge and confidence in managing asthma.[21,22] Improving PA in urban historically marginalized children with asthma may require simultaneously addressing these multiple barriers. Several small studies have evaluated exercise training programs, such as treadmill training and active video games, in children with asthma, establishing the benefits of PA on asthma control.[23-26] However, to our knowledge, there are no multicomponent interventions aimed at addressing barriers to PA in urban historically marginalized schoolchildren with asthma.

We developed an asthma management program to promote activity for students in schools (Asthma-PASS), a multicomponent school-based asthma intervention to address the barriers to PA in schoolchildren with asthma. The purpose of our study was to assess the impact of the Asthma-PASS intervention on accelerometer-determined PA levels and symptom-free days (SFD) in urban, historically marginalized children with asthma.

## METHODS

We conducted an open-label pilot cluster randomized controlled trial at 4 elementary schools (2 intervention, 2 control) in the Bronx, NY (ClinicalTrials.gov NCT01873755). The study was approved by the New York City Department of Education and institutional review boards.

From [a]the Department of Pediatrics, Albert Einstein College of Medicine, Children's Hospital at Montefiore Einstein, Bronx; [b]the Department of Pediatrics, University of Rochester, Rochester; [c]the Department of Biostatistics, Columbia University, New York; [d]Adobe Inc, Waltham, Mass; and [e]the Albert Einstein College of Medicine, Montefiore Einstein Health System, Bronx.

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Corresponding author: Marina Reznik, MD, MS, Department of Pediatrics, Albert Einstein College of Medicine, Children's Hospital at Montefiore Einstein, 3411 Wayne Ave, 8th Fl, Bronx, NY 10467. E-mail: mreznik@montefiore.org.



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*Abbreviations used*
CHW: Community health worker
MVPA: Moderate-to-vigorous PA
PA: Physical activity
PCP: Primary care provider
SD: Standard deviation
SFD: Symptom-free days

## Participants and settings

To identify students with asthma, a 6-item survey in English and Spanish was sent home with students attending second to fourth grades.[4] To determine eligibility, research staff completed a telephone screening with caregivers who indicated their child had asthma on the screening survey and gave consent to being contacted. Families were eligible for participation if they had children 7-10 years of age with: (1) caregiver report of physician-diagnosed asthma; (2) prescription for asthma medication in the past 12 months; and (3) English- or Spanish-speaking caregiver. Children with other chronic pulmonary diseases (eg, cystic fibrosis) and those who were previously enrolled onto the study were excluded.

## Study procedures

Once eligibility was confirmed, research staff met with the caregiver and child to obtain written consent and assent. Caregivers completed surveys at baseline, 6, 9, and 12 months. Children's PA was assessed with an accelerometer at baseline, 6, 9, and 12 months. Baseline data collection was completed in late fall–early winter, and 6-month data collection occurred after intervention in June, before the end of the school year. Data collection at 9 months was completed in September of the subsequent school year before reimplementation of the classroom-based PA intervention component. After all baseline data were collected, 4 schools were randomly assigned to the intervention or control group by the study biostatistician using a computer software program. Caregivers received $20 after completion of each survey. Children received a small toy (eg, pencil, sticker) for each day they wore the accelerometer and $10 each time the device was returned.

## Asthma-PASS intervention components

The intervention included the following components: primary care provider (PCP) collaboration, school-wide asthma awareness week, family asthma education, workshops for school personnel, and a classroom-based PA program. A community health worker (CHW) delivered educational aspects of the intervention and assisted with PCP collaboration. The classroom-based PA program was implemented by study personnel and continued by teachers and students.

**PCP collaboration.** CHWs established connection with PCPs of students with persistent or uncontrolled asthma identified by baseline surveys. They contacted PCPs via letter and phone call to inform them of the child's asthma severity/control and prompt for guideline-based management and appropriate medication prescription. In the absence of a PCP, a referral to a physician in the community was provided. CHWs also assisted intervention group participants with obtaining asthma medication administration forms. These forms, completed by PCPs, are required for children to receive asthma medication at school.[4]

**School asthma awareness week.** A school-wide, week-long event was held at each intervention school aimed at addressing stigma associated with asthma.[22] All students, with and without asthma, participated in activities such as classroom door-decorating contests, art projects, poems about asthma, and asthma-fact morning announcements delivered by students.

**Asthma family education.** CHWs scheduled one educational session with caregivers and their children that was conducted at either the participant's home or in school. This session was designed to address illness beliefs that prevent PA participation and covered topics such as asthma triggers, proper metered-dose inhaler spacer technique, medication adherence, and communication between child, caregiver, school staff, and PCPs. CHWs also addressed fears regarding asthma and exercise, and rescue inhaler use before exercise if the child had exercise-induced symptoms.

**Workshop training for school personnel.** CHWs provided a 45-minute workshop developed using the National Heart, Lung, and Blood Institute guidelines on asthma management and PA during school.[5] It included methods to encourage PA in children with asthma, asthma symptom identification, management of acute attacks in a classroom, and a question-and-answer session.

**Classroom-based PA.** A 10-minute classroom-based, education-focused PA program called CHAM JAM was previously developed and evaluated in elementary school students.[27] The program consists of lessons prerecorded on audio CDs by professional actors and set to contemporary music. It includes interval training with alternating intensity of exercises. These lessons were played via CD player in the classroom, and students followed the recorded instructions.

