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No Differences in Physical Activity in (Un)Diagnosed Asthma and Healthy Controls

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Summary. To establish whether asthma affects physical activity levels in children (aged 7–10 years) we evaluated physical activity levels in children with undiagnosed asthma (UDA), diagnosed asthma (DA), and healthy controls (HCs). A cross-sectional community-based study was performed which included a parental questionnaire on their child's respiratory health, and testing of airway reversibility and bronchial hyperresponsiveness (BHR). DA was defined as the parents' confirmation of a physician's diagnosis of asthma in the past 12 months. UDA was defined by asthma symptoms combined with airway reversibility or BHR in children without a physician's diagnosis of asthma. Physical activity was measured during 5 days with an accelerometer and a diary, and with the habitual activity estimation scale which reviews the physical activity during the past 2 weeks. The final study population comprised 1614 children of whom 81 (5%) had DA, 130 (8%) UDA, and 202 HCs. Baseline FEV₁ % was lowest in children with UDA (UDA FEV₁ 94% predicted, DA FEV₁ 98% predicted, HCs FEV₁ 100% predicted). Using the three methods, no differences were found in the physical activity between children with UDA, DA, and HCs. Childhood asthma does not appear to be associated with a decreased level of daily physical activity in our study population. *Pediatr Pulmonol.* 2007;42:1018–1023. © 2007 Wiley-Liss, Inc.

Key words: asthma; children; exercise; physical activity.

INTRODUCTION

Physical activity is an important part of both a healthy lifestyle and of a child's daily routine.¹ Development of good health and fitness habits in childhood is associated with physical fitness, and international guidelines recommend children to be active 60 min/day.^{1,2} However, in modern society physical activity in children is declining, resulting in a higher prevalence of obesity and cardiovascular diseases.^{3,4} Lower levels of activity in asthma seem to have more impact on physical fitness than the degree of airway obstruction.⁵ Furthermore, high physical fitness seems to be associated with a reduced risk of asthma, and the amount of daily physical activity is associated with aerobic fitness.^{5,6} Therefore, regular physical activity and participation in sports are considered to be important components in the overall management of asthma, and the American Academy of Pediatrics guidelines for sports medication states that “with proper medication and education, only athletes with the most severe asthma need to modify their participation.”⁷ However, in the AIRE study, 30% of the children appeared to be limited in their sporting activities.⁸

Since 1980, it has been suggested that asthma in children is underdiagnosed and subsequently undertreated.^{9–15} Recent data show that underdiagnosis is still a problem. Chew et al.¹⁶ reported that 49% of all children

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with asthma-like symptoms had not been diagnosed with asthma, whereas Joseph et al.¹⁷ reported a prevalence of undiagnosed asthma (UDA) of 11.7%. The prevalence of exercise-induced asthma is as high as 90% in children with asthma and a majority of children report that the worst thing about their asthma is their inability to participate in sports.^{18,19} Finally, asthma, whether undiagnosed or diagnosed, can have a negative effect on the level of physical activity in these children.

Therefore, the present study investigates whether asthma decreases the physical activity level in children. For this we compared physical activity levels in children (aged 7–10 years) with UDA, diagnosed asthma (DA), and in healthy controls (HCs).

MATERIALS AND METHODS

Population and Study Protocol

The study was conducted in 41 out of 44 primary schools in four cities in the Netherlands. We asked all children aged 7–10 years and their parents to participate in our study. All participating parents completed a questionnaire on respiratory symptoms, demographic and household characteristics. The questions about respiratory symptoms were identical to those of the well-known International Study of Asthma and Allergies in Childhood the ISAAC questionnaire.²⁰ All participating children were invited for lung function testing with assessment of reversibility to salbutamol. Children with asthma symptoms in the past 12 months or reversible airway obstruction were invited for bronchial challenge with hypertonic saline. A child was considered to have DA if the parents confirmed that their child had physician-DA in the past 12 months. A child was considered to have UDA if the child had (1) no physician-DA in the past 12 months, (2) asthma symptoms (wheeze or dry cough at night apart from a cough associated with a cold or chest infection) in the past 12 months, and (3) either had reversible airway obstruction or bronchial hyperresponsiveness (BHR). For each child with asthma, a HC was randomly selected from the same classroom. HCs had no asthma diagnosis, no asthma symptoms in the past 12 months, and no airway reversibility to salbutamol.

We obtained approval for the study from the Central Committee on Research involving Human Subjects (The Hague, The Netherlands), from the Hospital Ethics

Committee, and from the principals of the schools involved. Informed written consent was obtained from the parents of all children.

