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Exercise and Lifestyle Changes in Pediatric Asthma

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Abstract

Purpose of Review: The purpose of this review is to discuss the most recent studies on lifestyle interventions in pediatric asthma. We include studies on physical activity and exercise, sedentary time, nutrition, behavioral therapy and the role of schools.

Recent Findings: Several small studies in children with asthma suggest that exercise interventions can improve aerobic fitness, asthma symptoms or control, and quality of life. Existing evidence supports recommending higher intake of fruits and vegetables for asthma risk and control. In contrast, the “Western diet” –high in refined grains, highly processed foods, red meats, and fried foods with low intake of fruits and vegetables– has a pro-inflammatory effect and may alter microbiota composition leading to worse asthma outcomes. Lastly, there are opportunities to utilize schools to promote physical activity, though standardization of asthma management in the schools is needed.

Summary: Assessing physical activity/fitness levels, sedentary time, and nutritional status is important in the management of children with asthma, as they are modifiable factors. Larger rigorous studies evaluating lifestyle interventions are needed to better inform current asthma guidelines as well as to understand the underlying mechanism(s) related to physical activity and diet in asthma.

Keywords

exercise; sedentary time; nutrition; behavioral therapy; schools; childhood asthma

INTRODUCTION

Asthma is the most common chronic disease of childhood, affecting over 6 million children in the U.S., with children from minority and low socio-economic groups disproportionately affected(1). Despite recent advances in pharmacological treatment and standardized

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management guidelines, asthma continues to cause significant morbidity in children(2). Moreover, asthma is one of the leading causes of school absenteeism, with approximately 49% of school-aged children with asthma missing one or more school days per year(3). While the pathways underlying asthma (and asthma morbidity) are multifactorial, unhealthy lifestyle factors including decreased physical activity/exercise, increased sedentary time, poor nutrition and obesity likely play a role(4).

Physical activity (PA) plays an essential part in normal childhood growth and development. Rates of PA have significantly declined over the past 50 years, with only 24% of children 6–17 years of age meeting the recommended guidelines of 60 minutes of PA daily(5). Simultaneously, there have been significant increases in sedentary time, particularly excessive screen time in children(6). Independent of aerobic fitness, sedentarism is associated with poor health outcomes, including type 2 diabetes, all-cause mortality and mortality from cardiovascular disease(7,8). However, studies with objective measures of sedentary time in children with asthma are lacking. Furthermore, patients with asthma have not been spared by the unrelenting childhood obesity epidemic, and it is well established that obesity is a significant risk factor for both asthma development and increased asthma morbidity(9). Obese asthmatics have poorer asthma control resulting in increased symptoms, increased utilization of emergency departments, increased risk of asthma related hospitalizations, and longer stays in the intensive care units(10–12).

The purpose of this review is to discuss the most recent studies on lifestyle interventions in pediatric asthma, including research on physical activity and exercise, sedentary time, nutrition, behavioral therapy and the role of schools.

Physical Activity and Sedentary Time in Asthma

Exercise is a common trigger for bronchoconstriction in children with asthma. Factors that can affect PA in these children include negative self-efficacy, child and parental health beliefs, and poor asthma control(13,14). Fear of an asthma attack emerged as the main barrier to exercise in a group of adolescents evaluated by Winn and colleagues(15). Additional barriers to PA include an unsafe environment and lack of parental encouragement(16). Furthermore, neighborhood walkability factors including street connectivity and population density can affect risk of incident or ongoing asthma(17).

Studies looking at physical activity and asthma have yielded mixed results, with some showing that children with asthma tend to be less physically active than their healthy peers(18,19) while others report similar levels of activity in children with asthma and healthy controls(20). Pike et al found a low proportion (50–56%) of children, whether healthy or asthmatic, meeting the daily recommended PA guidelines in large U.K. cohort(21). They reported no significance differences in levels of moderate/vigorous physical activity (MVPA) between those with asthma and healthy controls, by asthma severity, or by prescription of inhaled corticosteroids. Only children with a recent asthma admission had lower levels of total activity compared to controls (–48 total counts/min, 95%CI –68, –28). Similarly, Sousa et al found similar levels of total steps, number of steps and time spent in MVPA between children with asthma and healthy controls(16). Similar results were reported in a longitudinal cohort of adolescents, with no significant differences

in PA patterns between adolescents with and without asthma, although overweight and obese adolescents had lower MVPA and high sedentary time independent of asthma diagnosis(22). Matsunga et al did not find any associations between survey-reported physical activity and asthma control, pulmonary function or quality of life in children with atopic asthma aged 7–17 years(23).