## Control group condition

Similar to children in the Asthma-PASS group, children in the control group received a symptom assessment to determine level of asthma severity/control and education that school nurses may have provided as part of their routine practice. For students in control schools who were not receiving appropriate asthma therapy according to our initial assessment, we instructed caregivers to make an appointment with the student's PCP for further asthma management. We offered the control schools all the components of the intervention after collection of 12-month follow-up assessments.

## Measures

**Measurement of PA.** PA levels (primary outcome) included time in minutes spent in sedentary activity, light PA, and moderate-to-vigorous PA (MVPA) and total count of steps during school hours. Triaxial accelerometers, validated in school-age children,[28,29] were used to objectively measure PA. Devices were attached to a belt outfitted to each child and worn for 7 consecutive days (5 school days, 2 weekend days), which were only removed during sleep or water activities (eg, bathing, swimming). Research staff visited schools daily to collect information on the child's attendance, whether the monitor was worn, and PA participation during the school day (eg, physical education class, recess, or PA programs such as Mighty Milers[30]). If the child was absent

or did not wear an accelerometer, the child was asked to wear the accelerometer for an additional day. Here we analyzed data collected during school hours only.

**Accelerometer data reduction.** ActiGraph software (Actilife 6) was used to download and convert raw acceleration into activity counts per 10-second epochs. The data were cut to include only the times the child was in school (8:20 AM to 2:20 PM). Activity counts were classified into the minutes spent in sedentary, light PA, and MVPA using the cut points of Evenson et al,[31] whose work has been shown to be most accurate for children.[32] An interval of at least 60 consecutive minutes of 0 counts, with an allowance of 2 minutes under the sedentary count threshold, was defined as nonwear time.[33] A school day was considered valid if daily wear time during school hours had at least 4.5 hours of data, which is 72% of the average number of hours in a school day.

Child participation in physical education class, outdoor recess, and other school PA on days of activity monitoring was collected and recorded as yes or no. These were used as covariates in data analysis.

**Caregiver survey.** Caregiver surveys (English or Spanish) were delivered verbally, one-on-one, by trained research staff at school or at home. Surveys included child's sex, race, ethnicity, and duration of asthma diagnosis, as well as questions on number of daytime and nighttime symptoms and receipt of short-acting $\beta_2$-agonists in the past 14 days, which were used to derive the SFD variable (secondary outcome). SFD were derived by subtracting number of days/nights with symptoms or days with short acting $\beta_2$-agonist receipt from the overall 14 days. Caregivers were asked questions to determine asthma severity and control based on National Heart, Lung, and Blood Institute guidelines.[5] Caregivers also provided a list of the child's prescribed asthma medications. Children who were not prescribed controller medications were categorized as having intermittent or mild, moderate, or severely persistent asthma. Disease of children prescribed controller medications was categorized as well controlled, not well controlled, or very poorly controlled. A severity-control variable was created with 3 asthma control categories, as follows: 1, intermittent or well controlled; 2, mildly persistent, moderately persistent, or not well controlled; and 3, severely persistent or very poorly controlled.

## Statistical analysis

Descriptive statistics were generated and compared (between the intervention and control groups) for variables collected at baseline by *t* test for continuous variables and chi-square test for categorical variables. Generalized linear model with identity link function was used to examine group differences in the change from baseline to different time-point follow-ups for the primary outcome, PA levels. The generalized estimating equations methodology with independent working correlation structure was used to account for within-subject correlation due to repeated measures from the same subject at various follow-ups. To adjust for potential confounding, prespecified baseline covariates (ie, age, sex, ethnicity, body mass index, insurance, asthma severity, and asthma duration) were included in the analyses. Besides the abovementioned baseline covariates, the analyses for PA outcomes also included variables of physical education class, outdoor recess, and other school PA to further adjust for potential confounding. A similar analytical approach (generalized linear model with generalized estimating equation) was used for SFD. The regression coefficient corresponding to the intervention-by-time interaction is the difference in change over time for the outcome of interest between the intervention and control group and thus represents the effect of the Asthma-PASS intervention. We report this regression coefficient (ie, the interaction term) and its corresponding *P* value. We declare any finding of a *P* value no greater than .05 as statistically significant.

The analyses were conducted for both the full sample and the subgroup of participants with (1) mildly persistent, moderately persistent, or not well-controlled asthma; or (2) severe persistent or very poorly controlled asthma (hereafter *persistent or uncontrolled asthma*). All analyses were carried out by R v4.0.3 statistical software (R Project; www.r-project.org).

# RESULTS

Fig 1 illustrates study enrollment and retention based on CONSORT criteria.

## Sample demographics

A total of 109 children (89% participation rate) from second through fourth grades and one caregiver were recruited from 4 elementary schools with similar sociodemographic characteristics.[34] One child dropped out before any data collection and another child dropped out after baseline data collection, leaving a total of 107 child–caregiver dyads (child age, mean [standard deviation (SD)] 9.01 [1.04] years; 53.3% male; 81.9% Hispanic ethnicity; 85.7% and enrolled in Medicaid). There was a significant difference in age between the control and intervention groups (Table I). The control group had significantly more obese children (47.9%) than the intervention group (20.3%, $P = .002$). The groups were similar in sex, duration of asthma diagnosis, and asthma severity. Overall, 47.9% of children had moderate-to-persistent asthma or asthma that was not well controlled, and 26.7% had severe-to-persistent or very poorly controlled asthma.