Questionnaire

Parents completed a questionnaire that included the ISAAC core questions on symptoms of asthma, rhinitis, and eczema which have been reported elsewhere.²⁰ Additional data were collected on household characteristics such as parental education and passive smoking. Asthma symptoms were defined as wheeze or a dry cough at night in the past 12 months.

Spirometry and Reversibility

Maximal flow-volume curves were measured using a hand-held spirometer (Vitalograph Ltd, Buckingham, UK) according to the ERS guidelines.²¹ A minimum of two technically acceptable baseline flow-volume curves were performed and the highest of two reproducible (within 5%) measurements of forced expiratory volume in 1 second (FEV₁) was recorded as baseline FEV₁. Subsequently, 800 microgram of salbutamol was administered via a metered dose inhaler using a Volumatic spacer (GSK, Uxbridge, UK). Airway reversibility was defined as an increase of FEV₁ of $\geq 10\%$ of the predicted value 10 min after administration of salbutamol.²²

Hypertonic Saline Testing

BHR was assessed by inhalation challenge with nebulized hypertonic (4.5%) saline using an ultrasound nebulizer (Klava 2000/4000, Klava Eltromed, Bielefeld, Germany) according to the ISAAC protocol. BHR was assessed on a different day than the spirometry.²³ All children were asked to withhold all asthma medications for at least 12 hr beforehand. Children with a baseline FEV₁ $\leq 75\%$ predicted were excluded. The children inhaled the saline for periods of increasing duration: 0.5, 1, 2, 4, and 8 min. FEV₁ was measured 1 min after each inhalation period and the next inhalation period started after 3 min. Bronchial challenge was stopped if FEV₁ had fallen at least 15% from baseline or if the total inhalation period of 15.5 min had been completed. A child was defined as having BHR if FEV₁ had dropped by $\geq 15\%$ from baseline during the inhalation challenge.

Daily Physical Activity

Physical activity was assessed in all participating children. We evaluated the physical activity with both an accelerometer and a diary during 3 week days and 2 weekend days, and with the habitual activity estimation scale (HAES), which is described in more detail below.

ABBREVIATIONS

BHR	Bronchial hyperresponsiveness
DA	Diagnosed asthma
FEV ₁	Forced expiratory volume in 1 second
HAES	Habitual activity estimation scale
HC	Healthy controls
PAM	Physical Activity Monitor
UDA	Undiagnosed asthma

Physical Activity Monitor (PAM)

The daily physical activity level was assessed using the (PAM) accelerometer (type AM 100; Pam B.V., The Netherlands). The PAM is a small-sized (58 mm × 43 mm × 12 mm), light weight (28 g) accelerometer, which is worn on a belt at the hip. The PAM measures accelerations in two dimensions on the *x*- and *y*-axis. The PAM was worn during waking hours except during showering and swimming. Validity and reliability are good.²⁴ At the end of the monitoring period data were downloaded into a personal computer. Measurements are expressed as PAM points, that is, the ratio between the amount of energy used while active and the amount of energy used in rest, multiplied by 100%. The output can also be expressed in min/day in different activity levels. Activity that burns 3 to 6 METs was defined as moderate-intensity activity and any activity that burns >6 METs as vigorous-intensity activity. Data were averaged in 1 min blocks.

Activity Diary

Children wrote down their activities (intensity and type of activity) during the day in blocks of 15 min.²⁵ Activities were categorized into nine levels from the lowest activity, 1, representing sleep or rest in bed, to the highest level, 9, during very intense sport.

HAES

Physical activity was also assessed with the HAES, designed to categorize daily physical activity (hours spent inactive, somewhat inactive, somewhat active, and active).²⁶ This scale reviews the subject's activity level for 1 week day and 1 weekend day during the previous 2 weeks. Each child was given a detailed explanation and

demonstration how to use the different methods. The total percentage of time spent being active is presented.

Data Analysis

All data of the questionnaires were double entered into the database using Microsoft Access software. Chi-square tests and ANOVA with a Bonferroni post-hoc test were used to analyze differences in each of the three physical activity measurement groups. Data were analyzed using the statistical package SPSS version 13.0.

RESULTS

Participants

Of 44 eligible schools, 41 participated in the study. Reasons for non-participation were recent involvement in another study (*n* = 2) and school policy never to participate in medical studies (*n* = 1). We invited 2,745 children and their parents to participate in the study in the period September 2002 to April 2005 of which 64% (*n* = 1758) gave informed consent to participate. We excluded 144 children from further analysis. Reasons for exclusion were missing questionnaire data (*n* = 60), refusal to participate in bronchial challenge testing (*n* = 31), inability to complete the bronchial challenge test due to nausea or coughing (*n* = 3), or inability to meet technical conditions (*n* = 50).