Screen time is perhaps one of the most pervasive sources of sedentary time in children and adolescents, and it was recently assessed in a large cohort of urban children(24). In that study, children with asthma reported almost 10 more hours of “out of school screen time” per week compared to healthy controls (35hr/week compared to 26hr/week, respectively). The authors did not find any differences in sports or reported physical activity between groups or perceived barriers to physical activity. Additionally, while 72% of families reported that their child experienced wheezing or dyspnea with activity, only 26% reported that asthma prevents their child from playing or exercising, suggesting that children with asthma may still participate in different activities despite their symptoms.

In summary, a significant proportion of children do not meet the recommended daily PA guidelines, independent of asthma. Among children with asthma, factors adversely affecting PA time include obesity, poor asthma control, and frequent exacerbations. Further studies are needed that include objective measures of physical activity/sedentary time in asthma, and in particular to assess the impact of screen time on asthma risk and morbidity in children.

Exercise Interventions in Asthma (Table 1)

Routine exercise is very safe in children with asthma as long as there is adequate asthma control(25). Many studies suggest that better fitness can improve asthma symptoms, control, and quality of life, in addition to the known benefits for cardiovascular health –although it is less clear whether it leads to consistent improvements in lung function or exercise-induced bronchoconstriction(25,26). Ensuring robust interventions that lead to measurable changes in fitness is critical in order to interpret the effect of exercise interventions on asthma(27). Wanrooij et al recommend that training programs should last at least 3 months (at least 2 sessions/week), with a personalized training intensity goal of a ventilatory threshold or 80% of the maximum heart rate(27). More recently, a systemic review of exercise training on nocturnal asthma symptoms, including five studies in children, found that aerobic exercise programs reduced the prevalence and frequency of nocturnal symptoms(28).

In a 10-week randomized controlled trial (RCT) of aerobic exercise in 38 children with asthma, Abdelbasset et al found significant improvements in VO_2 max, pulmonary function including FEV_1 % predicted, FVC % predicted, and all measures of quality of life (QOL) in the exercise group compared to control(29). In another RCT, Zhang et al evaluated the role of exercise in addition to montelukast (compared to montelukast alone) in 72 children(30). The authors found that the exercise group had improvement in clinical symptoms and QOL without any changes in lung function. Pulmonary rehabilitation has been increasingly recognized as an important component of respiratory disease management, and its effect in children with asthma was recently evaluated by Kirkby et al(31): the majority of participants were overweight or obese, and the authors found improvements in the 6-minute walk test

(6MWT), FEV₁, symptoms, and QOL despite no changes in body mass index (BMI) or weight.

While evidence points to the positive effects of exercise on asthma outcomes, it is unclear if a particular form of exercise would be more beneficial than others. A systematic review by Lahart et al summarized the physiological effects of swimming in non-elite or non-competitive swimmers, and it included seven studies in children with asthma(32). Their meta-analysis revealed significant improvements in VO₂max and peak expiratory flow (PEF) but not any other lung function measures. Other studies have reported significant reductions in exercise-induced bronchoconstriction, methacholine challenge testing and maximal inspiratory and expiratory pressures(32). A RCT of three different exercise interventions (swimming, football and basketball) and a control group in 41 children with asthma reported a significant improvement in FVC % predicted across all three exercise groups compared to control, as well as significant increase in PEF in the swimming group(33). Additionally, the swimming group had significant improvements in their asthma symptoms and general well-being compared to the other groups.

