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Exercise-induced bronchospasm and its associated factors among secondary school students in an urban community

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ABSTRACT

Introduction: Exercise-induced bronchospasm (EIB) is a transient narrowing of the airway that usually occurs shortly after exercise. It occurs commonly in people with asthma; however EIB has also been reported in individuals without clinical asthma. The study aimed to determine the prevalence and factors associated with EIB among secondary school students.

Methods: It was a descriptive cross-sectional school-based study involving secondary school students aged between 10 and 17 years without previous history of asthma. Subjects undertook a six-minute running test, spirometry was done and the best of three FEV₁ readings were obtained pre-exercise, at 5, 10, 15 and 30 minutes post exercise. The diagnosis of EIB was made when there was a decrease in FEV₁ of $\geq 10\%$ from baseline after exercise.

Results: Of the 265 participants studied, 34 (12.8%) had EIB at 5 minutes post exercise. EIB was significantly more in the 10–13 years age group ($\chi^2 = 18.416$, $p = <0.001$), there was no significant gender difference. The presence of allergic (vernal) conjunctivitis and rhinitis were both significantly associated with the development of EIB ($\chi^2 = 13.574$, $p < 0.001$ and 0.011 respectively). There was no significant association with previous history of wheeze and exposure to indoor air pollution such as cooking with biomass fuel and parental cigarette smoking.

Conclusion: EIB exist among non-asthmatic school children, and it is more frequent in the early adolescent age-group. Students with allergic conjunctivitis and rhinitis are more likely to manifest exercise induced bronchospasm.

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Exercise-induced bronchospasm; airway hyper-responsiveness; forced expiratory volume in 1second



1. Introduction

Exercise-induced bronchospasm (EIB) is a transient airway narrowing that usually occurs shortly after or rarely during exercise [1]. It is a manifestation of airway hyper-responsiveness. Exercise induced bronchospasm can manifest clinically with cough, wheezing, chest tightness or pain and unusual shortness of breath after a burst of strenuous and continuous aerobic exercise [1,2]. Some individuals with EIB may however have a normal physical examination.

The objective diagnosis of EIB is made when there is a decrease in FEV₁ of $\geq 10\%$ from baseline after exercise, with or without symptoms [2,3]. Exercise challenge test used to detect EIB include running on treadmill, bicycle ergometer or a free range nonstop running exercise. The treadmill or bicycle ergometer are standardized and can easily be controlled, however these equipment are relatively expensive [4]. The free range running method is inexpensive and sophisticated equipment is not required for performing it. The free range nonstop exercise has been used in the community settings to evaluate students [5,6]. It has an advantage that it mimics the normal physical

activity the individual undertakes on daily basis and it has increased tendencies to precipitate bronchospasm [1,3].

Exercise-induced bronchospasm has been reported in patients with or without asthma, and in individuals with atopy and allergic rhinitis [2]. In the general population, EIB occur in more than 10% of individuals with no history of allergy or asthma, while it may be up to 40–50% in those with allergic rhinitis and about 90% in asthmatic individuals [7]. Epidemiological surveys have shown that the prevalence of EIB in children from the general population varies widely [7,8]. Ng'ang'a *et al* [9], reported a prevalence of 22.9% among urban school children in Kenya while Kuti *et al* [6] recorded a prevalence of 23.8% among school children in south west Nigeria. Both studies used a $\geq 10\%$ decrease in FEV₁ after a running exercise as diagnostic criteria. Addo-Yobo *et al* in a study conducted among Ghanaian school children recorded a prevalence rate of 8.3% [10]. These varying prevalence rates are due to the different cutoff values used for diagnosing and also the methods used to detect the response (FEV₁ or PEF_R).

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Exercise induced bronchospasm is often a neglected diagnosis, however it is an important condition as it may limit exercise performance and quality of life of an individual if undetected and untreated. The prevalence of EIB within the non-asthmatic population remains understudied in Nigerian children; in particular, the prevalence of EIB in non-asthmatic school children in Osogbo is unknown. There is thus a need for more studies to allow the prevalence of EIB in individuals without asthma to be better understood. The study aimed to determine the prevalence and factors associated with EIB among secondary school students.

