

Prevalence of exercise-induced cough in schoolchildren: A pilot study

Łukasz Cichalewski, M.D.,¹ Paweł Majak, M.D., Ph.D.,¹ Joanna Jerzyńska, M.D., Ph.D.,¹ Włodzimierz Stelmach, M.D., Ph.D.,² Adam Kaczmarek,³ Kamila Malewska,³ Katarzyna Smejda, M.D., Ph.D.,¹ and Iwona Stelmach, M.D., Ph.D.¹

ABSTRACT

Association between exercise-induced bronchoconstriction (EIB) and physical activity has not been investigated in a natural school environment in a general pediatric population. Our objective was to determine the prevalence of exercise-induced symptoms (cough, wheeze, chest tightness, dyspnea) and bronchospasm among schoolchildren during physical education (PE). A total of 557 schoolchildren from seven public schools were enrolled. Information regarding demographic characteristic, previously diagnosed asthma was obtained. All children attended 45-minute PE lesson with similar exercise intensity. Pulmonary function tests were performed before and immediately after PE lesson. The diagnosis of EIB was defined as a forced expiratory volume in one second (FEV₁) decrease from baseline of more than or equal to 10% with exercise. Cough and dyspnea after exercise were recorded. A total of 557 participants were included into the analysis. After PE lesson, 15.3% children suffered from cough, 0.9% reported dyspnea, and 10.1% had more than 10% fall in FEV₁ from baseline. Among all participants, 5.9% had doctors' diagnosed asthma, 4.8% of them were treated with inhaled corticosteroids (ICS). Among children with cough, 21.5% had asthma and 17.6% experienced EIB. Among asthmatics, 48.6% suffered from cough and 18.2% had more than 10% fall in FEV₁ from baseline after PE lesson. EIB was not affected by age, gender, body mass index, asthma diagnosis, and ICS use. Only cough (odds ratio: 2.21, 95% confidence interval: 1.16–4.23; $p = 0.0161$) was independently associated with EIB. This study showed a high prevalence of exercise-induced cough and/or 10% fall in FEV₁ during activity lesson in a natural school environment in a large urban population of schoolchildren. Our results call for another studies addressing the impact of environment on exercise-induced symptoms.

(Allergy Asthma Proc 36:65–69, 2015; doi: 10.2500/aap.2015.36.3810)

Physical activity is generally accepted to be an advantage to young children in terms of bone development, motor skills, improved cardiovascular fitness, and self esteem.¹ Recent literature outlines the growing problem of physical inactivity among young people and explores various dimensions, which may explain inactivity, and potentially relevant interventions and strategies and the principles that should underpin them. There is growing evidence that physical inactivity predisposes to the development of asthma.^{2–4} Symptoms of exercise-induced bronchospasm include cough, wheeze, chest tightness, and dyspnea during or after physical education (PE) lessons. Previously diagnosed asthma or allergy are one of the many reasons of absence from PE lessons and physical inactivity. However, associations between exercise-in-

duced bronchoconstriction (EIB) and physical activity have not been investigated in a general pediatric population. The aim of this pilot study was to provide an overview of evidence and argument to inform future research and underpin strategies to increase physical activity among schoolchildren. This study represents an attempt to determine the prevalence of exercise-induced symptoms and bronchospasm among schoolchildren during PE, after taking into account potential confounders, such as doctor diagnosed asthma and age, gender, and body weight.

METHODS

Participants, 557 schoolchildren, whose parents signed the written consent form, aged 13–16 years (1st to 3rd middle school) from seven randomly selected public schools located in the greater Lodz area (Lodz, Poland) were enrolled. Information regarding previously diagnosed asthma by physician and the regular use of inhaled corticosteroids (ICS) were obtained by short questionnaire to parents, together with a written consent form. Children were asked to stop the use of antiasthmatic medications within 12 hours before testing. Information regarding demographic characteristic (age, gender, height, body weight) were obtained by one of the researchers at the school visit, before PE