## PA (primary outcome)

Table II and Fig 2 display the average time spent in PA at each time point for intervention and control groups, and the intervention effect. At baseline, the control group had more sedentary time and less MVPA, with an average of 15.24 minutes of MVPA per day compared to the intervention group, which had an average of 17.86 minutes of MVPA per day. Step counts were higher in the intervention group at baseline (mean [SD] 3358.20 [1289.74] steps) compared to the control group (2865.79 [1186.58] steps). MVPA in the control group increased from baseline (15.24 [9.69] minutes) to 6 months (21.49 [14.43] minutes). However, at 12 months, the control group decreased to an average (SD) of 13.17 (8.48) minutes of MVPA per day. The intervention group spent 17.86 minutes per day in MVPA at baseline, which increased to 22.82 minutes at 6 months, 15.91 minutes at 9 months, and 17.14 minutes at 12 months. While the change from baseline to 6-month and 9-month follow-up in MVPA did not differ significantly between the intervention and control groups ($\beta = 1.44$, $P = .656$; $\beta = -0.871$, $P = .75$, respectively), the change in MVPA from baseline to 12-month follow-up for the intervention group was significantly higher than for the control group by approximately 6.05 minutes ($P < .0001$). For step counts,

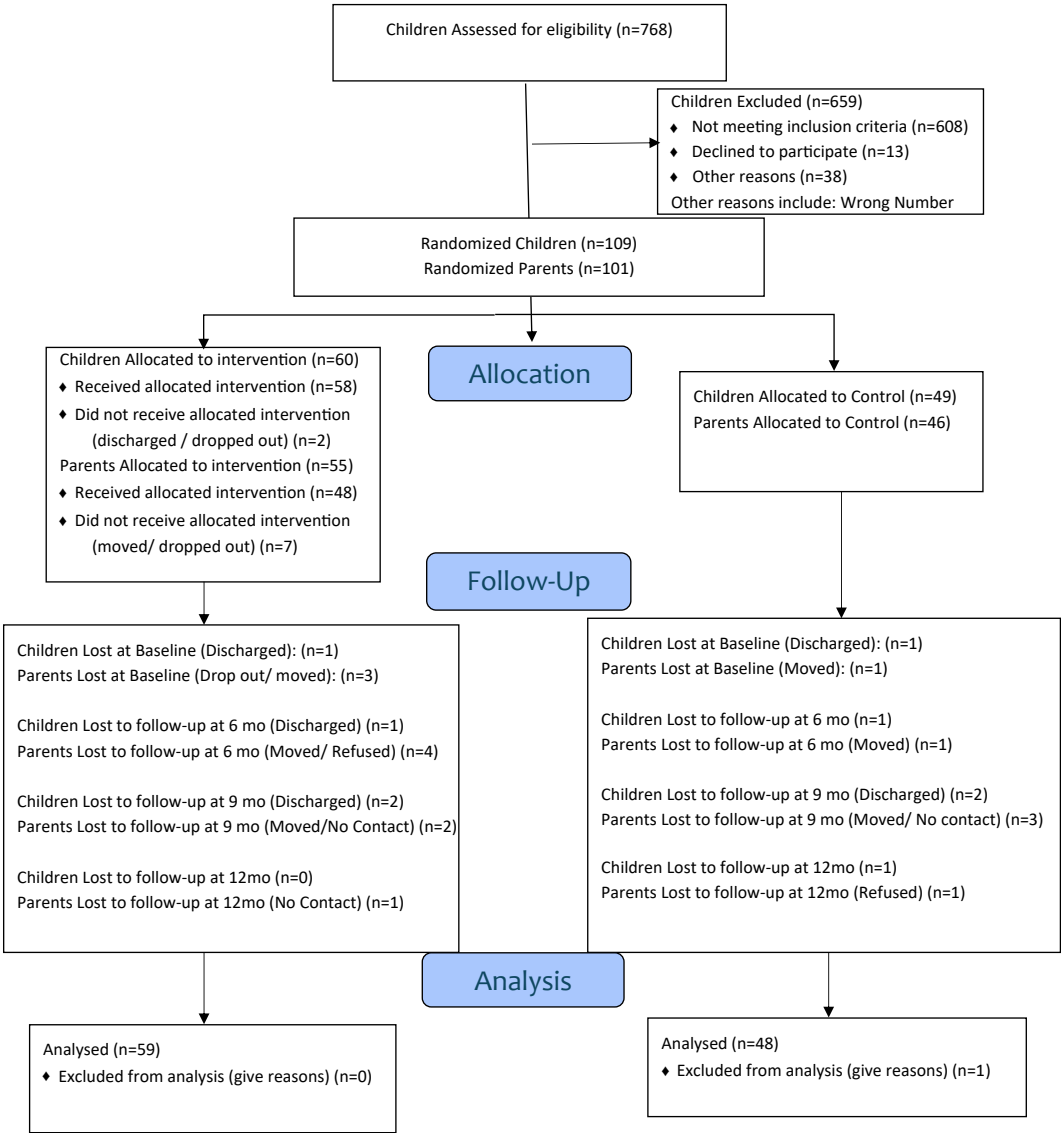


**FIG 1.** CONSORT (Consolidated Standards of Reporting Trials) diagram.

the intervention group had significantly greater change than the control group by about 579.11 steps ($P = .008$) from the baseline to 12-month follow-up; however, the change from baseline to 6-month and 9-month follow-up did not differ by group ($\beta = 441.84$, $P = .433$; $\beta = -100.499$, $P = .792$, respectively).

