

Effect of asthma treatment on fitness, daily activity and body composition in children with asthma

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To cite this article: Vahlkvist S, Inman MD, Pedersen S. Effect of asthma treatment on fitness, daily activity and body composition in children with asthma. *Allergy* 2010; DOI: 10.1111/j.1398-9995.2010.02406.x.

Keywords

asthma control; body composition; cardiovascular fitness; children; physical activity.

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Accepted for publication 11 April 2010

DOI:10.1111/j.1398-9995.2010.02406.x

Edited By: Hans-Uwe Simon

Abstract

Background: Although several cross-sectional studies have assessed the daily physical activity in children with asthma, the impact of the level of asthma control remains unknown.

Aim: To assess the influence of asthma treatment-induced changes in asthma control on daily physical activity, cardiovascular fitness and body composition in children with asthma.

Methods: Daily accelerometer-measured physical activity, cardiovascular fitness, body composition (percent fat, percent lean tissue and bone mineral density) and a variety of asthma outcomes (to assess the level of asthma control) were measured over 4 weeks in 55 children with newly diagnosed untreated asthma and 154 healthy, sex and age-matched controls. Treatment with inhaled corticosteroids was initiated after the baseline period. All outcome measurements were repeated after 1 year and some also during the year of treatment.

Results: Asthma control improved markedly during the year of treatment. The improvement in control was associated with a significant increase in total daily activity of 2.8 h/week compared with the healthy controls ($P < 0.001$). In addition, significant increases were seen in moderate-vigorous activity (33 min/week; $P = 0.01$) and in cardiovascular fitness (1.2 ml O₂/min*kg) compared with the healthy controls. The improvement in activity was mainly seen during the last 6 month of the study. No difference was seen between the two groups in changes in percent body fat.

Conclusion: Poorly controlled asthma is associated with reduced physical activity and cardiovascular fitness. Improvement in asthma control is associated with a clinically relevant increase in daily physical activity and cardiovascular fitness.

Background

Physical inactivity, poor physical cardiovascular fitness and obesity are potential threats to children's well-being, social development and short as well as long-term health (1–3). Because of the high frequency of exercise-induced bronchoconstriction in children with asthma, they are often considered at special risk of being physically inactive. On the other hand, with proper medical care, most children with asthma are able to, and are recommended to, be as physically active as healthy children (4). However, the present literature about the level of physical activity in children with asthma is conflicting. Some studies have reported lower activity (5, 6) in

children with asthma compared to healthy children whereas other studies found no difference in activity between healthy and children with asthma (7, 8). One study even found children with asthma to be more physically active or more fit than healthy children (9). Because the various studies were of cross-sectional design and generally without a thorough clinical characterization of patients, little is known about the potential causal relationship between cardiovascular fitness, daily physical activity and asthma, including the effect of the level of asthma control on these parameters.

Several studies have found an association between childhood asthma and obesity (10), and some have suggested that obesity may precede the asthma diagnosis (11, 12). However,

the importance of asthma-induced changes in lifestyle or the level of asthma control for this association still remains unclear.

The aim of this study was to compare cardiovascular fitness, daily physical activity and body composition in children with newly diagnosed, untreated asthma and healthy, age and sex-matched control children and to assess the association between changes in the level of asthma control and changes in these parameters. Recently, we reported that children with newly diagnosed, untreated asthma were less fit, ran shorter distances during an exercise test, had a higher percent body fat and were more frequently obese than age and sex-matched healthy peers (13). In addition, cardiovascular fitness and time spent in high activity during daytime correlated negatively with the level of asthma control and the percent body fat. Because of the cross-sectional nature of the study, no firm conclusions about causal effects could be made. To further explore the importance of asthma control on the differences in activity between asthmatics and their healthy peers, this article reports the results from the second part of the study: The influence of 1 year's treatment induced changes in asthma control on the changes in daily physical activity and cardiovascular fitness in the children with asthma compared with the changes in their healthy controls over the same period.