2. Materials and methods

2.1. Study area

The study was conducted in Osogbo local government area of Osogbo. Osogbo is the capital city of Osun state in south-west Nigeria. It lies at 318 m or 1043 feet above sea level.

2.2. Study design

The study was a descriptive cross-sectional school based study involving 265 secondary school students aged between 10 and 17 years. The study was carried out over a period of nine months (January 2018- September 2018). Subjects were eligible for the study if they were between 10–17 years, gave assent and whose care-givers gave informed consent. The students were excluded from the study when there was suspected heart disease, musculoskeletal symptoms (deformity) or any other illness or conditions that could interfere with exercise tolerance. Also, students with history of asthma, abnormal pre-exercise respiratory and cardiac findings such as wheeze, rhonchi and abnormal pulse rate or heart sounds, those unable to carry out an acceptable lung function test, and students who do not attain the predicted maximum heart rate after the six minutes of exercise were excluded from the study.

2.3. Sample size determination

The minimum number of subjects required for this study was determined using the Leslie-Fishers formula [11]:

$$n = \frac{Z^2 P}{D^2}$$

Where Z is a constant usually set at 1.96, P is a predetermined value of the prevalence of EIB obtained from previous study (6.0%) [5], Q is the proportion of the population not involved in the

study i.e. 1-P and D is the degree of accuracy desired usually set as 0.05.

Minimum sample size was determined to be 241. A total of 265 pupils were studied.

2.4. Subject recruitment

Subjects were recruited into the study by multi-stage sampling technique. From the two local government area (LGA) in Osogbo, one LGA was selected by simple balloting using numbers 1 and 2. Number 1 (Osogbo LGA) was randomly selected. The list of secondary schools in the selected local government area (Osogbo LGA) was obtained from the Local Education Authority. Ten per cent of the total number of secondary schools in the selected (Osogbo) local government area was studied. There were 47 secondary schools in Osogbo LGA (16 public and 31 private secondary schools) Ratio of public: private was 1: 1.81 \approx 1: 2. Thus ten per cent of schools selected by random sampling were two public and four private schools (1: 2). There was proportional allocation of respondents to the selected schools depending on number of pupils in each school. An arm was selected from all the arms of each class by simple random sampling technique (balloting method). List of students within the age group 10–17 years from the selected classes was obtained. Subjects were selected by picking the pupil whose name appear after every 5 pupils from the list until the proportional sample size was completed.

2.5. Study procedure

Questionnaires were administered to the participants using interviewer method. The demographic data, symptoms of allergies, history of wheeze, exposures to indoor air pollution (biomass fuel and cigarette smoke) were obtained. The socio-economic classification was done as described by Ogunlesi *et al* [12]. Features of vernal (allergic) conjunctivitis sought for were recurrent eye itching, brownish discoloration and/or watery discharge [13]. Features of allergic rhinitis were excessive sneezing, recurrent sniffing, recurrent runny nose and itchy throat in the absence of cold [14]. Eczema was defined as recurrent itchy, scaly, dry skin. Their anthropometric measurements *i.e.* weight, height were recorded, using a weighing scale with an inbuilt height meter (Bright future Medical- England, model RGZ-160) after ensuring that they were minimally dressed. The Body mass index (BMI) was calculated using Weight (kg) divide by Height (meter)². The BMI percentile was interpreted as <5 percentile being underweight, ≥ 5 and <85 percentile as normal weight, ≥ 85 and < 95 percentile as overweight and ≥ 95 percentile as obesity. The clinical findings including features of

allergies were documented. The pre- and post-exercise respiratory rate and heart rate were also recorded.