A subgroup analysis of PA including only children identified with persistent or uncontrolled asthma showed similar trends (Table III and Fig 3). The control group was found to have more sedentary time, less MVPA, and fewer steps during school hours at 12 months compared to the intervention group. Participants with persistent or uncontrolled asthma in the intervention group had significantly greater change in total MVPA per day by about 6.20 minutes ($P < .0001$) and step counts by about 639.08 steps ($P = .004$) compared to the control group at 12 months.

### SFD (secondary outcome)

Children in the intervention group had a significantly greater increase in SFD compared to the control group ($\beta = 1.38$, $P = .018$) at 12 months (Table IV). Participants with persistent or uncontrolled asthma in the intervention group also had a greater improvement in SFD at the 12-month follow-up ($\beta = 1.82$, $P = .011$) (Fig 4).

## DISCUSSION

In this pilot randomized controlled trial, we found that a multicomponent school-based intervention to address barriers to PA in students with asthma increased the amount of time spent in MVPA, number of steps during the school hours, and number of SFD. These findings were consistent in our subgroup analysis of children with persistent or uncontrolled asthma. The intervention group children with persistent or uncontrolled asthma had an almost 2 days' increase in SFD—an improvement found to be clinically meaningful and even greater than in other school-based intervention studies.[35-37] Only one small school-based telehealth intervention showed a similar increase in SFD of 1.96 from study week 0 to week 24.[38] The average age of children in that study was

**TABLE I.** Characteristics of study participants

| Characteristics | Total | Control | Intervention | *P* |
|---|---|---|---|---|
| No. of subjects | 107 | 48 | 59 | |
| Child age (years), mean (SD) | 9.01 (1.04) | 9.26 (0.94) | 8.81 (1.08) | .024 |
| Sex | | | | .999 |
| Female | 50 (46.7) | 22 (45.8) | 28 (47.5) | |
| Male | 57 (53.3) | 26 (54.2) | 31 (52.5) | |
| Ethnicity* | | | | .052 |
| Hispanic | 86 (81.9) | 35 (72.9) | 51 (89.5) | |
| Non-Hispanic | 19 (18.1) | 12 (27.1) | 6 (10.5) | |
| Race† | | | | |
| African American | 30 (29.1) | 17 (35.4) | 13 (23.6) | .273 |
| Non-African American | 73 (70.9) | 31 (64.6) | 42 (76.4) | |
| White | 13 (12.6) | 7 (14.6) | 6 (10.9) | .793 |
| Non-White | 70 (87.4) | 41 (85.4) | 49 (89.1) | |
| Duration of asthma diagnosis (years), mean (SD)* | 6.89 (2.34) | 7.08 (2.59) | 6.72 (2.11) | .444 |
| Insurance* | | | | .139 |
| Medicaid | 90 (85.7) | 38 (79.2) | 52 (91.2) | |
| Asthma severity/control* | | | | .454 |
| Intermittent/well controlled | 25 (23.8) | 14 (29.2) | 11 (19.3) | |
| Mild, moderately persistent/not well controlled | 52 (49.5) | 23 (47.9) | 29 (50.9) | |
| Severe, persistent/very poorly controlled | 28 (26.7) | 11 (22.9) | 17 (29.8) | |
| Body mass index | | | | .002 |
| Normal/underweight | 45 (42.1) | 12 (25.0) | 33 (55.9) | |
| Overweight | 27 (25.2) | 13 (27.1) | 14 (23.7) | |
| Obese | 35 (32.7) | 23 (47.9) | 12 (20.3) | |

Data are presented as nos. (%) unless otherwise indicated. Data are presented by subjects and by data observations per school.
*Data available for 105 participants.
†Data available for 103 participants. Race/ethnicity is caregiver reported.

**TABLE II.** Asthma-PASS intervention effect on PA in entire cohort

| | | PA | | | |
|---|---|---|---|---|---|
| Characteristic | Time | Sedentary | Light | Total MVPA | Steps |
| Control | Baseline | 261.28 (43.65) | 94.74 (32.69) | 15.24 (9.69) | 2866.79 (1187.58) |
| | 6 months | 236.54 (47.73) | 113.96 (38.74) | 21.49 (14.43) | 3748.36 (1760.64) |
| | 9 months | 263.60 (36.89) | 87.83 (29.56) | 14.20 (8.98) | 2779.51 (1083.42) |
| | 12 months | 267.11 (37.55) | 88.82 (30.81) | 13.17 (8.48) | 2629.15 (1062.13) |
| Intervention | Baseline | 245.09 (44.00) | 113.54 (35.32) | 17.89 (10.70) | 3358.20 (1289.74) |
| | 6 months | 234.97 (43.14) | 119.19 (35.28) | 22.82 (13.69) | 4289.03 (2063.45) |
| | 9 months | 258.50 (43.31) | 93.58 (34.51) | 15.91 (9.99) | 3060.89 (1305.11) |
| | 12 months | 255.78 (47.77) | 98.14 (37.91) | 17.14 (11.65) | 3139.04 (1365.27) |
| Difference between study groups in change from baseline | 6-month β (95% CI) | 8.89 (−11.37, 29.17) | −8.62 (−21.34, 4.10) | 1.44 (−4.90, 7.78) | 441.84 (−663.25, 1546.94) |
| | *P* | .390 | .184 | .656 | .433 |
| | 9-month β (95% CI) | 6.93 (−6.74, 20.60) | −7.88 (−21.59, −5.83) | −0.16 (−4.83, 4.51) | −100.50 (−846.87, 645.87) |
| | *P* | .320 | .260 | .946 | .792 |
| | 12-month β (95% CI) | −5.10 (−22.9, 12.69) | −3.58 (−11.28, 4.12) | 6.05 (3.50, 8.60) | 579.11 (149.32, 1008.89) |
| | *P* | .574 | .363 | <.0001 | .008 |