¹Department of Pediatrics and Allergy, Medical University of Lodz, N. Copernicus Hospital, Lodz, Poland, ²Department of Social and Preventive Medicine, Medical University of Lodz, Lodz, Poland, and ³Student of Medical University of Lodz, Poland This study was supported by the National Science Centre (NCN) Grant UMO-2012/07/B/NZ5/02684

The authors have no conflicts of interest to declare pertaining to this article Address correspondence to Iwona Stelmach, M.D., Ph.D., Department of Pediatrics and Allergy, N. Copernicus Hospital 62 Pabianicka Street, 93-513 Lodz, Poland E-mail address: alergol@kopernik.lodz.pl Copyright © 2015, OceanSide Publications, Inc., U.S.A.

lesson. The exclusion criteria were as follows: a recent airway infection (four weeks before the study), neurologic or orthopedic disorders, respiratory diseases other than asthma, and cardiac diseases. The same day from 9 AM to 1 PM, all children attended 45 minutes of an indoor PE lesson (regular practice of physical exertions in schools) with similar exercise intensity: football, basketball, or volleyball, preceded by a 10-minute warm-up. Due to seasonal factors influencing exercise-induced asthma, the study was performed between October and April during one school year.^{5,6} Pulmonary function tests, including forced expiratory volume in one second (FEV₁), FEV₁ % of vital capacity was performed for each participant before the PE lesson and immediately after the lesson (nonstandardized exercise challenge). The maximum waiting time for a child to study was around 10 minutes, which is consistent with the pathophysiology of EIB.⁷ Spirometry was performed using a portable spirometer (Spirolab III; MIR SRL, Italy). Three technically acceptable measurements were performed, and the highest FEV₁ and FEV₁ % of vital capacity were recorded as % predicted values.^{8,9} The diagnosis of exercise-related bronchoconstriction was defined as a FEV₁ decreased from baseline of more than or equal to 10% with exercise. Each child underwent a careful postexercise physical examination: signs and symptoms such as cough and shortness of breath were recorded. Children who exhibited asthma symptoms were managed with 400 µg of inhaled salbutamol and were reexamined before they returned to class. The investigators were participating in the PE lessons, to “record” all symptoms; the persons testing the children at school were blinded to the results of the questionnaire. All children requiring further diagnosis and treatment were referred to Allergy Outpatient Clinic at Copernicus Hospital (Lodz, Poland), where differential diagnosis, cardiac, pulmonary, ear, nose & throat, gastrointestinal, allergy consultations, and standardized exercise tests were performed (the second part of this study; data not published). In the school, during PE lessons, air temperature, humidity, and pressure in the room were taken (HT4000 Air Velocity Meter; HT Italy). After PE lessons, the samples of dust were taken for indication of environmental allergens. The study was approved by the Medical Ethical Committee of the Medical University of Lodz. The study was registered on www.ClinicalTrials.gov NCT01798823. Written consent from study participants was obtained.

Statistical Analysis

All comparisons were assessed by logistic regression. First, logistic regression was used to assess the relationship between dependent variables and each of the independent variables. Multivariate models allowed to

Table 1. Patient characteristics

Variable	
Age (years), mean ± SD	14.0 ± 1.0
Male gender, n (%)	271 (48.7)
BMI (kg/m ²), mean ± SD	20.3 ± 3.4
Asthma, n (%)	33 (5.9)
Dyspnea, n (%)	5 (0.9)
Cough, n (%)	85 (15.3)
ICS use, n (%)	27 (4.8)
FEV ₁ (% pred.), mean ± SD	97.5 ± 13.1
FEV ₁ %FVC (% pred.), mean ± SD	106.0 ± 9.5
Change in FEV ₁ (during ETC), median (quartile range)	−1.9 (−5.7 to 2.8)
10% or more fall in FEV ₁ after physical education, n (%)	56 (10.1)
<i>FEV₁%FVC = forced expiratory volume in 1st second/forced vital capacity ratio</i>	

assessed interaction effect of potential confounders. All of the statistical analyses were performed using SPSS 11.5. The null hypothesis was rejected if $p < 0.05$.