Subjects and methods

The methods and design have been described earlier (13). In short, children aged 6–14 suspected of asthma in general practice were referred for evaluation. All children with symptoms (cough, wheeze, dyspnoea) and variability in forced expiratory volume in 1 s (FEV1) > 12% of the predicted value after a β_2 -agonist reversibility test or an exercise challenge were invited to participate in the study. For each asthma case, three healthy, sex- and age-matched controls were included. The control children were recruited from local schools in the uptake area. During the first 4 weeks after inclusion (baseline period), the patients were seen three times at the clinic where the following measurements were made: Beta2 reversibility test, a dual energy X-ray absorptiometry (DEXA) scan, an ergometer bicycle cardiovascular fitness test (14) and a Childhood Asthma Control Test (C-ACT) (15) in children < 13 and an Asthma Control Test in older children (16) (first visit); a methacholine challenge test and Pediatric Asthma Quality of Life Questionnaires (PAQLQ) (17) (second visit); a treadmill exercise challenge, pulse rate and blood pressure and (third visit). In addition, measurement of exhaled nitric oxide (eNO), height and weight and lung function was taken at all visits. Throughout the whole 4-week baseline period, daily physical activity was measured 24 h a day using the RT3 accelerometer (18). Daily recordings of symptoms, rescue β_2 use, morning and evening peak expiratory flow rates and fractional eNO using Nioxmino (19) (Aerocrine AB, Stockholm, Sweden) were made in diaries. Except for methacholine challenges and asthma questionnaires, the healthy controls performed the same measurements at the clinic visits, but their home monitoring was restricted to accelerometer measurements of daily activity.

After the baseline period, the patients with asthma and their age and sex-matched healthy controls were followed for 1 year in an open parallel group study design. Treatment with inhaled corticosteroids and a prn rapid acting β_2 agonist was initiated in the asthma group after the baseline period. The dose of inhaled corticosteroid was adjusted according to guideline recommendations at the clinic visit after 5 months or in case of worsening of the disease. Concomitant rhinitis and atopic dermatitis were treated by nasal steroids and topical steroids, respectively. No interventions were made in the healthy controls. All measurements performed during run-in were repeated after 1 year (same month as run-in) in the healthy controls as well as the children with asthma. In addition, the measurements at home were repeated during the first 4 weeks after run-in and 5 months after treatment initiation (3 weeks). At these times, children with asthma also measured lung functions and eNO at the clinic and filled out the asthma questionnaires. The monitoring periods and clinic visits took place during the same periods in healthy and asthmatic controls to minimize the influence of seasonal variations.

Asthma treatment adjustments were carried out at the clinic visits depending on the level of asthma control.

Data management

Activity was quantified as overall daily activity in counts/minute, and as minutes per day spent at activity levels corresponding to rest (level 1), light (level 2), moderate (level 3) and vigorous (level 4) activity. These cut points for activity levels have been validated to correspond to energy expenditure of three metabolic equivalents (MET's) for the light level and six METs for the moderate level (18). For analysis, the higher categories were summarized to calculate time spent in levels 2–4, in levels 3–4 or in level 4. Days where the monitor had not been carried for at least half of the daytime were excluded from analysis.

Overweight was defined in two ways: (i) As a percent body fat > 30% and (ii) As a Body Mass Index exceeding the age adjusted cut point as defined elsewhere (20).

To characterize the patients more thoroughly at baseline, a 0–8 graded scoring system of asthma control was developed based on objective clinic measurements only: Reversibility test, exercise challenge, methacholine challenge and eNO (13).

Statistical methods

All comparisons between asthmatic and control subjects and between time periods were made using a 2-factor repeated measures analysis of variance (factor 1 = asthma/control; factor 2 = period). Following significant main effects, *post hoc* analysis was performed using Duncan's test. Data from the three matched pair control subjects were meaned, giving a single data point for comparison. Missing data were replaced by substituting a value corresponding to the group mean, corrected by the average difference between the group mean and the subject's value at all other available occurrences of that variable. Within the asthma group, Spearman's

correlations were done between changes in parameters of asthma control and changes in parameters of activity. A P -value < 0.05 was considered statistically significant.

Ethics

The study was approved by the local Ethics committee, and informed consent obtained from all participants and their parents before any study-related procedures were undertaken.