Despite the limitations of a small number of studies with modest sample sizes, current literature supports the role of exercise in improving asthma symptoms, QOL, and aerobic fitness. Additional efforts are needed to demonstrate longer term effects, sustainable and pragmatic studies that are generalizable to the “real world”, and addressing barriers to intervention particularly in higher risk communities.

Nutrition and Asthma

Beyond specific foods or nutrients, there has been growing attention to the effect of dietary patterns on asthma risk and morbidity(34). Several recent systematic reviews have summarized the effects of diet and associated micronutrients on asthma, including on the airways, immune response, and gut microbiota(35–37). A “Western” diet, low in fruits and vegetables and high in saturated fats, promotes a pro-inflammatory environment; such changes may affect the airways and alter the gut microbiota, playing a role in the immune response to diet in contrast to the Mediterranean diet, which is high in fruits and vegetables, wholegrains, and has anti-inflammatory properties. Douros et al did not find any differences in Mediterranean diet quality between groups or correlations with IL-4, IL-33, or IL-17(38). In a systematic review and meta-analysis of the effects of fruit and vegetable intake on asthma and immune responses(37), Hosseini et al reported that the majority of the studies reported a protective effect of fruit and vegetable consumption on asthma or wheeze. Their meta-analysis revealed that vegetable intake was associated with lower asthma risk (primary prevention studies) and that fruit intake was inversely related to asthma severity (secondary prevention). They were unable to perform a meta-analysis of immune responses and respiratory infections due to lack of studies reporting on these outcomes.

In addition to observational studies, to date there have been two nutritional supplementation trials in children with asthma (see Table 2). Bseikri evaluated the effect of a novel, nutrient dense, high-fiber, fruit-based supplement bar (CHORI-bar) in a pilot RCT of overweight and obese adolescents with poorly controlled asthma(39). The bar had been previously associated with improvements in metabolic dysregulation among overweight/obese

adults(40). In their trial, Bseikri reported that both groups had improvements in triglycerides, VLDL levels, asthma control and quality of life. However, there was no significant weight loss in either group, and there were no differences in lung function, symptoms, lipid levels, or inflammation between groups; moreover, insulin and HOMA-IR decreased in the control group and increased in CHORI-bar group. A subgroup analysis of compliant participants with $F_{E}NO < 50$ ppb found within-group improvements in FVC%, FEV₁% in CHORI-bar group but not in the control group; however, this was not a pre-determined outcome, and the subgroup analysis was significantly underpowered due to small sample size (n=16 in CHORI-bar group, n=15 controls).

Supplementation of omega-3 fatty acids (n3PUFA) can inhibit production of leukotrienes and other pro-inflammatory mediators(41,42). However, studies evaluating the role of n3PUFAs in children have been inconsistent. In a 24-week RCT of supplemental (n3PUFA) on symptoms among adolescent and young adults with overweight/obesity and uncontrolled asthma(43), Lang et al found no significant differences in asthma control or lung function between or within-groups at 3 or 6 months. They also performed a stratified analysis based on ALOX5 promoter polymorphisms, which have been previously show to influence response to n3PUFA, and found no treatment differences based on ALOX5 genotype(44).

In summary, nutritional interventions in pediatric asthma are scarce, and to date have not found effects on asthma symptoms or lung function compared to control –although this may be in part due to small sample sizes. The Mediterranean diet, which is high in fruit and vegetable consumption, has anti-inflammatory properties and its effect on asthma risk and control needs to be further studied.

Mixed and Behavioral Therapy Interventions in Asthma (Table 3)

Most interventions targeting pediatric asthma, particularly those with comorbid obesity, have utilized targeted dietary or diet and exercise programs(45–49). Lucas et al evaluated the effect of a 12-week nutrition and activity program in children with asthma and obesity and found significant improvements in BMI and VO₂max(50); however, this was a retrospective analysis and the authors did not report on any asthma-related outcomes. Fedele and colleagues evaluated a pilot behavioral family-based lifestyle intervention in overweight/obese children with asthma(51) and found no differences in outcomes between the two groups post-intervention and at the 6 month follow-up; however, they reported medium to large effects on BMI z-score change, asthma control and lung function in the intervention group. Horner and colleagues evaluated the feasibility of a 12-week combined lifestyle behavioral and asthma self-management program, and found significant improvements in BMI z-score, increased servings of vegetables, and both child and parental quality of life, but no significant differences in asthma self-management or severity compared to control. Overall, existing studies have had small sample sizes and have demonstrated that maintaining adherence to the programs can be challenging.