2.6. Spirometry and exercise challenge

The spirometry procedure was explained and demonstrated to all the children. The subjects had a practice session pre-exercise to ensure the technique had been mastered. The spirometer was calibrated daily with a 3-Liter calibration syringe. A new disposable mouth-piece was attached to the spirometer for each participant to ensure strict infection control. The subjects were instructed to breathe in as deeply as possible to full inspiration, hold his or her breath just long enough to seal the lips around the mouth piece, and then blow maximally. Nose clip was worn by the participants to prevent air leakage through the nostrils. The spirometry was performed in the sitting position using the Minispir® light spirometer. The FEV₁ measurements (pre-exercise) were obtained; the best FEV₁ of three acceptable tests was recorded. The predicted reference values used in this study were based on the data of Knudson *et al* using their gender, weight and height [15]. A six-minute free running test was done, at the end of each sixth minute; the whistle was blown to stop the exercise session for each subject. (The running test was done at same time every day in order to limit the effect of variation in environmental conditions). Their heart rate was expected to reach at least 80% of predicted maximum heart rate (HR_{max}) after the six-minute exercise [16]. The predicted maximum heart rate was calculated using the formula; $208 - 0.7 \times \text{age}$ [17].

The percentage change in FEV₁ post-exercise was calculated using the following equation [3,16]:

$$\frac{\text{Pre-exercise FEV}_1 - \text{Post-exercise FEV}_1}{\text{Pre-exercise FEV}_1} \times 100$$

A reduction in FEV₁ of $\geq 10\%$ from the baseline value was considered a positive EIB test. Post-exercise measurements (the best FEV₁ of three acceptable tests) were taken at 5, 10, 15 and 30 minutes. The FEV₁ measurements recorded were those that met the ATS/ERS acceptability criteria [18].

2.7. Data management and analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS Chicago Inc., IL, U.S.A). The prevalence of EIB among the students was calculated by proportion of student with EIB over the total number of study participants. The relationship between categorical variables was determined using Pearson's Chi-square test and Fisher's exact test. The level of significance was set at p-value less than 0.05.

2.8. Ethics

The procedures followed were in accordance with the ethical standards of the Helsinki Declaration of 1975, as revised in the year 2000. Ethical approval for the study was obtained from the Ethics and Research Committee of Ladoko Akintola University of Technology (LAUTECH) Teaching Hospital, Osogbo, Osun State (LTH/EC/2016/01/256). Approval for the study was also obtained from the Osun State Ministry of Education. Permission was obtained from the school principals and class teachers of the pupils before proceeding with the study. The study objectives and procedures were explained to participants, parental consent and assent was obtained from the participants.

3. Results

A total of 265 students who met the study criteria were enrolled. Of these, 138 (52.1%) were females and 127 (47.9%) were males giving a male to female ratio of 0.9: 1. One hundred and twenty-two students (46.0%) belong to the lower social class. Twenty-three (8.7%) participants had allergic features. (Table 1)

The Mean FEV₁ of the participants before and after exercise is as shown in Figure 1.

3.1. Prevalence of exercise-induced bronchospasm

Thirty-four (12.8%) of the 265 participants had EIB at five minutes post exercise, this value reduced to 21 (7.9%) at 10 minutes post exercise and 10 (3.8%) at

Table 1. Socio-demographic, anthropometric characteristics, allergic symptoms and FEV₁ measurements.

Variables	Frequency (n) n = 265	Percentage (%)
Age (in years)		
10–13	135	50.9
14 – 17	130	49.1
Gender		
Male	127	47.9
Female	138	52.1
Social class		
Upper	71	26.8
Middle	72	27.2
Lower	122	46.0
BMI percentile		
Underweight	26	9.8
Normal weight	201	75.8
Overweight	32	12.1
Obesity	6	2.3
Allergic symptoms		
Vernal conjunctivitis	13	4.9
Allergic rhinitis	8	3.0
Eczema	1	0.4
Past history of wheeze	1	0.4
In-door air pollution		
Use of biomass fuel for cooking	115	43.4
Exposure to parental cigarette smoking	9	3.4
History of cigarette smoking	0	0