RESULTS

A total of 557 participants were included into the analysis. Clinical characteristics are given in Table 1.

After PE lesson, 85 (15.3%) children suffered from cough, 5 (0.9%) reported dyspnea, and 56 (10.1%) had more than 10% fall in FEV₁ from baseline measurement, which took place before the lesson. Among all participants, 33 (5.9%) were diagnosed with asthma by doctors, and 27 (4.8%) of them were treated with ICS.

Coincidences of asthma, ICS use, and symptoms after PE lesson (cough and 10% fall in FEV₁) are given in Fig. 1. Among children with cough after PE lesson, 21.5% ($n = 18$) had asthma and 17.6% ($n = 15$) experienced more than 10% fall in FEV₁ from baseline. Among asthmatics, 48.6% ($n = 16$) suffered from cough during PE lesson and 18.2% ($n = 6$) had more than 10% fall in FEV₁ from baseline.

In the next step, we followed the logistic regression analysis with more than 10% fall in FEV₁ from baseline as dependent variable (Table 2). We showed that prevalence of 10% fall in FEV₁ from baseline during PE lesson was not affected by age, gender, body mass index (BMI), or asthma diagnosis and ICS use. Logistic regression analysis showed that only cough during PE lesson was independently associated with more than 10% fall in FEV₁ from baseline (final model of multivariate analysis is shown in Table 2). Dyspnea after PE lesson, due to relatively low level of observation, was not included into the regression analysis. We assessed the timing of postexercise lung function as a potential confounder, and we showed that the time gap between

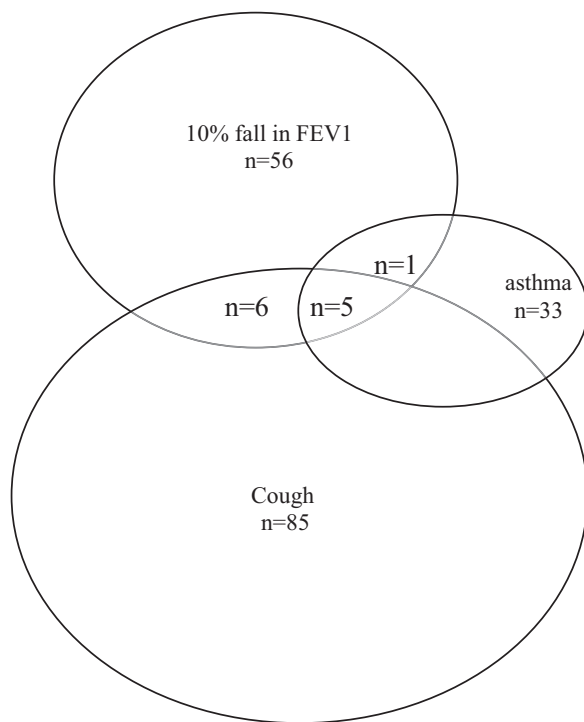


Figure 1. Coexistence of cough, asthma and $\geq 10\%$ fall in FEV_1 during physical education lesson.

cessation of exercise and lung function did not affect the results. Mean values of environmental factors indoor schools were as follows: air pressure, 1002 hPa; temperature, 20.8°C; and humidity, 46%. These parameters did not significantly differ between schools.

DISCUSSION

This study highlights the issue of unrecognized exercise-related bronchoconstriction, on one hand, as well as the issue of insufficiently controlled asthma in affected children. The results of our study focused on the high prevalence of exercise-related bronchoconstriction during PE lesson measured shortly after exercise in a general population of schoolchildren. The principle finding of this study is that decrease in FEV_1 by at least 10% with exercise was observed in more than 10% of studied children. Cough was the strongest predictor of EIB. This association was independent of BMI status, age, gender, asthma presence, and ICS use. Children (with EIB) had no lower baseline lung function, as compare with children without EIB. Among all participants, 16% cough after exercise, almost 18% of coughing children had EIB, 21% had asthma, and almost one third of coughing asthmatics had decreased FEV_1 by at least 10% with exercise. Because, in our study a cough and a fall in FEV_1 of more than 10% is most common in those who have not received an asthma diagnosis, in itself is uncertain (based on previous data), then afterwards in the second part of the study in clinical settings. Our findings raise several