Diagnosis and Demographics

The final study population comprised 1,614 children of whom 81 (5%) had DA and 130 (8%) UDA according to our criteria. Of the remaining HCs, we randomly selected 202 children. Table 1 presents the characteristics of the study population. There were no differences between groups for gender, age or parental education. Children with DA more frequently had a father with asthma

TABLE 1—Characteristics of the Three Groups

	Undiagnosed asthma (<i>n</i> = 130)	Diagnosed asthma (<i>n</i> = 81)	Healthy controls (<i>n</i> = 202)
Gender, <i>n</i> (%)			
Male	73 (56)	47 (58)	100 (50)
Female	57 (44)	34 (42)	102 (50)
Mean age ± SD (years)	9.4 ± 0.7	9.4 ± 0.8	9.4 ± 0.7
Mother asthma ever, <i>n</i> (%)	19 (17)	16 (23)	4 (2)
Father asthma ever, <i>n</i> (%)	7 (7)	11 (16)	12 (7)
Mother current smoker, <i>n</i> (%)	26 (20)	10 (14)	41 (22)
Father current smoker, <i>n</i> (%)	30 (26)	17 (24)	42 (22)
Mother's education			
Low, <i>n</i> (%)	17 (15)	14 (20)	33 (17)
Moderate, <i>n</i> (%)	56 (49)	34 (48)	95 (50)
High, <i>n</i> (%)	41 (36)	23 (32)	62 (33)
Father's education			
Low, <i>n</i> (%)	20 (20)	16 (24)	37 (20)
Moderate, <i>n</i> (%)	41 (40)	22 (32)	65 (35)
High, <i>n</i> (%)	40 (40)	30 (44)	82 (45)

compared to the children with UDA and HCs, whereas having a mother with asthma occurred more frequently in children with both diagnosed and UDA.

Table 2 presents clinical characteristics of the three groups. Wheeze was reported for 56%, 86%, and 0% of the children with respectively UDA, DA, and HCs ($P < 0.001$ for all comparisons). Children with UDA had lowest baseline FEV₁, which showed the greatest increase after inhalation of salbutamol (9%, 5%, 2% respectively; UDA vs. HC; $P < 0.001$, UDA vs. DA; $P = 0.07$). Furthermore, children with UDA more frequently had airway reversibility and BHR than children with DA and HCs.

Daily Physical Activity

We found no differences between the three study groups for daily physical activity measured by the three different methods (Table 3). PAM scores were 49 for respectively UDA and DA and 47 for HCs. According to the diary and the HAES all diagnosis groups performed an average of 110 min of physical activities per day. Analyses of different intensity levels were performed for the PAM accelerometer, diary and HAES, but revealed no differences between the study groups.

DISCUSSION

Mild asthma does not seem to affect physical activity levels in children aged 7–10 years, as we found no differences in daily physical activity or differences in intensity levels of physical activity between children with UDA, DA, and HCs. Furthermore, on average, the children of all three groups meet the international guidelines that recommend participation in regular physical activity for children at least 30 min of moderate activity on at least 5 days per week, or 20 min of vigorous physical activity at least three times per week.²⁷

Levels of FEV₁ were only mildly decreased in both groups with asthma, which shows that this study deals with mild asthma. Furthermore, FEV₁ in all groups is high enough to be able to participate in physical activities.²⁸ We found a higher frequency of BHR and a lower FEV₁ in children with UDA than children with DA. This might suggest that children with UDA had more severe asthma than those with a diagnosis of asthma, and this might be the result of proper treatment with inhaled corticosteroids after diagnosis. However, BHR and lung function reversibility was used in the definition of UDA, whereas BHR or lung function reversibility was not required in the definition of DA. Thus our definition selected for children with BHR. However only those with asthma symptoms were considered to have UDA.

Our results are in agreement with the results of Nystad et al.²⁹ who also found no differences between children with asthma and HCs, and with Pianosi and Davis³⁰ who found no differences in physical activity level in children with different asthma severity. Our results are, however, not in agreement with Firrincieli et al.³¹ who observed lower levels physical activity in wheezing children as compared to HCs, and Lang et al.³² who also found that children with asthma were less active than HCs. None of these studies, however, used an accelerometer according to the recommendations as suggested by Trost et al.,³³ which is known to be the only objective measurement of daily physical activity in field studies. However, it remains to be said that differences between these studies and our study could also be due to different methodologies and inclusion criteria (i.e., definition of asthma, asthma severity and age) in our study.

