Exercise Training on Disease Control and Quality of Life in Asthmatic Children

ADRIANA FANELLI[1], ANNA LUCIA BARROS CABRAL[2], JOSE ALBERTO NEDER[3], MILTON ARRUDA MARTINS[4], and CELSO RICARDO FERNANDES CARVALHO[5]

[1]Physical Therapy Department, University City of Sao Paulo, Sao Paulo, BRAZIL; [2]Hospital Darcy Vargas, Sao Paulo, BRAZIL; [3]Respiratory Division, Department of Medicine, Federal University of Sao Paulo, Sao Paulo, BRAZIL; [4]Clinical Medicine Department, and [5]Physical Therapy Department, School of Medicine, University of Sao Paulo, Sao Paulo, BRAZIL

ABSTRACT

FANELLI, A., A. L. CABRAL, J. A. NEDER, M. A. MARTINS, and C. R. CARVALHO. Exercise Training on Disease Control and Quality of Life in Asthmatic Children. *Med. Sci. Sports Exerc.*, Vol. 39, No. 9, pp. 1474–1480, 2007. **Purpose:** Aerobic training has been shown to be effective in improving cardiopulmonary fitness in asthmatic children. However, the actual impact of physical training on clinical indicators of disease control remains controversial. **Methods:** Thirty-eight children with moderate to severe persistent asthma were randomly assigned to control ($N = 17$) and training ($N = 21$) groups. Spirometry, exercise challenge, and maximum incremental cardiopulmonary exercise tests were performed 16 wk apart. Daily doses of inhaled steroids and Pediatric Asthma Quality of Life Questionnaire (PAQLQ) scores were also recorded. **Results:** Physical training was associated with significant improvements in physiological variables at peak and submaximal exercise ($P < 0.05$); in contrast, no significant changes were found in controls. Severity of exercise-induced bronchoconstriction (EIB) and postexercise breathlessness were significantly lessened in trained patients; improvement in fitness and EIB, however, were not linearly related ($P > 0.05$). In addition, PAQLQ scores improved only in trained children ($P < 0.01$). Daily doses of inhaled steroids were reduced in trained patients (52%), but they remained unchanged or increased in controls (70.6%) ($P = 0.07$). **Conclusion:** Supervised exercise training might be associated with beneficial effects on disease control and quality of life in asthmatic children. These data suggest an adjunct role of physical conditioning on clinical management of patients with more advanced disease. **Key Words:** ASTHMA, EXERCISE-INDUCED BRONCHOCONSTRICTION, PHYSICAL TRAINING, QUALITY OF LIFE

Subjects with asthma frequently present with a paradoxical response to physical activity. Although vigorous exertion can increase postexercise airways resistance, regular physical activity may be useful in the management of asthma (25). Unfortunately, the fear of inducing breathlessness inhibits many patients from taking part in regular play and sports with their peers (10). A low level of regular physical activity, in turn, leads to chronic deconditioning. It is not surprising, therefore, that some studies have found that patients with asthma tend to have lower cardiorespiratory fitness than their healthy counterparts (8,13,21).

Physical training programs in asthma have been designed to enhance aerobic power, neuromuscular coordination, and self-confidence (25). Although such programs seem to be effective in improving physical working capacity, their effects on health-related quality of life (HQoL) or disease control—as reflected by the daily use of inhaled steroids, for example—are still uncertain (27). Moreover, the value of physical training in ameliorating exercise-induced bronchoconstriction (EIB) remains controversial (20–22). As stated in a recent Cochrane review about the effects of exercise training in asthma (27), it is still currently unclear what the precise role is of this intervention in the clinical management of the disease, especially in more severe patients.

The main goal of the present study was to evaluate whether exercise training would improve HQoL and reduce EIB severity in children with moderate to severe persistent asthma. Secondarily, we assessed the effects of training on aerobic fitness and daily use of inhaled steroids.