Results

Fifty-seven children with asthma and 157 healthy children were included. Two boys with asthma and two healthy boys dropped out shortly after inclusion because they found the study too demanding. One girl was lost to follow-up after first visit. Therefore, 55 children with asthma and 154 healthy children were included in the analyses. In most tests, the numbers of missing data were negligible, except for the baseline cardiovascular fitness test, where seven children with asthma were too short to reach the pedals of the bicycle, and

two were assessed to not quite achieve their maximum pulse rate (this was also the case for five children in the control group). At baseline, the two groups were comparable with respect to age (9.6 vs 9.7 years), height, weight and Tanner stage. The percent body fat was significantly higher in children with asthma (22.8%) than in the controls (19.5%), and more children with asthma were overweight (13). At baseline, 65% of the children with asthma had a positive ($\geq 15\%$ fall) exercise challenge test and 82% had at least one positive reaction in the skin allergy test (13).

The children with asthma mainly suffered from mild, uncontrolled disease with a mean FEV1 of 90% of predicted. Thirty-seven patients received budesonide in a mean daily dose of 400 mcg whereas 16 patients received fluticasonepropionate in a mean daily dose of 467 mcg. Four children were changed to combination therapy during the year of treatment.

After treatment initialization, all components of asthma control improved markedly (Table 1 and Fig. 1). The effect was seen rapidly after the start of treatment, and it was maintained with some additional improvements throughout

Table 1 Asthma outcome parameters

Variable	Group	<i>n</i>	Baseline (1) mean ($\pm 95\%$ CI)	Four weeks (2) mean ($\pm 95\%$ CI)	Six months (3) mean ($\pm 95\%$ CI)	Twelve months (4) mean ($\pm 95\%$ CI)
FEV1 % predicted	Asthma	55	90 (± 3.4) $\ddagger$	97 (± 3.4) $\S$	98 (± 3.2) $\S$	97 (± 3.9) $\S$
	Healthy	153	103 (± 2.9)		100 $\pm$ 2.9	99 (± 2.9)
EIB (% Fall)	Asthma	55	29.2 (± 5.7) $\ddagger$			9.6 (± 3.4) $\ddagger$ $\S$
	Healthy	153	4.6 (± 0.8)			4.5 (± 1.0)
eNO (ppb)	Asthma	55	37.0 (± 9.4) $\ddagger$	15.4 $\pm$ (5.0) $\S$	14.6 (± 3.8) $\S$	17.3 (± 5.1) $\ddagger$ $\S$
	Healthy	154	10.2 (± 1.6)		7.8 (± 1.8)	10.3 (± 1.7)
β_2 Reversibility (%)	Asthma	55	9.0 (± 1.9) $\ddagger$	6.5 (± 1.6) $\S$	6.0 (± 1.5) $\S$	4.5 (± 1.8) $\ddagger$ $\S$
	Healthy	154	2.9 (± 0.7)			1.8 (± 0.7)
PD20 (μ mol)*	Asthma	55	2.2 (± 0.8)			4.7 (± 1.6) $\S$
C-ACT (0–27)	Asthma	49	19.7 (± 1.2)	22.4 (± 0.9) $\S$	23.7 (± 1.0) $\S$	24.2 (± 0.7) $\S$
ACT (0–25)	Asthma	6	18.4 $\pm$ (2.0)	20 $\pm$ (1.6)	20.0 $\pm$ (1.7)	20.6 $\pm$ (0.6)
Poor control (%) $\ddagger$	Asthma		43.6 (30–60)	12.4 (5–25) $\S$	10.9 (4–22) $\S$	7.2 (2–18) $\S$
PAQLQ (1–7)	Asthma	55	5.7 (± 0.26)	6.1 (± 0.23) $\S$	6.2 (± 0.23) $\S$	6.4 (± 0.17) $\S$
Day symptoms (0–3)	Asthma	53	0.5 (± 0.1)	0.3 (± 0.1) $\S$	0.28 (± 0.1) $\S$	0.2 (± 0.1) $\S$
Night symptoms (0–3)	Asthma	53	0.3 (± 0.1)	0.08 $\S$ (± 0.1)	0.09 (± 0.1) $\S$	0.06 (0.0) $\S$
β_2 use (puffs/day)	Asthma	53	0.6 (± 0.2)	0.4 (± 0.2) $\S$	0.3 (± 0.1) $\S$	0.2 (± 0.1) $\S$

Asthma outcome parameters measured during the study. All asthma outcomes improved during treatment. No between group comparisons were made at 4 weeks and 6 months.