PA data are provided as mean (SD) minutes in PA categories or step counts unless otherwise indicated.

13.4 years, which is higher than the age of our study population, and that study was conducted in a rural rather than urban setting. Additionally, this study did not address potential confounders or effect modifiers.

School-based PA programs provide a unique opportunity to leverage the accessibility, safety, and resources available in schools and address barriers to PA in inner-city schoolchildren with asthma by providing additional opportunities for PA.[39,40] School-based programs can increase PA levels and improve the overall health of children.[41,42] However, these school-based programs have not been evaluated in children with asthma. Beemer et al evaluated the feasibility of a classroom-based PA intervention and its effects on MVPA in children with and without asthma.[43] MVPA was measured via direct observation, and they found an increase in MVPA for both groups of children as well as increased confidence for participation in PA in children with asthma, suggesting that an in-class PA program is feasible in children with asthma. School-based after-school coach- or trainer-led

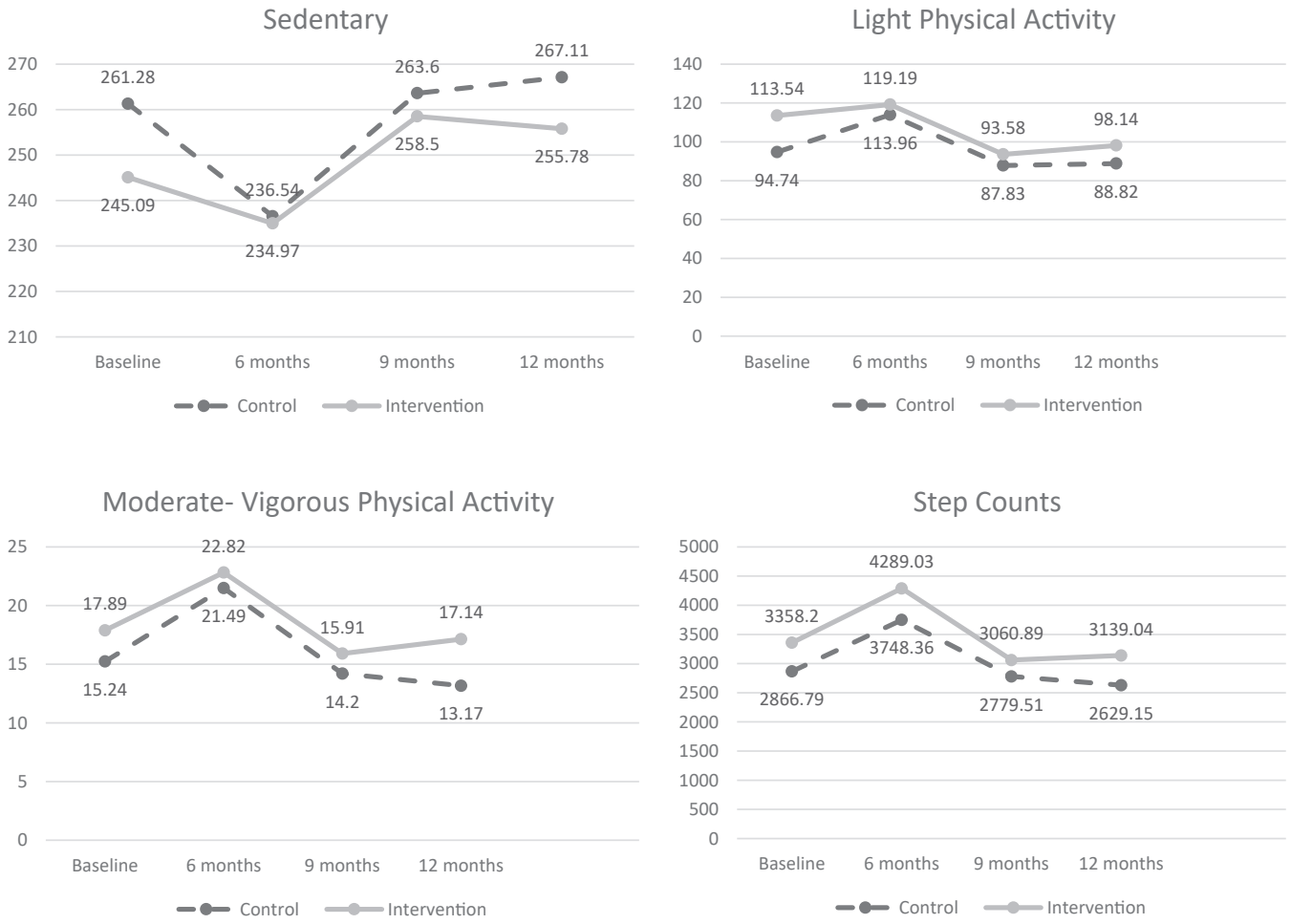


**FIG 2.** Asthma-PASS intervention effect on PA in all study participants.

**TABLE III.** Asthma-PASS intervention effect on PA in participants with persistent or uncontrolled asthma

| | | PA | | | |
|---|---|---|---|---|---|
| **Characteristic** | **Time** | **Sedentary** | **Light** | **Total MVPA** | **Steps** |
| Control | Baseline | 261.92 (43.11) | 94.85 (32.62) | 15.25 (9.69) | 2869.37 (1212.10) |
| | 6 months | 239.64 (48.17) | 110.38 (39.57) | 20.65 (13.73) | 3610.40 (1812.33) |
| | 9 months | 263.99 (37.18) | 87.76 (30.75) | 14.97 (9.49) | 2866.37 (1183.81) |
| | 12 months | 265.82 (36.81) | 88.87 (30.42) | 13.86 (9.27) | 2692.31 (1129.69) |
| Intervention | Baseline | 245.58 (44.93) | 113.23 (35.88) | 18.32 (10.89) | 3433.66 (1295.27) |
| | 6 months | 236.17 (45.89) | 119.09 (37.44) | 22.74 (14.63) | 4256.83 (2134.09) |
| | 9 months | 257.44 (44.43) | 94.66 (35.45) | 16.26 (10.44) | 3129.16 (1366.39) |
| | 12 months | 253.39 (49.33) | 99.07 (39.05) | 17.71 (12.27) | 3221.00 (1406.05) |
| Difference between study groups in change from baseline | 6-month β (95% CI) | 5.71 (−12.39, 23.81) | −4.08 (−14.27, 6.11) | 1.93 (−4.26, 8.11) | 488.09 (−462.83, 1439.02) |
| | *P* | .537 | .433 | .541 | .314 |
| | 9-month β (95% CI) | 4.94 (−5.33, 15.20) | −5.91 (−16.38, 4.56) | −0.87 (−6.22, 4.48) | −156.72 (−886.83, 573.40) |
| | *P* | .346 | .268 | .750 | .674 |
| | 12-month β (95% CI) | −6.94 (−25.92, 12.04) | −1.47 (−11.55, 8.61) | 6.20 (3.97, 8.43) | 639.08 (199.21, 1078.94) |
| | *P* | .474 | .775 | <.0001 | .004 |

PA data are provided as mean (SD) minutes in PA categories or step counts unless otherwise indicated.

exercise programs in children with asthma have shown improvements in fitness and health outcomes.[24,44,45] Similar to these programs, our program utilized schools as a safe, familiar, and easily accessible location; however, the PA component of our study did not require additional space or staff for implementation. Our PA component was integrated within the classroom and encouraged