questions. Only 6 of 56 children develop a fall in FEV_1 of more than or equal to 10% from baseline were asthmatics. This is indeed very surprising, because EIB is a well-known common condition in asthma patients and athletes, which adversely affects the quality of life and the ability to participate in sports.^{10,11} The exercise challenge is considered to be a rather specific test for asthma in contrast to direct challenges, such as histamine or methacholine. We speculate that one of the reasons for this finding is undiagnosed asthma. One answer could be the local underdiagnosis of asthma, which is as high as 71% in children in the Lodz region.^{12,13} Because almost half of the children with asthma cough after exercise in the school environment, is their asthma well controlled? Because 18% of coughing nonasthmatic children had EIB, do they have undiagnosed asthma? What is most "true," the earlier asthma diagnosis or the falls in FEV_1 and the recorded symptoms? Also, children without any clinical symptoms have EIB. Do they require further diagnosis? A large number of coughing children had no EIB or asthma. Do they have hyperreactivity due to past infection? And, finally, how important is the environmental influence on EIB? What are the reasons for high prevalence of exercise-induced symptoms such as coughing, which limits physical activity in children?

There are several possible ways to explain our results. One of them is that irregular physical activity may up-regulate airway and systemic inflammation, thus resulting in a negative effect on bronchial hyperreactivity (BHR), and predisposition to EIB.^{3,4} According to American Thoracic Society, the severity of EIB % fall in FEV_1 from the preexercise can be classified into changing in FEV_1 more than 10%–25%, 25%–50%, and more than 50%, respectively. In our study, there were many children who had more than 10% fall in FEV_1 , and it would be more informative to know the severity of EIB. However, in this pilot study, it was not in our interest to divide our patients into subgroup analyses. We intended to do this analysis together in association with control/noncontrol asthma and EIB severity in a general pediatric population in the next step of the study. Although we observed significant association between cough and EIB, a large proportion of children with cough had no significant fall in FEV_1 during PE lesson. However, cough is not always an expression of bronchoconstriction, and other nonobstructive mechanism may occur.¹⁴ On the other hand, we observed a group of children with EIB without any clinical symptoms at all, indicating that the relation between BHR and physical activity may be subclinical. Although investigators of other studies suggest that children experience exercise-induced symptoms in proportion to their BHR,¹⁵ the direction of causality remains unclear. An unidentified cough could be partially caused by emotional reaction and managed by engaging in cop-

Table 2. Risk factors of 10% or more fall in FEV₁ after physical education

Variable	Less Than 10% Fall in FEV ₁	More Than or Equal to 10% Fall in FEV ₁	OR ^a	95%CI		p
Age (years), mean ± SD	14.0 ± 0.9	14.0 ± 1.0	1.02	0.76	1.37	0.87
Male gender, n (%)	235 (49.0)	28 (50.0)	1.04	0.6	1.81	0.88
BMI (kg/m ²), mean ± SD	20.3 ± 3.5	20.4 ± 2.9	1.01	0.93	1.09	0.81
Asthma, n (%)	27 (5.8)	6 (12.0)	2.21	0.87	5.65	0.1
Cough, n (%)	70 (14.8)	15 (27.8)	2.21	1.16	4.23	0.02
ICS use, n (%)	22 (4.6)	5 (9.1)	2.08	0.76	5.74	0.16
FEV ₁ (% pred.), mean ± SD	97.4 ± 12.8	98.4 ± 16.5	1.01	0.98	1.03	0.59
FEV ₁ %FVC (% pred.), mean ± SD	106.3 ± 9.5	104.1 ± 9.9	0.98	0.95	1.01	0.11

^a = dependent variable: 10% fall in FEV₁ after physical education.

ing behaviors. This may be by avoiding physical activity or engaging in it depending on beliefs and past experience.^{16,17}