To our knowledge no other studies have compared daily physical activity levels of children with UDA with those with DA and HCs. Moreover, the finding of equal physical activities in the three different groups was consistent with

TABLE 2—Clinical Characteristics of the Three Groups

	Undiagnosed asthma (n = 130)	Diagnosed asthma (n = 81)	Healthy controls (n = 202)	P-value
Symptoms in last 12 months				
Wheeze, n (%)	72 (56)	70 (86)	0 (0)	<0.001 ^{1,2,3}
Dry cough at night, n (%)	90 (71)	54 (70)	0 (0)	<0.001 ^{1,2,3}
Lung function parameters				
Mean baseline FEV ₁ % predicted	94	98	100	<0.001 ²
Mean baseline FVC % predicted	89	95	95	<0.05 ^{1,2}
FVC after bronchodilation	94	97	95	
Change in FEV ₁ after BD (%)	+9	+5	+2	<0.001 ²
Reversibility ≥10%, n (%)	67 (52)	19 (24)	0 (0)	<0.001 ^{1,2,3}
BHR, n (%)	93 (73)	38 (47)	21 (11)	<0.001 ^{1,2,3}
Inhaled corticosteroids	12 (9%)	60 (74%)	0 (0)	

BD, bronchodilator; BHR, bronchial hyperresponsiveness.

¹Significant difference between undiagnosed asthma and diagnosed asthma.

²Significant difference between undiagnosed asthma and healthy controls.

³Significant difference between diagnosed asthma and healthy controls.

TABLE 3—Daily Physical Activity in the Three Groups

	Undiagnosed asthma (n = 130)	Diagnosed asthma (n = 81)	Healthy controls (n = 202)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
PAM (score/day)	49 (44–54)	49 (42–56)	47 (43–50)
PAM: moderate intensity activity (min/day)	86 (76–95)	78 (66–90)	78 (71–85)
PAM: vigorous intensity activity (min/day)	22 (15–25)	21 (14–28)	20 (14–21)
Diary (minutes active/day)	110 (105–116)	112 (105–119)	111 (107–116)
HAES (minutes active/day)	109 (98–120)	111 (99–121)	113 (106–120)

all used methods. Since the majority of children with asthma also have exercise induced asthma, we expected that children with UDA would have the lowest physical activity and that the children with DA would perform less physical activities than HCs. Our opposite findings could mean that asthma per se does not affect physical activity in asthma. In the UDA group this may have several explanations: that is, poorer symptom perception, ignorance of symptoms, or not labeling symptoms to disease. In the diagnosed group this could be due to adherence to treatment regimes and the emphasis on recommendations for children with asthma to attend physical activities without restrictions.

Although we found no differences in physical activities between children with asthma and HCs, several studies showed that children had limitations with sport.^{19,34,35} For instance the AIRE study showed that 30% of children had limitations with sport activities.⁸ In that study, the interviewers only asked whether children had activity limitations due to their asthma (i.e., information about perception), but they did not quantify the duration of daily physical activity. Perception of physical activities is an important limiting factor for physical activities in children with asthma; that is, perceived competence in physical activity is associated with maximal aerobic power, but asthma severity in children does not correlate with physical activity.³⁰ This might explain the difference in results of our study compared with the AIRE study. In fact, the results of Pianosi and Davis³⁰ also suggest that asthmatic children can achieve a level of exercise performance similar to that of healthy children, provided that they have a comparable level of habitual physical activity.

Some possible limitations of our study should also be addressed. First, measuring physical activity in children remains difficult. Children tend to have short burst of activities that are more difficult to measure than the more circumscribed activities in adults.³⁶ The gold standard for assessing physical activity in field studies is probably the double-labeled water method.³⁷ However, for use in a large population survey this method is expensive, does not provide information about activity patterns, and is limited due to parental reluctance about the ingestion of even a non-radioactive isotope. Second, accelerometers

selectively record movement of the specific part of the body to which they are attached and thus differences in types of physical activities are mostly indistinguishable or unmeasured. Subsequently, some activities, such as swimming and cycling, cannot be adequately measured.^{38,39} Third, the diaries we used and the HAES questionnaire might have been subject to recall bias. We have, however, no reason to believe that this recall bias differed between the three study groups. A last comment addresses the definition of UDA. There is no golden standard for asthma diagnosis in childhood. To prevent misclassification we used the well-known ISAAC questionnaire and included objective parameters (airway reversibility and BHR) for the definition of UDA. Comparisons of physical activity between the different study groups are valid, but our results might be more difficult to compare with other studies due to different asthma diagnosis in other studies.

In conclusion childhood mild asthma, whether diagnosed or not, does not seem to be associated with a decreased level of daily physical activity compared to HCs.

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