PATIENTS AND METHODS

Patients

Thirty-eight children (aged 7–15) with moderate to severe persistent asthma according to clinical criteria were enrolled in this study. The children were recruited from a tertiary center specialized on pediatric asthma. All children presenting the following inclusion criteria were invited for

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Address for correspondence: Prof. Celso R. F. Carvalho, School of Medicine, University of Sao Paulo, Department of Clinical Medicine, Av. Dr. Arnaldo 455, sala 1216, 01246-903, São Paulo, SP, Brazil; E-mail: cscarval@usp.br.

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study participation: (i) asthma diagnosis and graduation of severity according to the Global Initiative for Asthma (GINA) guidelines (15); (ii) under medical treatment for at least 6 months before the study; and (iii) on a stable phase of the disease—that is, without any recent (15 d) disease exacerbation or change in medication usage. No children/parents declined the invitation. Children were recruited during a 12-month period. All enrolled children concluded the trial (i.e., there were no dropouts during the study). Asthmatic children were medically treated according to the GINA guidelines by a single pediatric pulmonologist. No child was attending a regular exercise training program. Patients with other cardiopulmonary and/or musculoskeletal diseases were excluded. The study was approved by the hospital ethical committee, and written informed consent was obtained from the patients and their parents. The costs of medication and transport for all children and their parents were covered by the researchers. No remuneration was offered.

Study Design

Before study inclusion, the children underwent a 2-wk run-in period to confirm disease stability. The patients firstly underwent an educational program in asthma control (as detailed below). Afterwards, they were randomly allocated (by drawing lots) to a supervised exercise training group (*N* = 21; 12 males) or a nonexercising control group (*N* = 17, 11 males). Before and 16 wk after the control or the intervention periods, the children answered the Pediatric Asthma Quality of Life Questionnaire (PAQLQ) and were submitted to pulmonary function tests, incremental cardiopulmonary exercise testing (CPET), and exercise challenges with posteffort breathlessness measurements. As cited, a single physician, who was blinded to patients' group allocation, was in charge of the medical follow-up.

Educational program. This program comprised two once-a-week classes, each lasting 2 h. The core activity was based on an educational videotape about the "ABCs of Asthma," with an interactive class to clarify doubts. The program also included lessons on disease pathophysiology, use of medication (relief and maintenance), and a written plan of action in case of worsening of symptoms.

Training program. Physical training was performed twice a week for 90 min during 16 wk. The program was divided into four parts: (i) 15 min of warm-up and stretching exercises, (ii) 30 min of aerobic exercise on cycle and/or treadmill, (iii) 30 min of upper- and lower-limb and abdomen endurance exercises, and (iv) 15 min of cooling down, stretching, and relaxation. Aerobic training was performed at the heart rate (HR) corresponding to two thirds of the difference between the anaerobic threshold (AnT) and the respiratory compensation point (RCP) as obtained in the incremental CPET (see below). This exercise intensity was selected to provide a sufficiently high metabolic/cardiovascular stress (i.e., above AnT) but still sustainable for a 30-min period. There was an initial (eight sessions) build-up period in which training intensity was gradually increased to allow the children to reach the proposed exercise intensity. Intensity was then increased by 5% when the child was able to continuously perform the proposed activity for two consecutive days. Respiratory discomfort (modified Borg (6) scale) and HR (by a HR monitor) were followed every 10 min throughout the aerobic training phase. Upper- and lower-body endurance exercise was performed with free weights at 70% of a 10-maximal repetition test. Participants performed two types of exercise with the upper limbs and two with the lower limbs (three sets of 15 repetitions). In addition, three flexion abdominal exercise sets were also performed (15 repetitions each).

Assessments

Spirometry. Spirometric evaluation was performed before and after the inhalation of 200 μg of salbutamol via a MDI (Kokko Spirometer, Pulmonary Data System). Technical procedures and acceptability and reproducibility criteria were those recommended by the American Thoracic Society (3). The following variables were recorded and expressed as body temperature, ambient pressure, saturated with water vapor (in Body Temperature and Pressure Saturated, BTPS) conditions: forced vital capacity (FVC, in liters), forced expiratory volume in 1 s (FEV_1, in liters), and the FEV_1/FVC ratio. Predicted normal values were those proposed by Polgar et al. (26) Maximum voluntary ventilation (MVV, in liters per minute) was obtained in a 12-s standard maneuver. A 12% and 200-mL increase in FEV_1 from baseline characterized a positive flow response to bronchodilator (3).