*Two patients did not reach a PD20.

$\ddagger$ C-ACT below 20 was defined as poor control.

$\ddagger$ Statistically significant difference in between-group-comparisons.

$\S$ Significant difference in within-group-comparisons (compared with baseline).

C-ACT, Childhood Asthma Control Test; FEV1, Forced expiratory volume in 1 s; EIB, Exercise-induced bronchoconstriction; eNO, Exhaled nitric oxide (ppb = parts per billion); PD20, dose of methacholine causing a fall in FEV1 = 20%; C-ACT, Childhood Asthma Control Test; PAQLQ, Pediatric Asthma Quality of Life Questionnaire.

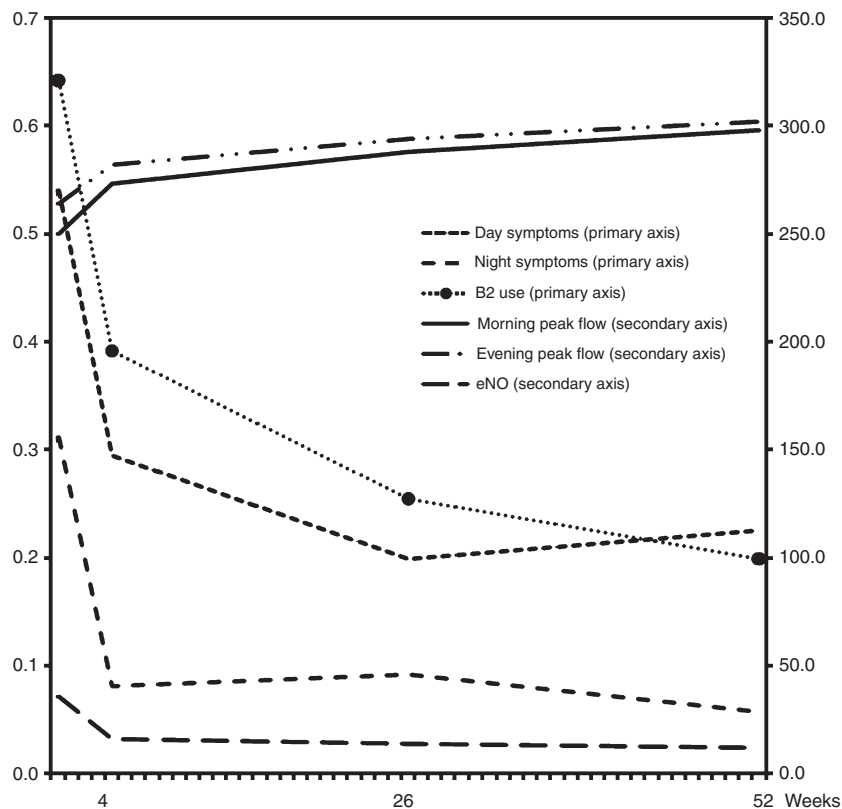


Figure 1 Diary recordings before (base-line) and during 1 year of asthma treatment in 55 children with newly diagnosed asthma.

the study year, with the vast majority of the improvement being reached at 6 months. At the end of the study, there was no statistically significant difference in FEV1 between patients with asthma and their healthy controls, whereas β_2 reversibility, fall in lung function after exercise and the level of eNO were still significantly higher in the asthma group.

At baseline, there was no overall statistically significant differences between the two groups in daily activity (13). However, the subgroup of 38 children with asthma whose asthma was most uncontrolled (composite control score > 3) spent significantly less time in level 4 (vigorous) activity (6.1 vs 8.3 min/day, $P < 0.05$) than their controls.