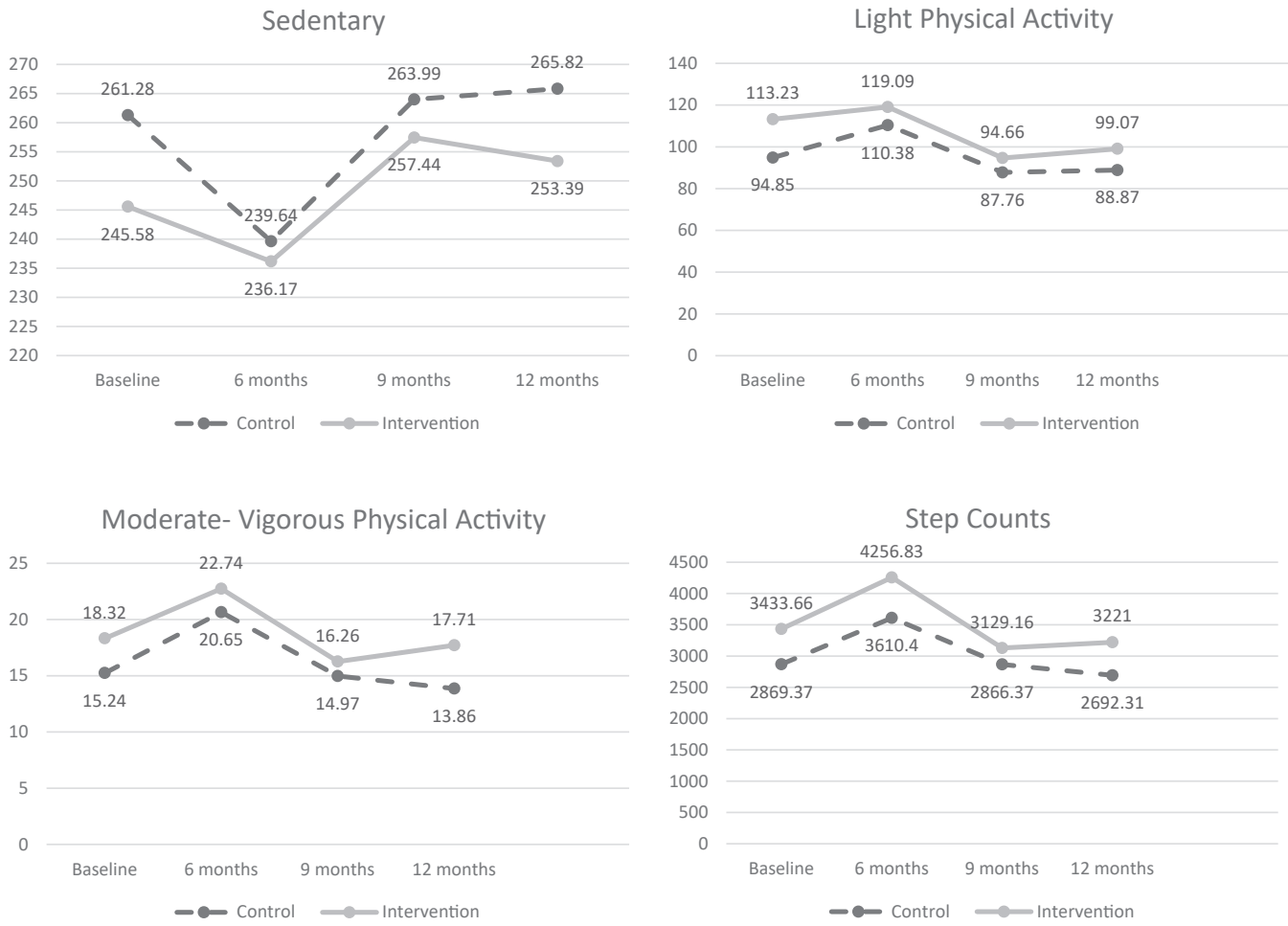


**FIG 3.** Asthma-PASS intervention effect on PA in study participants with persistent or uncontrolled asthma.

age-appropriate learning, which made it easy to incorporate into lesson plans, and was well received by teachers and students.[27] This ability to integrate PA into the educational curriculum without additional resources allowed a significant increase in minutes spent in total MVPA and step counts during the school day.

Previous studies that focused on improving access to PA in settings outside school required additional resources such as specialized equipment (eg, video games), additional personnel (eg, trainers), or travel to other facilities.[23,25] While these studies have shown increases in PA in children with asthma, they may not be practical for historically marginalized children in urban, lower socioeconomic areas. School-based programs are more easily accessible to students because they are often free of charge, are held in a safe setting, and do not require additional travel. However, classroom-based programs often compete with educational time. To circumvent this problem, our PA component includes grade-appropriate education that aligns with the required curriculum and allows for short bursts of moderate PA to be incorporated into lesson plans. Further, our PA intervention requires no training for students or teachers, can be student led, and helps meet school PA goals.

While PA has shown to improve asthma control in prior studies,[6] addressing lack of access to PA is not sufficient to encourage children to participate, especially those with asthma. Additional barriers such as child and parental fears and stigma associated with PA and asthma, concerns about acute asthma management and medication access at school, and lack of teacher knowledge and confidence in managing asthma in class should also be addressed.