The Role of Schools

Previous lifestyle interventions have required participants to travel to centralized training centers; however, this approach is not practical or sustainable in communities with high-risk

populations, particularly in lower-SES and minority areas. In contrast, schools are familiar, safe, and accessible venues. School-based interventions have been shown to improve cardiorespiratory fitness and physical activity in children as well as academic performance(52,53).

Reznik et al assessed levels of in-school physical activity using accelerometers in urban, minority children with asthma and found that the majority of time was spent in sedentary (252 ± 37 mins) and light physical activity (105 ± 31 mins) with only 17 ± 8 mins spent in MVPA(54). Less than 3% of participants reached 30min of MVPA a day. Factors affecting PA included sex, age, and obesity, as well as school factors such as outdoor vs indoor recess, frequency of PE classes, and availability of other in-school activities. The same group evaluated barriers to PA in children with asthma from several perspectives including physical education (PE) teachers, school officials and parents using qualitative semi-structured interviews, with key points highlighted in Table 4(55–57).

Lu and colleagues targeted an aerobic exercise school program for children with asthma in predominantly minority and poor communities(58). The four-month program occurred on school grounds during after-school hours, and it led to significant improvements in fitness, lean body mass and fat mass, quality of life, and HDL levels. The authors reported that the project was possible because of the strong relationships built with local schools and their active engagement with the families.

CONCLUSIONS

Overall, there is a limited number of studies evaluating lifestyle interventions in children with asthma, and many of them have small sample sizes. Despite these limitations, interventions involving exercise have shown consistent improvements in fitness, asthma symptoms and quality of life, and some studies have also reported improvements in lung function. Nutritional interventions in asthma are scarce, and to date have not shown improvements in asthma symptoms or lung function. Combined interventions involving behavioral therapy are encouraging but highlight the need to implement sustainable programs. Utilizing schools to increase physical activity is a promising strategy, as children spend a majority of their time in schools.

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Key Points

- Assessing physical activity, fitness level, sedentary time, and nutritional status is important in the management of children with asthma, as they are potentially modifiable factors.
- Lifestyle interventions, incorporating exercise and/or diet, and behavioral therapy have demonstrated improvements in fitness, asthma symptoms and control, and asthma-related quality of life.
- Long term follow-up and consideration of feasibility and sustainability are necessary for programs that can be disseminated and implemented in diverse communities.
- School-based programs and interventions could represent an important opportunity that should be further studied. In order to implement these programs, it will be important to standardize asthma management and educate school personnel.

Table 1.