Exercise challenge testing. Tests were performed as previously recommended by the American Thoracic Society (1). The children were instructed to refrain from using long-lasting or short-lasting bronchodilators according to published guidelines (1). Briefly, treadmill speed was quickly increased (less than 4 min) to elicit a high cardiovascular (and, presumably, ventilatory) stress—that is, 80% of the maximum HR previously obtained on the incremental CPET (see below). This speed was subsequently maintained for 6 min. Spirometry was performed before and 5, 10, and 20 min after the exercise bout. Patients were also asked to score their levels of perceived dyspnea after exercise, using the Borg scale at these specific time points; recorded values were the median. Tests were performed at the same day period. Air conditioning and active dehumidification were used to control room air conditions: temperature between 20 and 25°C and air humidity below 55%. A FEV_1 decline equal to or greater than 10% of its preexercise value was assumed as indicative of EIB (1).

CPET. Symptom-limited, cycle ergometer CPET was performed on a digital computer-based exercise system

(Sensormedics, Vmax 229), with breath-by-breath analysis of metabolic, ventilatory, and cardiovascular variables. The rate of power increment was individually selected to provide exercise duration of more than 8 and less than 12 min (15 $W \cdot min^{-1}$ for height < 150 cm; 20 $W \cdot min^{-1}$ for height > 150 cm) (16). The following data were recorded as moving averages of eight breaths: oxygen uptake ($\dot{V}O_2$, in milliliters per minute in standard temperature, pressure, and dry conditions), carbon dioxide production ($\dot{V}CO_2$, in milliliters per minute STPD), respiratory exchange ratio (R), minute ventilation ($\dot{V}_E$, in milliliters per minute BTPS), ventilatory equivalent for oxygen and carbon dioxide ($\dot{V}_E/\dot{V}O_2$ and $\dot{V}_E/\dot{V}CO_2$), end-tidal partial pressures of oxygen and carbon dioxide ($P_{ET}O_2$ and $P_{ET}CO_2$, in millimeters of mercury), and oxygen pulse ($\dot{V}O_2/HR$, in milliliters per minute per beat). $\dot{V}O_{2peak}$ was predicted according to the Cooper et al. (9) equations for children: aerobic impairment ($\dot{V}O_{2peak}$; % predicted) was then arbitrarily classified as absent (above the lower limit of normality), mild (lower limit of normality to 70% predicted), moderate (70–50% predicted), or severe (below 50% predicted). $\dot{V}O_2$ at the anaerobic threshold was established by the gas-exchange method, inspecting the inflection point of $\dot{V}CO_2$ with respect to $\dot{V}O_2$ (modified V-slope) (5) and, secondarily, by the ventilatory method, when $\dot{V}_E/\dot{V}O_2$ and $P_{ET}O_2$ increased while $\dot{V}_E/\dot{V}CO_2$ and $P_{ET}CO_2$ remained stable, respectively. $\dot{V}O_2$ at the respiratory compensation point was defined where $\dot{V}_E$ started to change out of proportion to $\dot{V}CO_2$—that is, a systematic increase in $\dot{V}_E/\dot{V}CO_2$ with a consequent decline in $P_{ET}CO_2$.

Pediatric asthma quality-of-life questionnaire. This outcome was assessed by a three-domain questionnaire (18). The *activity* domain is composed of five questions, the *symptom* domain is composed of 10 questions, and the *emotional function* domain consists of eight questions. The response options of the PAQLQ are on a seven-point scale, where lower score indicates maximum impairment and higher scores indicate no impairment. The interviewer reads the question and the child gives the response, from the card, that best describes his or her experiences during the previous week. The questionnaire takes approximately 10–15 min to complete at the first visit and 7 min at follow-up. In this study, only the total scores (average of domain scores) are presented.