The time spent in activity (i.e. levels 2–4) improved significantly in the asthma group ($P < 0.0001$), whereas it remained unchanged in the healthy controls over the year (Table 2 and Fig. 2). As a result, the time spent at rest (level 1) had decreased significantly in the asthma group by 2.8 h per week at study end compared to the healthy controls ($P < 0.01$).

The time spent in at least moderate activity (level 3–4) increased over the year in both groups. Compared with the controls, the increase was more pronounced in the asthma group: 1 h and 40 min per week vs 1 h and 7 min. The mean difference of 33 min per week was statistically significant ($P = 0.01$). The increase in activity was most marked during the last 5 months of the study, and the extra gain in activity in the asthma group was seen here (Fig. 2 and Table 2). This was in contrast to the changes in asthma control for which the main improvements were seen the first 5 months of the study (Tables 1 and 2 and Figs 1 and 2).

The time spent in vigorous (level 4) activity increased to the same extent in the two groups. At study end, there was no statistically significant difference in daily physical activity between the two groups (neither time at rest, light-vigorous, moderate-vigorous or vigorous activity).

The improvements in cardiovascular fitness was 2.3 ml O_2 /min*kg (7%) in the asthma group and 1.1 ml O_2 /min*kg (3%) in the control group ($P < 0.05$). Expressing fitness as VO_{2max} /kg fatfree body mass (using dexta scan results obtained the same day) gave similar results. As cardiovascular fitness was measured at baseline and study end only, it is not known whether it followed a similar time course of change as the changes in activity.

The distance run during the exercise challenge test improved to the same extent in the two groups [88 m (asthma) and 67 m (controls)]. Both cardiovascular fitness and running distance during the exercise test were still significantly decreased in the asthma group at study end compared with the controls.

In contrast to the changes in the measures of activity and cardiovascular fitness, no statistically significant changes were seen during the year between the two groups in body percent fat, bone mineral density, lean tissue, blood pressure heart rate and pubertal development but the children with asthma grew significantly less than their healthy controls (4.8 vs 5.9 cm, $P < 0.01$) (Table 3).

No statistically significant correlations were found between gain in parameters of asthma control (C-act/ACT, FEV1, PD20 or EIB), and gain in activity in the asthma group. Children with a negative exercise test at inclusion (< 15% fall

Table 2 Activity parameters at a given study period

Activity (minutes/day)	Group	n	Baseline mean ($\pm 95\%$ CI)	Four weeks mean ($\pm 95\%$ CI)	Six months mean ($\pm 95\%$ CI)	Twelve months mean ($\pm 95\%$ CI)	Change mean ($\pm 95\%$ CI)
Level 1 (rest)	Asthma	55	1269.5 (± 14.5)	1269.0 (± 13.8)	1258.93 (± 14.9)	1245.4 (± 15.1)†	-24.1 (± 15.5)*
	Healthy	153	1261.0 (± 8.9)	1261.8 (± 9.0)	1249.50 (± 12.5)	1252.4 (± 9.9)	-8.5 (± 8.8)
Level 2–4 (light-vig.)	Asthma	55	170.1 (± 14.4)	171.0 (± 13.4)	182.1 (± 15.0)	195.4 (± 15.4)†	25.2 (± 15.7)*
	Healthy	153	179.2 (± 9.0)	178.1 (± 8.6)	190.1 (± 12.0)	188.5 (± 10.3)	9.7 (± 9.1)
Level 3–4 (mod.–vig.)	Asthma	55	31.5 (± 4.7)	33.8 (± 4.6)	38.9 (± 6.0)†	45.8 (± 6.2)†	14.3 (± 5.5)*
	Healthy	153	34.2 (± 2.7)	36.1 (± 3.3)	40.5 (± 4.6)	44.0 (± 4.0)†	9.6 (± 4.2)
Level 4 (vigorous)	Asthma	55	7.16 (± 1.5)	8.8 (± 1.9)	10.8 (± 2.6)†	13.4 (± 2.8)†	6.6 (± 2.4)
	Healthy	153	8.4 (± 1.0)	10.4 (± 1.5)	10.9 (± 3.0)†	13.4 (± 2.0)†	5.0 (± 2.0)
Cardiovascular fitness (mlO ₂ /min*kg)	Asthma	55	34.7 (± 2.0)*			37.0 (± 2.0)*†	2.3 (± 0.9)*
	Healthy	152	39.2 (± 1.5)			40.4 (± 1.5)†	1.1 (± 0.7)
Running distance (m)	Asthma	55	811.8 (± 48.9)*			900.1 (± 45.5)*†	88.2 (± 35.0)
	Healthy	153	917.3 (± 8.2)			982.4 (± 31.1)†	65.1 (± 15.3)

