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Benefits of pulmonary rehabilitation in pediatric asthma

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Abstract

Introduction: There are limited studies evaluating the role of pulmonary rehabilitation (PR) in pediatric asthma.

Methods: A retrospective chart review was performed of all pediatric patients with a diagnosis of asthma enrolled in PR. Demographics, medications, and clinical records were reviewed. In addition, PFTs, 6-min walk test (6MWT), and patient/parent symptom and quality of life surveys before and after PR were evaluated.

Results: A total of 38 patients were enrolled in PR; 18 (47%) female and 20 (53%) male. Mean participant age was 11.33 ± 3.37 (range 4-19) years. Twenty-two (58%) were Caucasian and nine (24%) African American. Chart review was limited by incomplete data sets for many participants. Following PR, significant improvement was noted in mean 6MWT distance (1541 vs 1616 feet, $P = 0.05$) and FEV1 (89.9% of predicted versus 96.4%, $P = 0.04$). Survey instruments demonstrated improvement in several clinical factors, however, there was no significant change in weight following PR despite scheduled cardiovascular exercise and dietary counseling.

Conclusions: Structured PR for pediatric patients with asthma can improve 6MWT distance and FEV1 as well as subjective measures of SOB and QOL, suggesting a role for PR in the chronic management of pediatric asthma. Further prospective investigation is needed to determine if PR has positive effects on other clinical parameters of asthma control and its overall impact on childhood obesity.

KEYWORDS
asthma, obesity, pediatrics, pulmonary rehabilitation

1 | INTRODUCTION

Asthma is the most common chronic respiratory disease in children, affecting millions of patients throughout the world. Pediatric asthma negatively impacts quality of life, and is responsible for high levels of medications and healthcare resource utilization.[1–3] Treatment strategies are largely based on a pharmacological approach of using controller medications to alleviate chronic symptoms and to decrease the frequency and severity of acute exacerbations. While current asthma guidelines call for an individualized medicine treatment plan, there are limited data on non-pharmacological interventions.

Given that asthma is a heterogeneous disease with varying genetic, environmental, and immunologic phenotypes, a personalized approach to managing individual patients may help augment and improve traditional care.[4] Obesity among children is rising in prevalence and there is abundant evidence demonstrating an association between obesity and asthma.[5–7] Regular physical activity and nutritional intervention, in addition to standard asthma pharmacotherapy, may be very important clinical treatments to children with obesity and asthma.

Pulmonary rehabilitation (PR) involves structured and supervised exercise programs designed to improve endurance and overall

well-being in patients with chronic lung disease. Most PR programs are focused on adults with chronic obstructive pulmonary disease (COPD). PR improves quality of life and decreases healthcare utilization in patients with COPD and is, in fact, a recommended treatment for all patients with advanced COPD.[8] However, there is a lack of existing data on the benefits of PR programs as a treatment for asthma. Several small studies have suggested comparable clinical improvements for adults with asthma compared to those with COPD.[9,10] Furthermore, formal pediatric pulmonary rehabilitation programs are very rare in pediatric settings, and there is a lack of data describing the potential benefits of PR in children with asthma. The purpose of this research was to evaluate the effects of a structured, pediatric-specific PR program in a group of children with chronic asthma and obesity.

2 | METHODS

2.1 | Study design and subjects

The study was an observational, retrospective chart review performed at Nationwide Children's Hospital and The Ohio State University Department of Pediatrics. The study was approved by the Institutional Review Board (IRB#12-00428). Every child with asthma who was enrolled in the PR program from 2006 to 2012 was included in the study.

2.2 | Pulmonary rehabilitation program

The PR program at Nationwide Children's Hospital was certified by the American Association of Cardiovascular and Pulmonary Rehabilitation in 2009. It is a medically supervised, multi-disciplinary program consisting of two or three encounters per week for 6-8 consecutive weeks. For the purposes of this study we define "encounter" as the PR services provided on a given day, and "session" as the total group of encounters each patients received over the 6-8 weeks. Patients were expected to attend at least 80% of encounters in a session. Each encounter is 90-120 min in duration. Every patient included in the study received individual monitored exercise supervised by a respiratory therapist or exercise physiologist. Patients generally exercised for 30 min per session and performed various forms of supervised aerobic (treadmill or stationary bicycle), strength and flexibility exercises. In addition, all asthmatic patients and their caregivers received asthma-specific education by a trained asthma educator. This education occurred at encounters focused at the beginning and end of the PR session, with specific emphasis on proper inhaler technique, asthma action plans, and adherence with controller medications. For patients who were overweight or obese, formal nutritional counseling was provided by a trained dietician on a weekly basis. This included weight monitoring and education on healthy eating, exercise, and short- and long-term weight loss strategies optimized for the individual patient and caregivers.