Inhaled steroid use. Changes on the daily doses of inhaled steroids were established before and after the control and the intervention periods according to the physician's prescription. This assessment was based on the determination of the difference in clinical potency when comparing inhalatory corticosteroid doses: flunisolide = triamcinolone (0.33) < beclomethasone (0.60) < budesonide (0.98) < fluticasone (1.20) (15). All doses were converted to the drug with the highest prevalence of use in our sample (budesonide). As cited, medical follow-up was performed by the same staff physician, who was blinded for group allocation.

Statistical Analysis

Data normality was firstly assessed by means of the Kolmogorov–Smirnov test. If nonnormality was suspected, data were reported as median and interquartile range; otherwise, means and standard deviations were used. Between-group comparisons were performed at baseline and follow-up by using nonpaired t-test or Mann–Whitney test for variables with parametric and nonparametric distributions, respectively. To assess changes from baseline, we performed a between-group comparison of the absolute changes (Δ = post−pre) by using the Mann–Whitney test. Chi-square or Fisher test was used to evaluate the association between changes in clinical and functional outcomes and response to training. Sign test was used to determine changes on categorical variables (e.g., level of aerobic impairment) after the intervention periods. Spearman's ranked correlation coefficient determined the level of association between variables. The level of statistical significance was set at 5% for all tests ($P < 0.05$).

RESULTS

Patient characteristics. Resting and exercise challenge characteristics at baseline are presented in Table 1. Trained children presented with significantly higher absolute FEV_1 values than controls; however, no difference was found in percent predicted, as trained children tended to be taller and heavier than controls (P = 0.09 and 0.15, respectively). There were no significant between-group differences in prevalence and intensity of EIB (Table 1). Consistent

TABLE 1. Anthropometric, pulmonary function, exercise challenge, and quality-of-life scores (PAQLQ) in control and trained children at the baseline evaluation.

	Control Group (N = 17)	Trained Group (N = 21)
Demographic and anthropometric		
Age (yr)	10 ± 2	11 ± 2
Weight (kg)	35.6 ± 12.3	42.0 ± 14.3
Height (m)	1.41 ± 0.12	1.46 ± 0.11
BMI ($kg \cdot m^{-2}$)	17.3 ± 3.1	19.2 ± 4.7
Pulmonary function		
Prebronchodilator		
FEV_1 (L)	1.77 ± 0.50	2.09 ± 0.53*
FEV_1 (% pred)	78.5 ± 14.5	85.3 ± 14.9
FVC (% pred)	95.3 ± 9.1	88.9 ± 12.9
FEV_1/FVC	0.81 ± 0.11	0.81 ± 0.11
MVV (L)	77.7 ± 25.8	83.2 ± 17.3
Postbronchodilator		
FEV_1 (L)	1.88 ± 0.53	2.35 ± 0.66*
Positive response	7/17	9/21
Exercise challenge		
% decrease in FEV_1	19.0 (23.0)	17.5 (34.2)
EIB positive	12/17	15/21
Severe EIB (> 30%)	4/12	8/15
Dyspnea (Borg scores)	4.0 (3.5)	5.1 (6.4)
Total PAQLQ score	2.42 (4.11)	2.67 (2.58)
Budesonide dosage (μg)	532 ± 218	542 ± 266
Asthma diagnosis (yr)	5.9 ± 2.2	6.4 ± 2.3

Continuous data are reported as means ± SD with exception of % change in FEV_1 and dyspnea and quality-of-life scores (median and interquartile ranges). BMI, body mass index; FEV_1, forced expired volume in 1 s; FVC, forced vital capacity; MVV, maximal voluntary ventilation; EIB, exercise-induced bronchoconstriction; PAQLQ, Pediatric Asthma Quality of Life Questionnaire. * $P < 0.05$ (nonpaired t-test or Mann–Whitney test for parametric and nonparametric data, respectively).

TABLE 2. Changes (post−pre) on physiological and subjective responses during the incremental cardiopulmonary exercise testing after control and trained periods in the asthmatic children.