Daily time spent in activity levels 1–4 during the 1 year study. Time at rest decreased and time in at least light activity increased in the asthma group and remained unchanged in the healthy group. No differences in any activity levels were seen between the groups at study end. The changes in level 1, level 2–4, level 3–4 activity and in fitness were significantly higher in the asthma group than in the healthy group. No between groups comparisons were made at 4 weeks and 6 months.

*Statistically significant difference in between-group-comparisons.

†Statistically significant difference in within-group-comparisons (compared with baseline).

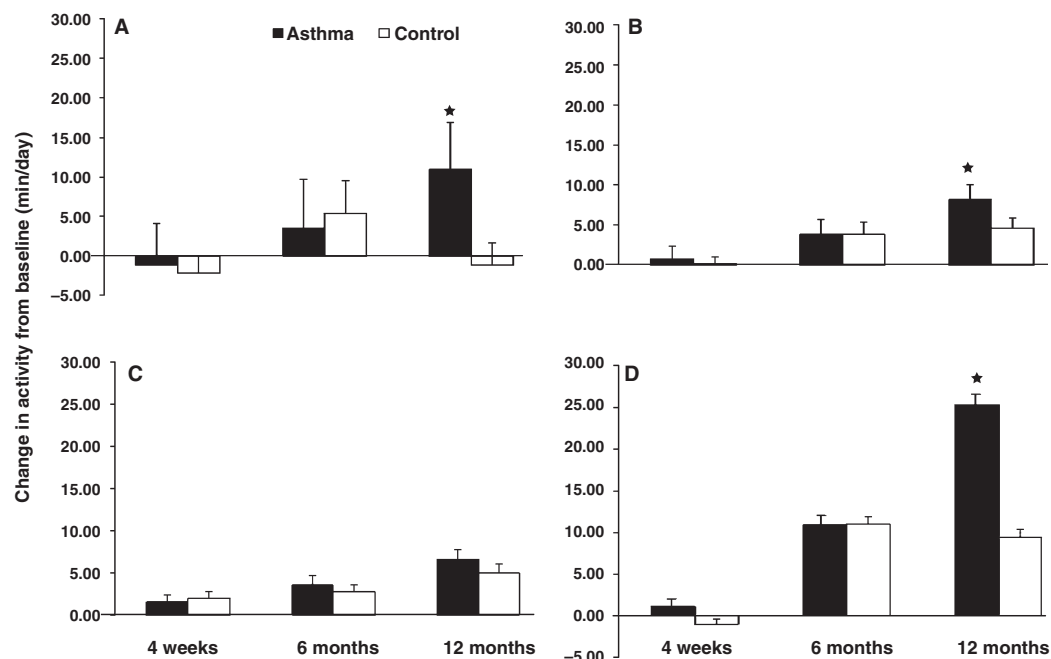


Figure 2 Changes from baseline in level 2 (A), 3 (B), 4 (C) and levels 2–4 (D) activity in healthy, control children and children with asthma. The differences between the two groups in activity were

in FEV1) improved 8.8 min per day in level 3–4 activity, whereas children with a positive test $\geq 15\%$ fall gained 17.4 min. In addition, the differences between asthmatics

statistically significant for level 2, 3 and 2–4 ($P = 0.006$ for all three). The difference between asthmatics and controls in level 4 activity failed to reach statistical significance ($P = 0.066$).

and controls in level 2–4 activity changes were greater for patients with an asthma control score > 3 at baseline (23.6 ± 65 min/day = 165.4 min/week) than for patients