Data analyzed for the purposes of this study included demographics, pulmonary function tests (PFT), 6-min walk test (6MWT) distance, and nutritional parameters such as weight and body mass index (BMI). Scores from patient-reported and parent-reported symptom and quality of life instruments including the UCSD Medical Center Pulmonary Rehabilitation Program Shortness of Breath (SOB) questionnaires, and the PedsQL Pediatric Quality of Life Inventories (QOLI) were recorded. Data were recorded at the beginning and also at the end of the PR session. In addition, the patient's clinical records were reviewed to obtain information on asthma co-morbidities and medication use, documented indications for referral to the PR program, and also whether there was any clinician documentation of a positive response to PR.

2.3 | Statistical analysis

Demographic and clinical data were reported as mean, median, and standard deviation, or frequency and percentage, depending upon the level of data. Differences between groups were calculated by paired *t*-tests or Wilcoxon signed rank test as appropriate. A *P*-value of <0.05 was considered significant.

3 | RESULTS

A total of 38 asthmatic patients enrolled and participated in 39 separate PR sessions (one patient was re-enrolled and completed sessions in differing years). Thus there were a total of 39 PR sessions included in the study analysis. All patients were included in the study, even if there were incomplete data available. There was near equal enrollment of boys ($N = 20$, 53%) and girls ($N = 18$, 47%). The mean participant age was 11.3 ± SD 3.4 years. Table 1 provides more information on patient demographics and clinical characteristics. The study population was overwhelmingly obese with 32 of 38 patients (82%) having a BMI% of greater than the 95th percentile. In addition, two patients (5%) were overweight with BMI% between the 85th and 95th percentile. Secondary complications of severe obesity were also reported in several patients: obstructive sleep apnea ($N = 7$, 18%), hypertension ($N = 2$, 5%), diabetes mellitus ($N = 4$, 10%).

Although a uniform classification of asthma severity was not obtained, the majority of children had medication-based evidence of persistent asthma at the time of their PR referral. Almost all patients were treated with combined inhaled corticosteroids (ICS)/long acting beta agonist inhalers ($N = 26$, 67%) or ICS inhalers ($N = 12$, 31%). In addition, 27 patients (69%) were treated with leukotriene inhibitors. Among key asthma co-morbidities, many patients had documentation of allergies requiring therapy with oral antihistamines ($N = 13$, 33%) or nasal corticosteroids ($N = 8$, 21%). Gastro-esophageal reflux disease (GERD) was prevalent in the group of patients and 26 of 39 patients (67%) were treated with proton pump inhibitors and/or histamine blockers at the initiation of PR. A small number of patients were reported by parents to be exposed to second hand cigarette smoke ($N = 6$, 16%), but no child reported that they actively smoked or used tobacco products. Patients were referred to the PR program by pulmonary and primary care physicians ($N = 25$, 64%) and pulmonary nurse practitioners ($N = 13$, 39%). The most common cited reasons (as

TABLE 1 Demographic and clinical characteristics (N = 38 patients)

Characteristics	Mean ± standard deviation
Age (years)	11.3 ± 3.4
	Frequency (%)
Boys	20 (53)
Girls	18 (47)
Age <7 years	4 (11)
Age 7-12 years	19 (50)
Age 13-18 years	15 (39)
Caucasian	22 (58)
Black	9 (24)
Hispanic/Latino	2 (5)
BMI% >95th percentile	32 (82)
BMI% 85-95th percentile	2 (5)
Co-morbid condition	
Obstructive sleep apnea	7 (18)
Hypertension	2 (5)
Diabetes mellitus	4 (10)
Gastroesophageal reflux disease	26 (67)
Medications	
Inhaled corticosteroids	12 (31)
Inhaled corticosteroids/long acting beta agonist	26 (67)
Leukotriene inhibitors	27 (69)
Oral antihistamine	13 (33)

documented in available clinician's records) for referral to the PR program were: obesity (74% of referrals), poorly controlled asthma (69%), and exercise limitation (69%).

A total of 33 patients (85%) completed 6MWT at the initial and final PR visit (Table 2). The 6MWT distance among these patients significantly improved with completion of the PR program (1541 vs 1616 feet, P = 0.05). Pre- and post-PR pulmonary function tests were completed in only 17 patients (45%). Compared to the initial PR assessment, children achieved a significant improvement in FEV_1 following completion of the PR program (FEV1 89.9% of predicted vs 96.4%, P = 0.04).

A total of 18 patients and their parent(s) completed both pre- and post-PR shortness of breath (SOB) and quality of life (QOL) questionnaires. There was a significant improvement (defined by decrease) in SOB score before and after PR (25.4 vs 15.3, P = 0.02). There was a significant improvement in patient-reported physical QOL score pre- and post-PR (59.8 vs 70.7, P = 0.04). However, there was no improvement in psychological QOL score (63.5 vs 77.9) A total of 24 patients (62%) had evidence of a positive clinical outcome from PR at a follow-up visit with the referring asthma clinician. Completion of the PR program did not have a measurable effect on nutritional parameters, as there was no significant change in weight, BMI, or BMI% predicted.