	Control Group ($N = 17$)	Trained Group ($N = 21$)
Peak exercise		
Power (W)	5 (3)	17 (7)*
$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})	0.5 (0.8)	3.3 (1.1)*
$\dot{V}O_2$/HR (mL·min^{-1} per beat)	0.5 (0.3)	1.4 (0.6)*
Dyspnea (Borg scores)	2 (2)	−2 (2)*
At the anaerobic threshold		
Power (W)	−3 (2)	16 (7)*
$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})	0.1 (1.1)	4.0 (2.1)*
$\dot{V}O_2$/HR (mL·min^{-1} per beat)	0.2 (0.4)	1.1 (0.6)*

Data are reported as means ± SD. $\dot{V}O_2$, oxygen consumption; HR, heart rate; $\dot{V}O_2$/HR, O_2pulse. * $P < 0.05$ (Mann–Whitney test).

with our inclusion criteria (see Methods), the participants were using moderate to high doses of inhaled steroids (median = 600 μg·d^{-1} of beclomethasone, ranging from 400 to 1000 μg·d^{-1}).

Physiological effects of training. Patients presented with moderate to severe reductions in maximal exercise capacity at baseline: 24/38 (63%) had peak $\dot{V}O_2$ values < 70% predicted. Although mean peak $\dot{V}O_2$ values did not differ between groups, more trained patients had peak $\dot{V}O_2$ values < 70% predicted than controls (15/21 vs 9/17, respectively; $P < 0.05$).

All subjects of the training group successfully completed the proposed exercise program; that is, they attended at least 80% of the training sessions (see Methods). These patients presented with significant improvements in selected parameters of aerobic fitness ($\dot{V}O_2$, work rate, and oxygen pulse) during submaximal (anaerobic threshold) and maximal exercise intensities as compared with the controls (Table 2). In fact, 11 children improved their levels of aerobic impairment after training (e.g., from moderate to mild impairment) ($P < 0.01$); in contrast, 10 controls did not change their scores, and four of them actually worsened in the second evaluation. In addition, breathlessness scores at peak exercise improved only in the trained group (Table 2).

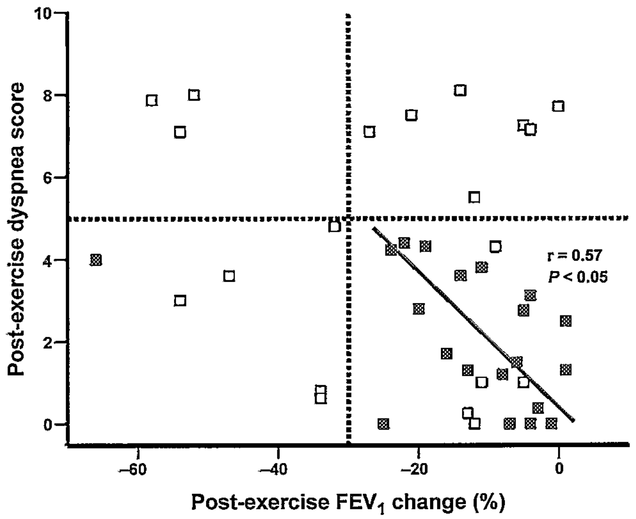

FIGURE 1—Relationship between EIB severity (FEV$_1$ decline) and postexercise breathlessness, either before (*open squares*) or after training (*closed squares*) ($N = 21$). Note that training was associated with marked reductions in dyspnea and EIB; in addition, only after training was there a significant correlation between posteffort airflow obstruction and symptoms ($P < 0.05$, Spearman's test). Reference lines indicate severe dyspnea (≥ 5) (11) and EIB (≥ 30% FEV$_1$ decline) (6).

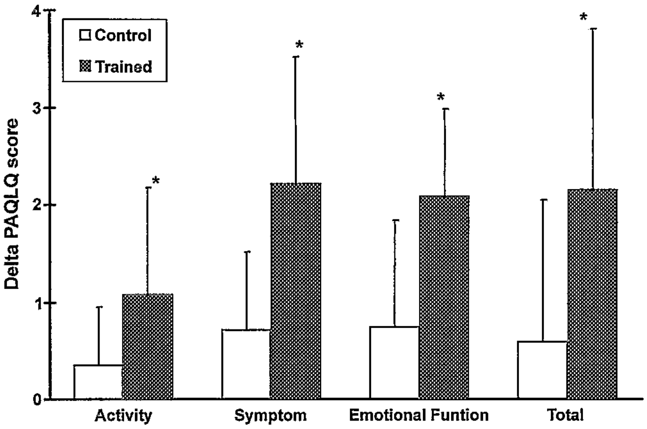

FIGURE 2—Trained children had significantly greater improvements in health-related quality of life (i.e., higher PAQLQ scores) compared with controls. * $P < 0.05$ (Mann–Whitney test). Data are presented as mean and standard deviation.