Table 3 Body composition parameters

Variable	Group	n (period)	Baseline (1) Mean ($\pm$ 95% CI)	Twelve months (4) Mean ($\pm$ 95% CI)	Difference Mean ($\pm$ 95% CI)
Age (years)	Asthma	55	9.6 ($\pm$ 0.5)		
	Healthy	154	9.7 ($\pm$ 0.5)		
Height (cm)	Asthma	55	139.1 ($\pm$ 3.4)	143.9 ($\pm$ 3.5)*†	4.8 ($\pm$ 0.4)*
	Healthy	154	140.4 ($\pm$ 3.4)	146.2 ($\pm$ 3.5)†	5.9 ($\pm$ 0.5)
Weight (kg)	Asthma	55	36.3 ($\pm$ 3.4)	39.9 ($\pm$ 3.7)†	3.5 ($\pm$ 0.6)
	Healthy	154	34.4 ($\pm$ 2.4)	38.3 ($\pm$ 2.7)†	3.9 ($\pm$ 0.4)
Tanner stage (1–5)	Asthma	55	1.3 $\pm$ (0.2)	1.7 $\pm$ (0.3)	0.4 $\pm$ (0.2)
	Healthy	154	1.4 $\pm$ (0.1)	1.8 $\pm$ (0.1)	0.4 $\pm$ (0.1)
Body fat (%)	Asthma	55	23.7* ($\pm$ 2.9)	24.4 ($\pm$ 3.0)*	0.7
	Healthy	154	20.0 ($\pm$ 1.7)	20.7 ($\pm$ 1.7)	0.7
BMC (g)	Asthma	55	1273.4 ($\pm$ 113.4)	1422.3 ($\pm$ 132.8)†	149.0 ($\pm$ 28.0)
	Healthy	154	1265.6 ($\pm$ 97.1)	1436.5 (116.2)†	170.8 ($\pm$ 21.6)
BMD (g/cm ²)	Asthma	55	0.92 ($\pm$ 0.04)	0.92 ($\pm$ 0.02)	0.00 ($\pm$ 0.03)
	Healthy	154	0.90 ($\pm$ 0.02)	0.93 ($\pm$ 0.02)	0.03 ($\pm$ 0.01)
Mean arterial pressure (mm HG)	Asthma	55	73.6 ($\pm$ 1.6)	75.4 ($\pm$ 1.9)	1.8 ($\pm$ 2.2)
	Healthy	154	72.7 ($\pm$ 1.9)	74.8 ($\pm$ 1.6)	2.1 ($\pm$ 2.1)
Heart rate (BPM)	Asthma	55	78.2 ($\pm$ 2.9)	80.4 ($\pm$ 2.7)	2.1 ($\pm$ 2.9)
	Healthy	154	81.8 ($\pm$ 1.9)	80.3 ($\pm$ 1.8)	−1.5 ($\pm$ 2.1)

Children in the asthma group grew significantly less than the healthy controls over the year. No statistically significant differences were found between the groups in changes in the remaining outcomes over the year. BMC, Bone Mineral Calcium; BMD, Bone Mineral Density; BMP, Beats per minute.

*Statistically significant difference in between-group-comparisons.

†Statistically significant difference in within-group-comparisons (compared with baseline).

with an asthma score <4 at baseline (-3.4 ± 61.9 min/day = -23.8 min/week). However, none of these differences reached significance.

Discussion

The main finding in our study was that the improvements in asthma control were associated with significant improvements in moderate-vigorous daily activity as well as cardiovascular fitness in the children with asthma. The improvements in these parameters were significantly greater in the asthma group than in their healthy controls, so that 1 year of treatment resulted in a net gain in activity of around 3 h per week and 33 min per week in moderate-vigorous activity compared with the healthy controls. The finding that these increases were associated with a significantly greater increase in cardiovascular fitness in the asthma group indicates that the magnitude of the changes in activity is clinically relevant and important. No other prospective, longitudinal studies have assessed this. The potential long-term implications of this on the risk of developing lifestyle-associated diseases need further study.