Exercise Interventions in Pediatric Asthma

Study	Population	Intervention	Outcomes	Results
Abdelbasset al(29) RCT	38 children with moderate persistent asthma, 8–12 years of age, 23 males, 15 females. Moderate persistent asthma: FEV ₁ =60–80% predicted, receiving combined ICS-LABA.	10 weeks of aerobic exercise vs conventional treatment Aerobic exercise (AE) group: medical treatment and moderate intensity aerobic exercise 3 sessions/week using treadmill (40mins sessions, 50–70% maximum heart rate). Control group: medical treatment only.	-Lung function (FEV ₁ , FVC) -Aerobic capacity: VO ₂ max, 6MWT, fatigue index, OOL (Pediatric Asthma Quality of Life Questionnaire) Timepoints: baseline and end of 10 week intervention.	Lung function: improvement in FEV ₁ % predicted, FVC% predicted within groups ($p<0.05$) and between groups in favor of AE group($p<0.05$) Aerobic capacity: improvements in VO ₂ max within groups ($p<0.05$) and between groups in favor of AE group ($p<0.05$); improvement in 6MWT and fatigue index in AE group only ($p<0.05$). QOL: All dimensions significantly improved in AE group ($p<0.05$). No significant sex differences in outcomes. Attendance: 97.7%
Carew et al(33) RCT	41 children with mild or moderate asthma, 9–16 years of age, 58% male.	6 weeks of exercise intervention Exercise: 3 groups (swimming, football, and basketball) for 40mins/once a week Control group	-Lung function (FEV ₁ , FVC, FEV ₁ /FVC); peak flow (PEF) measurements (twice daily). -Asthma diaries	Lung function: significantly higher FVC % in all 3 exercise groups compared to control (all $p<0.05$); swimming group demonstrated a significant increase in PEF % compared to control ($p=0.04$). Asthma symptoms: improvement in all three groups; swimming (77%), basketball (37.5%), football (25%) compared to control (0%). No change in asthma medications during intervention.
Kirkby et al(31) Retrospective chart review	38 children with asthma; 4–19 years of age with mean age of 11.3; 18 female and 20 male; 58% Caucasian and 24% African American; 87% overweight or obese. Asthma: majority with medication-based evidence of persistent asthma (67% on ICS/LABA or 31% ICS).	Pulmonary rehab program: 2–3 sessions/week for 6–8 weeks, each sessions lasting 90–120mins including aerobic exercise, strength and flexibility exercises. Referral reason: 74% obesity, 69% poor controlled asthma, 69% exercise limitation.	-Lung function -6MWT -Anthropometrics: weight, BMI -Clinical: shortness of breath (SOB) questionnaire, QOL (Pediatric Quality of Life Inventories)	Lung function: improvement in FEV ₁ (89.9% of predicted versus 96.4%, $p=0.04$). - 6MWT: improvement in distance ($p=0.05$). Clinical: improvement in SOB score ($p=0.02$), physical QOL score ($p=0.04$) Anthropometrics: no significant change in weight, BMI, or BMI %ile.
Lu et al(58) Prospective cohort	19 children, 6–13 years of age with asthma, 100% Hispanic, 11 overweight/obese and 8 normal weight. Asthma: 10 persistent asthma, 9 intermittent asthma.	4 months of exercise training Exercise training: at the schools during afterschool hours (3 sessions/week) and included mainly aerobic age-appropriate activities/games and a small component of muscle strength.	-Lung function -Aerobic fitness (peak VO ₂) -Habitual physical activity (accelerometers) -Body composition (BMI, DXA) -Clinical: asthma questionnaires (asthma control, QOL). -Cardiometabolic risk factors (lipid levels).	Lung function: no significant change. Aerobic fitness: peak VO ₂ improved significantly (8.1%, SD ± 10.1). Body composition: no significant change in BMI %ile but a significant improvement in lean body mass (1%, SD ± 2.0) and decrease in body fat (1.9%, SD ± 4.6). Clinical: improvement in QOL but not asthma control, 50% with persistent asthma decreased their maintenance medications. Cardiometabolic risk factors: Lipid levels did not change except HDL levels increased ($p=0.04$). Attendance: 17/19 participants completed the study, 85% adherence.
Zhang et al(30) RCT	72 children with mild asthma, 4 to 12 years of age Mild asthma: symptoms <1 per week, not on any asthma treatment.	6 weeks of intervention Treatment group: exercise plus montelukast (4mg) Control group: montelukast alone (4mg).	-Lung function (FEV ₁ , FEV ₁ /FVC) Secondary endpoints: -clinical symptoms -QOL.	Lung function: no improvement in FEV ₁ ($p=0.80$) and FEV ₁ /FVC ($p=0.44$) in treatment group compared to control. Clinical: significant relief in clinical symptoms in treatment group compared to control ($p<0.01$); improvement in QOL in treatment group compared to control ($p<0.01$).

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Study	Population	Intervention	Outcomes	Results
		Exercise program, consisting of 3 sessions/week of 40mins aerobic circuit training.	Timepoints: baseline, end of 6 week intervention, 2 week follow-up.	Both groups had similar safety profile.