Effects of training on bronchodilator response, EIB, and breathlessness. There were no significant changes on lung function after the training or the control periods. There was a significant improvement in EIB severity in trained children, but not in control subjects (median (interquartile range) Δ change in % FEV$_1$ decline = 5.4% (1.6%) vs 9.7% (2.2%), respectively; $P < 0.05$). Consistent with these data, only 1 out of 10 children with EIB after training presented with severe EIB (> 30% FEV$_1$ decline); in contrast, five out of nine controls had severe EIB in the final evaluation.

In line with these results, trained children, but not controls, presented with lower respiratory discomfort after the exercise challenges (median (interquartile range) Δ change in dyspnea scores = 0.7 (1.1) vs 3.3 (1.2), respectively; $P < 0.05$). Interestingly, there was a significant relationship between improvement in EIB after training and decrease in postexercise dyspnea ($P < 0.05$; Fig. 1). There was no relationship between EIB intensity and postexercise dyspnea at baseline: five children with severe EIB had mild to moderate dyspnea (Borg score < 5), whereas seven children with mild to moderate EIB had severe breathlessness.

Effects of training on PAQLQ and medication use. Exercise conditioning was related to a significant improvement in health-related quality of life (PAQLQ scores) compared with the controls (Fig. 2). Total score ($P < 0.04$) as well as all domain scores (activity, $P < 0.04$;

TABLE 3. Changes on daily dose of inhaled budesonide after the control and intervention periods.

	Control	Trained	Total
Reduced (< 100 μg·d^{-1})	4 (29.4%)	11 (52.3%)	15
Unchanged	12 (64.7%)	7 (33.3)	19
Increased (> 100 μg·d^{-1})	1 (5.8%)	3 (14.2%)	4
Total	17	21	38

$P = 0.07$ (χ^2 test).

symptom, $P < 0.02$; emotional function, $P < 0.03$) improved in the trained compared with the control group. There was no significant relationship between improvement in exercise capacity and EIB with increases in PAQLQ scores after training (data not shown). In addition, inhaled steroid doses were reduced in 11/21 (52%) of the trained children; in contrast, these drugs were reduced in only 4/17 (23%) of the control subjects ($P = 0.07$). Inhaled steroids doses, however, were increased in three children of the trained group: these patients presented with acute exacerbations before the posttraining evaluation (Table 3).

Relationship between EIB and response to bronchodilator. We also investigated whether there would be a relationship between the response to a short-acting β_2-agonist and EIB, either before or after training. Postbronchodilator response was a poor predictor of EIB in either circumstance ($P > 0.05$): for instance, whereas only two patients with a positive drug response did not show EIB at baseline, 14 patients with positive EIB had a negative bronchodilator response (Fig. 3). In contrast, a positive drug response was frequently associated with an equally positive EIB test (Fig. 3).