Earlier studies measuring daily physical activity by accelerometry in school-aged children with asthma have not found any significant difference in daily activity between healthy children and children with asthma (7, 8) In both studies, the

patients mainly suffered from mild and/or well-controlled asthma, and a substantial proportion of the subjects used daily ICS. The results from our study corroborated these findings. At study end when the patients were well controlled, no differences were seen between healthy controls and asthmatics in physical activity. However, before treatment was initiated, we found a decreased cardiovascular fitness and a significantly decreased level 4 activity in the group of children with the poorest asthma control compared to their controls. Furthermore, at baseline, a negative correlation was found between the level of asthma control and the level of cardiovascular fitness as well as the time spent in vigorous activity (13). This, together with the treatment improvements in asthma control as well as daily activity and cardiovascular fitness suggest that poorly controlled asthma has a negative impact on the children's ability to perform physically and that improving asthma control negates this impact.

In this light, it would have been expected that the children with the greatest improvements in asthma control would also show the greatest improvements in daily activity. This was also the case. However, although quite marked differences (around 3 h per week) in improvements in activity were seen between children, who were markedly uncontrolled at baseline and those who were only slightly uncontrolled, the difference failed to reach statistical significance. The reason for

this is unknown. The standard deviations of the differences were quite marked, probably because daily activity is affected by multiple factors, so lack power seems to have been an important factor.

The study shed some light on the time course of the changes in activity during the year of treatment. The vast majority of the improvement in the various asthma outcomes was observed as early as after 4 weeks of treatment, and little additional improvement was seen after 6 months. In contrast, the improvements in activity were most marked during the last 6 months of the study. Thus, the improved asthma control seemed to translate into improvements in daily activity with some delay. The reason for this is not known, but we believe that the children needed some time with good asthma control before they became confident that they could engage in activities, which they could not prior to treatment. As cardiovascular fitness was only repeated after the full year, we do not know the time course in this outcome. We would expect that it would be delayed compared with the changes in activity, because a certain period with increased activity is required before detectable changes in cardiovascular fitness are seen. This is probably why cardiovascular fitness was still somewhat lower at the end of the study. Longer studies would be required to assess whether longer periods of continuous good asthma control would also result in normalization of cardiovascular fitness.

Expressing fitness as $\text{VO}_{2\text{max}}/\text{kg}$ body mass may result in spurious conclusions (21). However, because the changes over the year in body composition (body fat, body lean mass) and weight were similar in the two groups, we find it unlikely that any of these parameters should have caused the observed differences between the two groups in improvements in fitness. However, at baseline, the asthma group was 1.9 kg heavier than the controls, and their % fat were higher. Therefore, we also calculated the fitness expressed as $\text{VO}_{2\text{max}}/\text{fat free body}$ (which was similar in the two groups). This did not change the conclusions with respect to fitness.

The asthma group did not become physically more active than their healthy controls. Therefore, it was expected that that the changes in body composition over the year would be

similar in the two groups. Because the percent body fat was higher in the asthma group at study entry, it is likely that the children with asthma had higher annual increases in percent body fat prior to the study, but as this was not measured, no firm conclusions about the effect of treatment and level of asthma control on the developments in percent body fat can be made. The finding that the height increased significantly less in the children with asthma during the first year of treatment was expected. The delay could be caused by the inhaled corticosteroids, the prepubertal delay in growth rate which is seen in many children with asthma not receiving inhaled corticosteroids (22) or a combination of the two. As we did not have a group of patients with asthma treated with placebo, our study cannot elucidate this further.

At baseline, we found a negative correlation between age and the time spent in moderate-vigorous activity, older children spending less time at these activity levels (23). Therefore, it was unexpected that both groups increased the time spent in moderate-vigorous activity when they had become 1 year older. The reason for this is not known. It cannot be excluded that participation in the study might have increased the focus on life style even if great care was taken to avoid this. It could also be a reminder not to make firm conclusions about longitudinal events based upon findings in a cross-sectional study.

Conclusion

Poorly controlled asthma is associated with reduced physical activity and cardiovascular fitness. Treatment-induced improvements in asthma control are associated with a clinically relevant increase in daily physical activity and cardiovascular fitness. The annual weight gain in children with controlled asthma is similar to the weight gain in healthy children.

Acknowledgments

This study was supported by a grant from Danish Pediatric Asthma Center and by an unconditional grant from Glaxo-SmithKline.

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