Our findings show that almost half of the children with asthma cough after exercise, what suggests that those diagnosed asthmatics in our study had uncontrolled asthma in school environment. There is evidence that asthmatic children with well-controlled disease, even those with documented BHR, can achieve levels of exercise performance similar to those of non-asthmatics.¹⁸ Several studies have identified significant improvements in aerobic fitness^{19,20} and asthma-related benefits such as reduced hospital admissions, reduced absences from school, reduced medication use, and fewer doctors visits after exercise performance.^{20,21} Overall, children with asthma should be medicated appropriately and encouraged to participate in regular physical activity.^{22,23}

Our study brings up other important point here. The relations of asthma, EIB, and obesity are complex and only partially understood. It remains controversial whether decreased physical activity predisposes to increased BHR independently of obesity, or whether obesity creates the conditions that foster the development of EIB irrespective of physical activity. In our study, we did not observe significant difference between BMI and exercise-induced bronchospasm in examined children. The association between physical activity and EIB was independent of age, gender, asthma presence, and ICS use. This is in agreement with the results of previous studies.^{4,15,24–26} On the other hand, we are not confident that our children with high BMI performed exercise at a similar level as those with a normal BMI. Carlsen *et al.* showed that the sensitivity of an EIA test depends highly on the exercise level.²² Also Ostrom *et al.* found that obesity is common in adolescents with poorly controlled asthma.²⁷ Therefore, the lack of a relationship between BMI and the findings in our study can not be definite.

The findings of the present study should be considered in the context of its potential limitations. First, our

EIB was assessed by physical activity lesson, not standardized challenge, as recommended,²⁸ or by measurement of EIB on repeat of the PE lesson (due to the high variability in assessing EIB). However, it was done in a natural school environment and uses a natural stimulus as well as conditions of school settings, which is an advantage for the clinical interpretation. These could lead to improved detection of EIB, particularly exercise-induced asthma. Second, our study population included only urban schoolchildren, and thus, the study findings may not be applicable to other populations, particularly those with different physical activity patterns. Third, the study sample was not adequate to allow full subgroup analysis. Another limitation is that our children were not assessed for allergic rhinitis, which may be associated with exercise-related cough. Addressing the multiple factors influencing participation in physical activity, outlined in this study, is likely to be challenging and complex. An overview of evidence suggests that strategies must include accurate detection, diagnosis and symptom management, and address the problem of symptom interpretation. Given the significance of the water content and temperature of inhaled air on EIB pathophysiology, there is a chance that the season contributed to the results of our study. However, it should be noted that the above study will be followed by the second part, which will answer all questions resulting from this pilot study.

In conclusion, this study showed a high prevalence of exercise-related cough and/or significant fall in FEV₁ during activity lesson in a natural school environment in a large urban population of schoolchildren. Second, development of exercise-related bronchoconstriction was independent of BMI, age, gender, asthma presence, and ICS use. These results underscore the importance of EIB as an integral part of programs that focus on primary prevention and treatment of EIB and improvement of asthma diagnosis in children. Finally, our results call for another study addressing the impact of environment on exercise-induced symptoms and EIB.