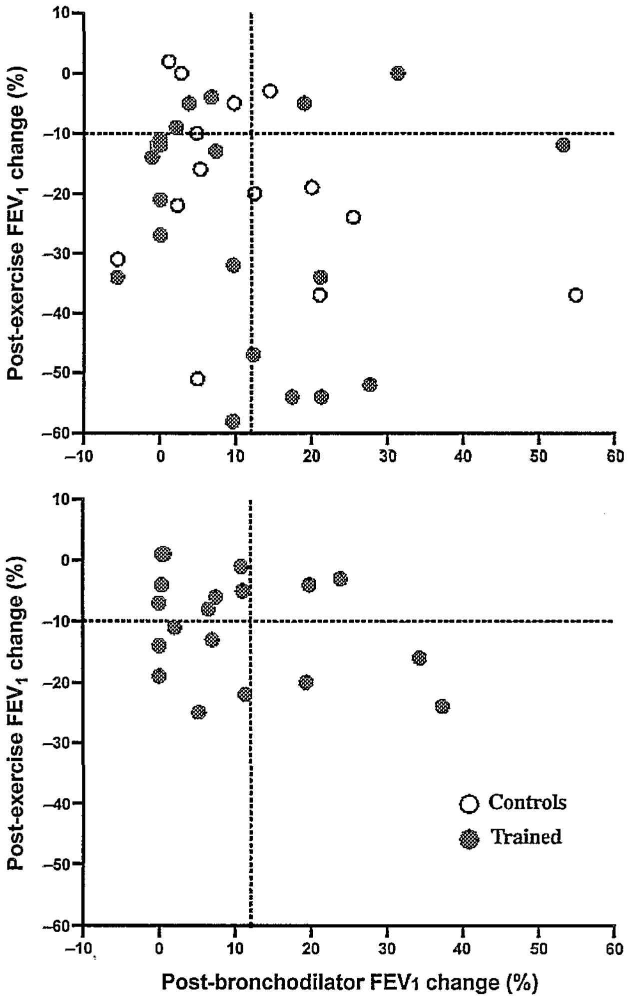

FIGURE 3—Association between postbronchodilator FEV_1 increase and postexercise FEV_1 change, either before or after training (*upper* and *lower panels*, respectively). As noted, a negative bronchodilator response (FEV_1 increase < 12%) had a low predictive value to rule out EIB (FEV_1 decrease > 10%); conversely, a positive response to bronchodilator was rarely associated with a negative EIB (*upper right quadrants*).

DISCUSSION

The present study shows that asthmatic children, even with moderate to severe disease, had their aerobic capacity significantly improved after a 16-wk physical training program. These beneficial changes were associated with a blunted response to an exercise challenge and reduced need of inhaled steroids after training as compared with a nontrained group. As a corollary, there was a significant improvement in the PAQLQ only in trained children. Our data, therefore, suggest that such structured exercise training programs might play a role as an adjunct therapeutic strategy for asthma control in this patient population.

Physical conditioning in asthma. Regular physical activity can improve aerobic capacity, body composition, flexibility, muscular strength, and some psychosocial measures in chronic respiratory diseases (2,12,19). However, there are still controversies regarding its effect on pulmonary function, EIB, corticosteroid use, and HQoL in pediatric asthma (27).

As stated in the recent Cochrane review about the effects of training on asthma, this intervention has been found to increase, on average, maximal workload (28 W) and $\dot{V}O_{2peak}$ (5.5 $mL \cdot kg^{-1} \cdot min^{-1}$) (27). In the present study, we found a lower improvement in maximal workload (17 W) and peak aerobic capacity (3.3 $mL \cdot kg^{-1} \cdot min^{-1}$; Table 2). In this context, we can speculate that a twice-a-week program might not be as efficient as more frequent exercise sessions (2). However, it is important to note that we did find positive changes on submaximal indices of aerobic capacity (anaerobic threshold), which do not depend on patients' motivation or willing to exercise maximally (see Study limitations). In fact, the ability to sustain submaximal exercise seems to be a more sensitive outcome to rehabilitative strategies than maximal exercise capacity (2,7). On a practical point of view, our study shows that persistent asthma does not preclude a significant improvement on effort-dependent (peak exercise) and independent (anaerobic threshold) parameters of aerobic function after training in the pediatric group.

Effects of physical training on EIB and related symptoms. In the present study, only children submitted to exercise training presented with a significant reduction in EIB severity. The children were evaluated for EIB at the same power output before and after training; considering that the anaerobic threshold improved (Table 2), it is likely that the ventilatory stress was diminished after training at a given submaximal exercise intensity. Unfortunately, we were unable to assess whether the decrease in EIB was or not related to the ventilatory stress during exercise, although recent data suggest that this is not the case (11). In fact, decreases in EIB after training were more likely to be found in studies in which the patients were trained above the anaerobic threshold, as in the present investigation (17,20,28). Future studies should be undertaken to investigate whether supraanaerobic threshold is superior to lower exercise intensities to reduce EIB severity in asthma.