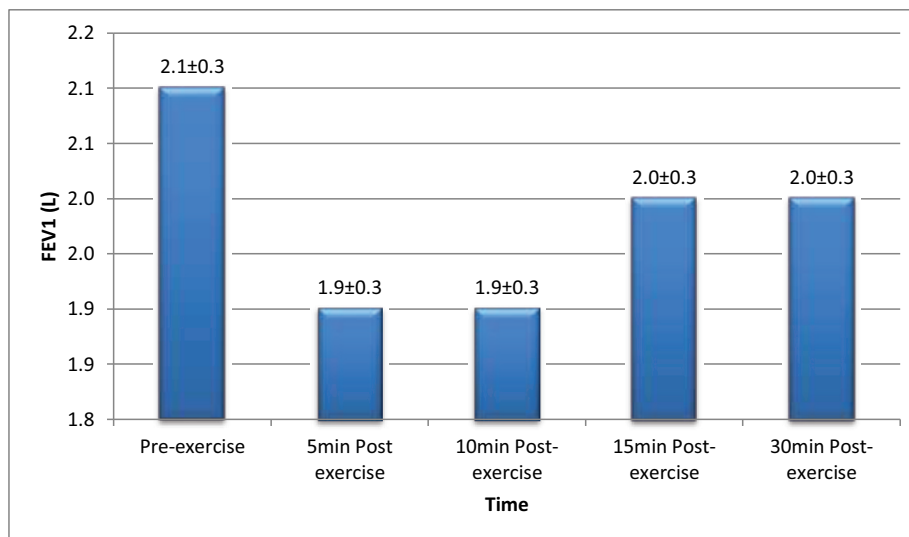


Figure 1. Forced Expiratory Volume in 1 second (FEV₁) (L) Mean±SD.

15 minutes post exercise. No student had EIB at 30 minutes post exercise. (Figure 2)

3.1.1. Association between socio-demographic profile, anthropometric characteristics and presence of exercise-induced bronchospasm at 5 minute post-exercise

Participants between ages 10–13 years had a higher frequency of EIB. There was a statistically significant association between age and EIB ($\chi^2 = 18.416$, $p < 0.001$). The gender, social class and BMI percentile did not show any significant association with EIB. (Table 2)

3.1.2. Association between EIB and allergic features, exposure to smoke from biomass fuel and cigarette smoke

The presence of vernal (allergic) conjunctivitis and allergic rhinitis were significantly associated with EIB

among the participants ($\chi^2 = 13.574$, $p < 0.001$ and $p = 0.011$ respectively). Cooking with biomass fuel and exposure to parental cigarette smoke were not significantly associated with the development of EIB. (Table 3)

4. Discussion

This study shows that EIB exist among apparently healthy secondary school students in Osogbo, with a prevalence of 12.8%. The prevalence observed in this study is comparable to the 13.2% reported by Sudhir *et al* among urban school children in India [19]. The prevalence of EIB in this study is however lower than the 23.8% reported by Kuti *et al* in Ilesa, Nigeria [6]. The disparity in the prevalence rates in these studies may be explained by the difference in study participants. Though the study was also conducted among children in an urban setting, the