FVC: Forced vital capacity. FEV₁: Forced expiratory volume in 1 second. ICS: inhaled corticosteroid. LABA: long acting beta agonist. QOL: quality of life.

Table 2.

Nutritional Interventions in Pediatric Asthma

Study	Population	Intervention	Outcome	Results
Bseikri et al(39) RCT	56 adolescents overweight/obese with poorly controlled asthma. Asthma: physical diagnosed, ACT score 19, BMI >85% ile.	2-month intervention (2:1 allocation ratio of CHORI-bar to control); randomized based on ACT score. Intervention group (CHORI bar): 2 bars daily and weekly exercise/nutrition classes. Control group: weekly exercise/nutrition classes. Subgroup: continued for 4 additional months, with monthly classes, and the CHORI-bar group ate 1 bar each day.	-Lung function (spirometry, FENO) -Clinical: asthma status, asthma control, QOL -Anthropometrics and other physical measures (blood pressure, HR, weight, waist circumference, BMI) -Biochemical analyses: fasting blood glucose, lipid levels, CRP, total IgE, Vitamin D 25-OH, HOMA-IR. Timepoints: baseline, 2 months, 6 months.	Intent-to-treat analysis Lung function: no differences Clinical: no differences Anthropometrics: no differences except HR decreased in controls only Biochemical: no differences except insulin and HOMA-IR decreased in control group and increased in CHORI-bar group (both $p<0.05$). Subgroup analysis (acceptable compliance and FENO <50 ppb, CHORI-bar, n = 16; controls, n = 15) Lung function: FVC%, FEV% increased in CHORI-bar group only primarily in participants with low chronic inflammation (CRP <1.5 mg/L). 1/3 of initially randomized participants lost to follow up.
Lang et al RCT	98 adolescents with overweight/obesity and uncontrolled asthma, mean age 14.6 years, 50% Black. Asthma: persistent asthma with poor asthma control, on daily ICS, evidence of bronchodilator reversibility or airway hyper-responsiveness.	24 weeks of intervention; randomized subjects in a 3:1 allotment to n3PUFA (4 g/d) or soy oil control.	Primary outcome: -asthma control Secondary outcomes: -Blood leukocyte n3PUFA levels -urinary leukotriene-E4 -lung function -asthma-related events. Timepoints: baseline, 3 months, 6 months.	Asthma control: no difference within groups, between groups at 3 or 6 months (all $p>0.05$). Lung function: no difference within groups, between groups at 3 or 6 months (all $p>0.05$). n3/n6 PUFA ratio: increased in circulating granulocytes and monocytes at 3 and 6 months in treatment group (all $p<0.05$). Clinical: no difference in asthma exacerbations, medication changes between groups except for decreased urgent phone calls in treatment group ($p=0.02$). ALOX5 genotype did not affect n3PUFA treatment responses. N3PUFA was well tolerated in majority of participants. Attendance: more than 86% completed all visits.

CRP: C-reaction protein. HOMA-IR: homeostatic model of insulin resistance. HR: heart rate. n3PUFA: omega-3 fatty acids

Table 3.