Another interesting finding of this study was the significant decrease in perceived breathlessness after the EIB test in patients submitted to exercise training. Surprisingly, however, only after training did we find a linear relationship between decreases in EIB and reductions in dyspnea scores (Fig. 1). As EIB severity and dyspnea seem to have decreased proportionally after training (Fig. 1), these data might indicate that the degree of EIB has an important role—though nonexclusive—on modulating post-exercise dyspnea in asthmatics.

Exercise training, antiinflammatory therapy, and HQoL. Some studies have suggested that improved physical capacity may be associated with a reduction in inhaled corticosteroid use (21,29). In the present study, we confirm these findings in that 52% of trained patients were found to need less inhaled beclomethasone (or its equivalent) at the final visit compared with at baseline (Table 3). Although the exact nature of this relationship is still elusive, it has been suggested that psychosocial factors, such as improved treatment adherence and self-care, could be related to physical training in asthmatics (13,23). Alternatively, lower levels of exercise ventilation after conditioning could decrease the frequency and severity of EIB and, therefore, daily symptoms—which are clinically relevant to guide inhaled corticosteroid prescription. Independent of the precise mechanism, there are sufficient preliminary data to justify larger randomized trials using subjects' daily need of inhaled steroids as a major clinical outcome of physical training in asthma.

There have been few previous studies evaluating the benefits of exercise training on HQoL in asthmatic patients (4,7); in fact, the aforementioned Cochrane review on physical training for asthma recommends that more studies on this issue be performed in this patient population (27). As depicted in Figure 2, physical training did improve this crucial outcome in the present study. In asthmatic children, the disease has a negative impact on HQoL because of several factors, including the impossibility to participate in games and sports with other children, and a low level of disease knowledge (23). Reduced activity levels observed in asthmatics may also increase the incidence of obesity, with negative consequences on self-esteem (14,23).

EIB and bronchodilator response. The presence and intensity of the responses to bronchodilators and exercise were not significantly related to each other, either before or after training (Fig. 3). Undoubtedly, these findings reflect the different underlying mechanisms of the responses. More importantly, however, they also show that a negative response to a bronchodilator is not useful for ruling out EIB in an individual patient; conversely, a positive response to a bronchodilator is likely to be associated with a positive EIB test (Fig. 3). These preliminary findings should also be confirmed on larger trials involving a sizeable number of steroid-naive children, because chronic steroid use may have lessened the bronchodilator responses in the present study.

Study limitations. This study has some limitations. The first FEV_1 measurement was performed 5 min after exercise: some children, however, may present with EIB in shorter periods of time. Furthermore, exercise challenge intensity was set according to a fraction of maximal HR, not ventilation; recent findings have demonstrated that the relationships among cardiovascular stress, ventilatory demand, and EIB are far from linear (11).

Another relevant caveat of this study was the lower exercise capacity at baseline in the trained group: although improvement in fitness was associated with changes in other clinical and physiological outcomes, we cannot rule out that the regression to mean effect has contributed to increase the exercise scores in this group. Also, we did not record the daily use of short-acting bronchodilators: it could be speculated that the observed reductions in corticosteroid use may have been associated with increased use of rescue medication. However, children or their parents did not report any increases in daily need for rescue medication after steroid reduction. In addition, the present study may not have been sufficiently powered to demonstrate a larger effect of training on inhaled steroid use.

Finally, it should be recognized that our control group received an educational intervention, which included the provision and use of a written action plan. Previous studies have found that education alone can significantly improve asthma control, and we cannot rule out that this intervention may have lessened the differences between study groups (24).

In conclusion, the present study shows that exercise training can improve health-related quality of life and EIB with positive consequences on the daily need of antiinflammatory therapy in moderately to severely asthmatic children.

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The results of the present study do not constitute endorsement of any product by the authors or the American College of Sports Medicine.

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