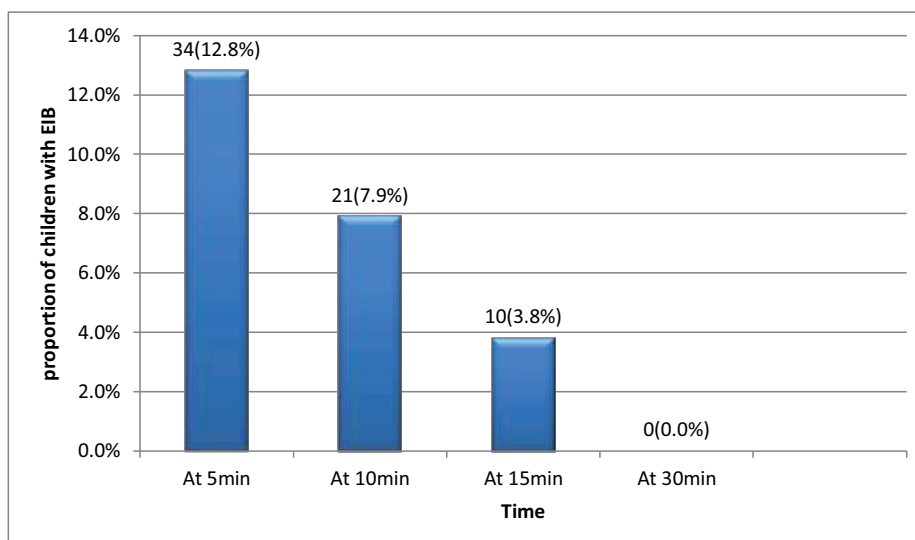


Figure 2. Prevalence of exercise-induced bronchospasm in the respondents.

Table 2. Association between socio-demographic profile, anthropometric characteristics and exercise-induced bronchospasm at 5 minute post-exercise.

Socio-demographic profile	EIB Status at 5 min		Test statistics	P-value
	Positive n (%) n = 34	Negative n (%) n = 231		
Age	29 (21.5)	106 (78.5)	$\chi^2 = 18.416$	<0.001
10–13	5 (3.8)	125 (96.2)		
14 – 17				
Gender	15(11.8)	112(88.2)	$\chi^2 = 0.226$	0.634
Male	19(13.8)	119(86.2)		
Female				
Social Class	6(8.5)	65(91.5)	$\chi^2 = 2.793$	0.247
Upper	8(11.1)	64(88.9)		
Middle	20(16.4)	102(83.6)		
Lower				
BMI percentile	5(19.2)	21(80.8)	$\chi^2 = 7.004$	0.072
Under weight	29(14.4)	172(85.6)		
Normal weight	0(0.0)	32(100.0)		
Overweight	0(0.0)	6(100.0)		
Obesity				

Table 3. Association between allergic features, exposure to biomass fuel, parental cigarette smoke and exercise induced-bronchospasm at 5 minute post-exercise.

Variables	EIB Status at five minutes post exercise		Test statistics	P-value
	Positive EIB n(%)	Negative n(%)		
Vernal conjunctivitis			$\chi^2 = 13.574$	<0.001
Yes	6(46.2)	7(53.8)		
No	28(11.1)	224(88.9)		
Allergic rhinitis			Fisher's exact test	0.011
Yes	4(50.0)	4(50.0)		
No	30(11.7)	227(88.3)		
Eczema			Fisher's exact test	1.000
Yes	0(0.0)	1(100.0)		
No	34(12.9)	230(87.1)		
Past history of wheeze			Fisher's exact test	0.128
Yes	1	0		
No	33	231		
Cooking with biomass fuel			$\chi^2 = 1.447$	0.229
Yes	18	97		
No	16	134		
Parental cigarette smoking			Fisher's exact test	0.609
Yes	0	9		
No	34	222		

inclusion of children with asthma may explain the higher prevalence. Higher prevalence of EIB has been reported in people previously diagnosed with asthma who are not on anti-inflammatory treatment [20]. These individuals usually experience exacerbation of underlying inflammation and airway hyperactivity during physical activity with resultant bronchospasm. The prevalence of EIB in this study is however higher than the 6.0% reported by Onazi *et al* among school children in Gusau, Nigeria [5]. The disparity in findings may be due to the different diagnostic criteria. While a decrease in FEV₁ of $\geq 10\%$ was used in this study, Onazi *et al* used a $\geq 15\%$ decrease in PEF_R as

their diagnostic criteria. The forced expiratory volume in one second (FEV₁) is a more accurate measure of airway bronchoconstriction than peak expiratory flow rate [18]. This is because PEF_R varies more with each use; it is highly effort dependent and mainly dependent on flow rate in larger airways [21]. Another reason for the difference in the prevalence rate observed in this study and that of Onazi *et al* may partly be explained by the difference in age categories of the school children evaluated. Onazi *et al* included younger age school children (5–9 years), while the present study involved school children aged 10–17 years. EIB has been noted to be more in the adolescent than in younger children [5,6].