[21,22,46,47] Our intervention addressed stigma associated with asthma and exercise via school asthma awareness week activities, fears about asthma and exercise and proper use of inhalers via CHW-delivered asthma family education, in-school medication availability via PCP collaboration, and teacher knowledge and confidence via school personnel asthma workshops.[48] All of these components may have contributed to improved SFD and PA levels in our study participants. Previous interventions have addressed these components separately and have shown some improvement in asthma outcomes.[38,49] Our multicomponent intervention is the first to address all these barriers while also increasing access to PA.

While we are not aware of other studies analyzing the effects of a multicomponent intervention with embedded in-school PA on asthma control and other asthma outcomes, multiple physical conditioning studies have shown improvement in aerobic fitness and decrease in exercise-induced asthma symptoms and wheeze frequency.[24,25] In our study, significant improvement in SFD and in PA levels were seen in the intervention group compared to the control group in change from baseline to 12 months, but no

**TABLE IV.** Intervention effect on SFD

| Characteristic | Time | Whole group | Persistent/uncontrolled asthma group |
|---|---|---|---|
| Control | Baseline | 9.60 (4.64) | 8.65 (4.67) |
| | 6 months | 10.98 (4.58) | 10.27 (5.09) |
| | 9 months | 11.73 (2.83) | 11.16 (3.11) |
| | 12 months | 10.93 (4.44) | 10.00 (4.89) |
| Intervention | Baseline | 8.95 (4.77) | 7.96 (4.75) |
| | 6 months | 11.94 (3.06) | 11.7 (3.25) |
| | 9 months | 10.76 (4.22) | 10.40 (4.48) |
| | 12 months | 11.64 (3.62) | 11.29 (3.87) |
| Difference between study groups in change from baseline | 6-month β (95% CI) | 1.64 (−0.33, 3.61) | 2.09 (−0.56, 4.73) |
| | *P* | .102 | .122 |
| | 9-month β (95% CI) | −0.23 (−2.27, 1.81) | −0.14 (−2.61, 2.33) |
| | *P* | .825 | .912 |
| | 12-month β (95% CI) | 1.38 (0.24, 2.53) | 1.82 (0.42, 3.22) |
| | *P* | .018 | .011 |

SFD data are provided as mean (SD) number of days unless otherwise indicated.