Combined Exercise, Nutrition and Behavioral Interventions in Pediatric Asthma

Study	Population	Intervention	Outcome	Results
Fedele et al.(51) Pilot RCT	24 children with asthma, BMI 85 th = percentile, mean age 8.7 years, 54% female, 67% African American.	16 week behavioral family lifestyle intervention (Childhood Health and Asthma Management Program (CHAMP)) for youth with overweight or obesity (OW/OB) and asthma. Intervention: 12 group based and 4 individual family sessions on asthma education, healthier eating, physical activity, and behavioral self-regulation strategies. Control: health education group ie. asthma management, nutrition, physical activity.	-anthropometrics: BMI -Lung function -Clinical: asthma control, QOL -Satisfaction Timepoints: baseline, 16 weeks, 6 months post-intervention	Anthropometrics: no statistically significant between group differences at post-intervention or follow-up; medium effect size in BMI z-score favoring intervention change ($d=-0.43$) Lung function: no statistically significant between group differences at post-intervention or follow-up; medium to large effect sizes in FVC ($d=0.94$), FEV ₁ ($d=0.66$), FEF ₂₅₋₇₅ ($d=0.54$) favoring intervention Clinical: no statistically significant between group differences at post-intervention or follow-up; medium effect size change in asthma control ($d=0.45$) and QOL ($d=0.34$) favoring intervention Satisfaction: high satisfaction of program; Attendance: 6/14 in intervention, 6/10 in control attendance >50% of sessions
Horner et al.(59) Pilot prospective cohort	13 children with asthma, 9-14 years, 61% female, 38.5% Hispanic, 46% African-American, 46% obese. Asthma: physician-diagnosed, symptoms in the past 12 months.	12-week family-focused combined lifestyle health intervention (Living Healthy with Asthma) 6 home visits, 3 phone calls addressing asthma self-management, healthy lifestyle behaviors, motivational interviewing. A matched comparison sample was drawn from a separate study that tested the same asthma self-management component (single intervention) used in the feasibility study.	-Healthy lifestyle variables: BMI, dietary quality). -Clinical: asthma severity, QOL, asthma-self-management, MDI skill	Healthy lifestyle variables: significant reductions in BMI z-scores ($p=0.007$), improvement in vegetable servings ($p=0.03$) Clinical: significant improvement in MDI skill ($p=0.005$), child QOL ($p<0.001$), parents' QOL ($p=0.03$). No significant differences in asthma self-management, MDI skill, or asthma severity after the interventions compared to comparison group. Attrition: 23%.
Lucas et al.(50) Post-hoc analyses	232 children: mean age 11 years; 54% were male, 64% were Hispanic, and 37% had asthma; BMI 90 th ile.	12-week nutrition and activity intervention program (Healthy Hearts Program) for children who are overweight, obese, or at risk for heart disease and other conditions. Exercise: 40min sessions, Optional motivational therapy by psychologist.	-Anthropometrics: BMI -Aerobic fitness: VO ₂ max (estimated) -Exercise intensity: METs	Anthropometrics: significant BMI decreases in asthmatic ($p=0.002$) and non-asthmatic ($p=0.001$) Fitness: increase in VO ₂ max for asthmatic males and females ($p=0.003$, $p=0.004$) and non-asthmatic males and females ($p<0.001$ for both). Exercise intensity: increase in METs in asthmatics and non-asthmatics ($p=0.033$, $p<0.001$). Attendance: median time in program of 9 weeks, 58% completed the program.

BMI: body mass index. MDI: metered dose inhaler. METs: metabolic equivalents. QOL: quality of life

Table 4.**Barriers to Physical Activity from Perspectives of Physical Education Teachers, School Officials, and Parents**

Physical Education Teachers(57)	<ul style="list-style-type: none"> • Most PE teachers were unaware of written asthma management plans and did not receive asthma-specific training. • Many teachers do not receive a list of students requiring asthma medications. • Some teachers reported fear or anxiety toward asthma management, particularly when the nurse is absent. • Despite PE requirements (in NY), the majority of PE teachers revealed that PE time is variable and often affected by inclement weather or lack of facilities.
School Officials(55)	<ul style="list-style-type: none"> • Procedures and policies around asthma management in school: ineffective ways of identifying students with asthma; lack of written procedures for asthma management. • Barriers to effective medication administration in school: difficulty in meeting the administrative requirements to administer asthma medication. • Barriers to PA in children with asthma: parental limitation of children's PA, schools not meeting the state physical education requirement.
Parents(56)	<p>Interpersonal barriers to PA:</p> <ul style="list-style-type: none"> • Parental fear of exercise-induced asthma due to lack of child symptom awareness. • Non adherence and refusal to take medications. • Challenges with asthma management. <p>Community barriers to PA:</p> <ul style="list-style-type: none"> • Lack of trust in school management of asthma. • Lack of school PA facilities. • Unsafe neighborhoods. • Financial burden of PA.