4 | DISCUSSION

In this retrospective review of predominantly obese or overweight children with asthma who participated in a formal pediatric PR program, we found evidence of clinical benefit in several parameters, including improved 6MWT, lung function, and patient and parent reported quality of life measures. Our study is unique in that we report outcomes from our novel pediatric PR program, which is structured in a similar manner to traditional adult PR programs.

Our findings expand upon the limited available literature on the benefits of exercise in childhood asthma. Bingol Karakoc et al randomized 28 children with mild persistent or moderate asthma to receive 30 days of daily home based exercise that was supervised by their parents or standard asthma care.[11] At the conclusion of this intervention, patients receiving exercise achieved improved lung function as well as improvements in quality of life index and medication scores. Basaran et al randomized 62 children with mild to moderate asthma to receive submaximal exercise (intensive basketball training) three times a week for 8 weeks.[12] At the completion of the study period, those patients receiving the exercise training had improvements in 6MWT and other measures of exercise capacity. Improvement in lung function was not observed, however, there was an improvement in symptom scores among those receiving the exercise intervention. While both of these studies involved randomized and prospective exercise as a treatment intervention for children with asthma, neither study involved a structured multidisciplinary PR program.

The majority of patients in our cohort were obese or overweight and weight was frequently cited as a reason for referral to the PR program. Although the PR program itself did not result in improved nutritional parameters, patients did have objective improvements in lung function and 6MWT distance. Furthermore patients and their parents reported subjective improvement post PR quality of life surveys. Clinicians noted benefits of PR in the majority of patients at follow-up visits. It is possible that the observed improvement in lung function sessions were a result of very close clinical follow-up during the PR session. This may have resulted in improved adherence with controller medications. It is also possible the effects of exercise-itself may have had positive benefits on lung function in this cohort of patients. The subjective improvements may have been multifactorial and related to exercise, improved adherence with medical therapy, and the educational intervention that was an inherent part of PR. It is unclear whether PR had any sustained, long-term benefits on asthma control or weight and exercise habits among these patients. This would be a very important outcome to evaluate in a future prospective investigation.

Our study has several important limitations. It was a single-center retrospective chart review of available clinical records. The PR program and was not designed a priori to capture several important measures of overall asthma control pre- and post-PR. There was no long-term follow-up after PR, and therefore, it was not possible to obtain long-term post-PR clinical information on many patients. Our study is also limited by incomplete data for many patients. There are numerous factors for this including an inconsistent approach to measurement of lung function and 6MWT in young children and the fact that our PR

TABLE 2 Comparison of pre- and post-pulmonary rehabilitation variables

	Pre-pulmonary rehabilitation				Post-pulmonary rehabilitation				
Variable	*N*	Mean	Median	Std Dev	*N*	Mean	Median	Std Dev	*P*-value
Weight (kg)	39	75.8	72	35.28	32	79.17	77.5	37.28	0.34[c]
6 min walk test (feet)	33	1541		405		1616		401	0.05[c]
FEV1 (%)	17	89.88	94	15.19	17	96.41	97	13.75	0.04[c]
SOB questionnaire[a]	18	25.39	22.5	14.14	18	15.28	14.5	11.22	0.02[c]
QOLI[b] child physical	8	59.77	57.81	22.31	8	70.7	70.31	15.66	0.04[c]
QOLI[b] child psychological	8	63.53	60.8	30.76	8	77.86	60.83	51.23	0.19[d]
QOLI[b] parent physical	8	52.72	50	18.93	8	61.72	68.75	26.08	0.19[c]
QOLI[b] parent psychological	8	60.99	52.5	32.49	8	74.56	54.97	45.22	0.02[d]

[a]UCSD Medical Center Pulmonary Rehabilitation Program Shortness of Breath (SOB) questionnaire.
[b]PedsQL Pediatric Quality of Life Inventories (QOLI) child self-reported and parent proxy-report.
[c]Paired *t*-test.
[d]Wilcoxon signed rank test.

program has used a combination of paper and electronic medical records and data collection.

Despite this study's inherent limitations, our work is unique in that it is the first report of the potential clinical benefits of a formal structured PR program for children with asthma. The fact that our patient group was overwhelmingly obese also suggests a clinical role for PR in those asthmatic children with chronic weight-related health problems. Although these obese patients did not lose weight during the time course of PR itself, the fact that they did experience an improvement in exercise capacity, lung function and QOL measures may be of subsequent and long-term benefit.

In conclusion, this retrospective study demonstrates the benefits or a structured PR program in a population of obese and overweight children with asthma. A prospective study is needed to determine if PR improves chronic asthma control, and to more clearly define subsets of asthmatic patients, like those with obesity, who may particularly benefit from PR programs.

AUTHORS' CONTRIBUTIONS

SK, study design and implementation, analysis of data, drafting and critical review of the manuscript. AR, DH, BA, SS, BK, AP, analysis of data, critical review of the manuscript.

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