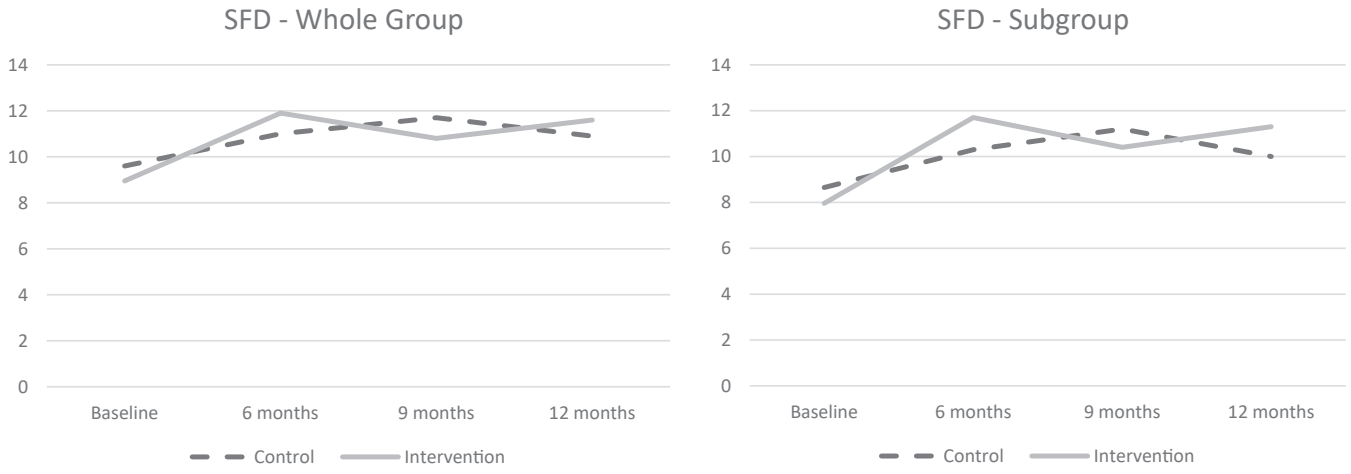


**FIG 4.** Mean SFD over 12 months for all study participants and subgroup of study participants with persistent or uncontrolled asthma.

significant difference was observed at 6 or 9 months. This may be partially explained by the long time it took to implement this multicomponent intervention, which was also constrained by the timeline of a school year. While mean SFD and MVPA in our intervention group increased from baseline to 6 months, both decreased at 9 months. There are several reasons that may explain these findings. Prior studies showed that children with uncontrolled asthma who participate as controls in clinical trials experience a significant increase in SFD with additional follow-up assessments.[50] A back-to-school viral asthma effect known as the September epidemic,[51] which refers to the seasonal increase in asthma health care utilization and asthma symptoms, could have contributed to our finding of no statistically significant difference observed in SFD between the groups at 9 months' follow-up. Another reason for our observed findings may have been contamination of the control schools with the intervention components. However, this is unlikely because all intervention components, with the exception of the classroom-based PA component (CHAM JAM), were delivered by the research team. Additionally, our 9-month data collection began at the start of the new academic year, but reimplementation of our in-class PA intervention component was delayed and took place after 9-month data collection was completed—the result of competing priorities for teachers at the beginning of the year and the need to introduce our PA intervention to teachers not familiar with it from the year before. This explains the observed decline in MVPA and step count at the 9-month time point.

Our study had some limitations. This study was conducted in urban public elementary schools in the Bronx, NY, enrolling historically marginalized students with asthma, so conclusions may not be generalizable to other communities. Accelerometers are the preferred method for PA measurement and provide objective measures of PA, but they cannot be worn during water activities, such as swimming. Some data during these activities were not recorded in our sample. However, to our knowledge, no child participated in water-based sports during school hours. Additionally, the responsibility of wearing monitors fell mainly on children and caregivers. This led to occasional days where children forgot to wear their monitor or the monitor was removed during the school day. However, to promote data accuracy,

research staff checked monitors daily to ensure that enough wear time was collected. If more data were required, the participant was asked to wear the monitor for an additional day. We analyzed accelerometer data collected during the school hours because children spend most of their days there; further, there was a lack of consistent after-school data available for analysis. Therefore, we might have missed data related to exercise outside of school. Our prior research with these schools revealed limited out-of-school PA to be due to community-level barriers, such as lack of affordable PA programs and neighborhood safety concerns.[21] Further, as a result of the multicomponent approach of the intervention, we cannot indicate that one component is more beneficial than another. Asthma-PASS was specifically designed with several components because multifaceted interventions yield the greatest success in asthma care for high-risk youth.[52,53]

In conclusion, a multicomponent school-based Asthma-PASS intervention is a promising approach to improving asthma outcomes and encouraging PA in urban children with asthma who come from historically marginalized racial and ethnic backgrounds. Our findings suggest that the classroom-based PA intervention component, in conjunction with components to address knowledge gaps in school staff and families, improve school medication access, and reduce stigma at home and at school, led to increased SFD and PA levels in students with asthma. A future large-scale clinical trial to evaluate Asthma-PASS, including a formal cost analysis, is needed to further assess whether Asthma-PASS represents a sustainable approach to asthma care for underrepresented children with asthma.

## DISCLOSURE STATEMENT

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**Clinical implication: A multicomponent school-based intervention was feasible to implement and improved SFD and PA levels in urban children with asthma from historically marginalized racial and ethnic backgrounds.**

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