REFERENCES

- Williams B, Powell A, Hoskins G, and Neville R. Exploring and explaining low participation in physical activity among children and young people with asthma: a review. *BMC Fam Pract* 9:40, 2008.
- Anthracopoulos MB, Fouzas S, Papadopoulos M, et al. Physical activity and exercise-induced bronchoconstriction in Greek schoolchildren. *Pediatr Pulmonol* 47:1080–1087, 2012.
- Rasmussen F, Lambrechtsen J, Siersted HC, et al. Low physical fitness in childhood is associated with the development of asthma in young adulthood: the Odense schoolchild study. *Eur Respir J* 16:866–870, 2000.
- Nystad W, Stigum H, and Carlsen KH. Increased level of bronchial responsiveness in inactive children with asthma. *Respir Med* 95:806–810, 2001.
- Goldberg S, Mimouni F, Joseph L, et al. Seasonal effect on exercise challenge tests for the diagnosis of exercise-induced bronchoconstriction. *Allergy Asthma Proc* 33:416–20, 2012.
- Choi IS, Ki WJ, Kim TO, et al. Seasonal factors influencing exercise-induced asthma. *Allergy Asthma Immunol Res* 4:192–198, 2012.
- Weiler JM, Bonini S, Coifman R, et al. American Academy of Allergy, Asthma & Immunology Work Group report: exercise-induced asthma. *J Allergy Clin Immunol* 119:1349–1358, 2007.
- Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J* 26:319–38, 2005.
- Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. *Eur Respir J* 26:948–968, 2005.
- Khan DA. Exercise-induced bronchoconstriction: burden and prevalence. *Allergy Asthma Proc* 33:1–6, 2012.
- Weiler JM, Anderson SD, Randolph C, et al. Pathogenesis, prevalence, diagnosis, and management of exercise-induced bronchoconstriction: a practice parameter. *Ann Allergy Asthma Immunol* 105:S1–S47, 2010.
- Majak P, Bąk-Walczak E, Stelmach I, et al. An increasing trend of the delay in asthma diagnosis after the discontinuation of a population-based intervention. *J Asthma* 48:414–418, 2011.
- Stelmach W, Majak P, Jerzynska J, and Stelmach I. Early effects of Asthma Prevention Program on asthma diagnosis and hospitalization in urban population of Poland. *Allergy* 60:606–610, 2005.
- Weinberger M, and Fischer A. Differential diagnosis of chronic cough in children. *Allergy Asthma Proc* 35:95–103, 2014.
- Brasholt M, Baty F, and Bisgaard H. Physical activity in young children is reduced with increasing bronchial responsiveness. *J Allergy Clin Immunol* 125:1007–1012, 2010.
- Brookes J, and Jones K. Schoolteachers' perceptions and knowledge of asthma in primary schoolchildren. *Br J Gen Pract* 42:504–507, 1992.
- Weinberger M, and Abu-Hasan M. Pseudo-asthma: when cough, wheezing, and dyspnea are not asthma. *Pediatrics* 120:855–864, 2007.
- van Gent R, van der Ent CK, van Essen-Zandvliet LE, et al. No differences in physical activity in (un)diagnosed asthma and healthy controls. *Pediatr Pulmonol* 42:1018–1023, 2007.
- Ram FS, Robinson SM, and Black PN. Effects of physical training in asthma: a systematic review. *Br J Sports Med* 34:162–167, 2000.
- van Veldhoven NH, Vermeer A, Bogaard JM, et al. Children with asthma and physical exercise: effects of an exercise programme. *Clin Rehabil* 15:360–370, 2001.
- Welsh L, Kemp JG, and Roberts RG. Effects of physical conditioning on children and adolescents with asthma. *Sports Med* 35:127–141, 2005.
- Carlsen KH, and Carlsen KCL. Exercise-induced asthma. *Pediatr Respir Rev* 3:154–160, 2002.
- Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. *J Pediatr* 146:732–737, 2005.
- Vahlkvist S, Inman MD, and Pedersen S. Effect of asthma treatment on fitness, daily activity and body composition in children with asthma. *Allergy* 65:1464–1471, 2010.
- Shaaban R, Leynaert B, Soussan D, et al. Physical activity and bronchial hyperresponsiveness: European Community Respiratory Health Survey II. *Thorax* 62:403–410, 2007.
- Trudeau F, and Shephard RJ. Contribution to school programmes to physical activity levels and attitudes in children and adults. *Sports Med* 35:89–105, 2005.
- Ostrom NK, Parsons JP, Eid NS, et al. Exercise-induced bronchospasm, asthma control, and obesity. *Allergy Asthma Proc* 34:342–348, 2013.
- Carlsen KH, Engh G, and Mork M. Exercise-induced bronchoconstriction depends on exercise load. *Respir Med* 94:750–755, 2000. □

Copyright of Allergy & Asthma Proceedings is the property of OceanSide Publications Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.