With regards to the demographic characteristics of the respondents, the early adolescents (age 10–13 years) had a significantly higher frequency of EIB than older children. This is similar to the studies of Onazi *et al* [5] and Kuti *et al* [22] who both reported a higher prevalence of EIB in the early adolescent age group; 10–14 and 11–13 years respectively. This finding may be explained by the fact that asthma and related disorders have been observed to be commoner during early puberty, and this is particular so in girls; this is because of the changes in level of female hormones during this period [23]. In addition, this study shows that EIB occurred more commonly in female than males; however this difference was not statistically significant. The gender difference observed in this present study is similar to what was reported by De Baets *et al* [8] and Joason *et al* [24]. The higher occurrence in females may be as a result of changes in sex hormone such as estrogen and progesterone during puberty [25]. Evidence have shown that sex hormones play an important role in the development of allergic immune response, estrogen promotes while androgen attenuates allergen-mediated type 2 airway inflammation which is most commonly seen in patients with asthma [26]. Airway inflammation is important in the development of asthma and EIB [27].

In this study, there was no significant association between EIB and BMI. This finding is contrary to previous studies where it was observed that EIB was significantly more frequent in children who are overweight or obese [28]. The absence of EIB in obese children in the present study may be explained by the small number (six) of obese children involved in the study. This finding is, however, similar to some other studies that observed no significant association between EIB and BMI [29]. For instance, Mansournia *et al* [29] observed that there was no significant association between EIB and BMI, while Lopes *et al* [30] reports that obesity does not contribute to increased EIB frequency in non-asthmatic adolescents. Findings on EIB and

body weight are not universal; hence more longitudinal studies may be needed to ascertain the relationship between BMI and EIB.

In the present study, children in the lower socioeconomic class had the highest frequency of exercise induced bronchospasm, although this difference was not statistically significant. This finding is similar to what was reported by Kuti *et al* [22] in Nigeria. Other researchers have also reported similar findings [29,31]. Our finding appears to contradict the general belief that EIB and/or asthma are commoner among children of higher socioeconomic class [32]. The reason for this finding is unclear. Other confounding factors that may be related to low social class such as presence of house dust mite, rearing of poultry/pets, were not investigated in this study. However, researchers have postulated that children from low socio-economic class were usually at a higher risk of intestinal parasite and this may contribute to the development of allergy [20].

In our study, allergic (vernal) conjunctivitis and allergic rhinitis were significantly associated with the development of EIB. This finding is in agreement with previous studies [5,6,33]. Atopy (allergy) is a major risk factor for the development of EIB. Epidemiologic data has demonstrated allergic rhinitis in up to 40% of Pediatric population with EIB [2]. Allergic sensitization induces systemic Type-2 T helper-cell immunity which predisposes the individual to airway inflammation thus promoting hyper-reactivity [2]. Eczema and a past history of wheeze were not significantly associated with EIB. Although history of wheeze has been reported in some studies to be associated with EIB [5,6], our finding was quite different. The disparity in findings may be explained by the fact that only one subject had eczema and past history of wheeze. Furthermore, individuals with present history of wheeze and those who had rhonchi on auscultation were excluded from the study.

This study showed no significant association between EIB and exposure to indoor air pollution such as cooking with biofuel mass and parental cigarette smoke. Although this finding is similar to that of some earlier researchers, it is, however, contrary to the general belief that indoor air pollution is significantly associated with asthma and EIB. The reason for this different finding may be because our study participants are school children who stay more outdoor (stay a minimum of eight hours in school) thereby giving them a limited period of exposure to these agents.

In conclusion, this study has shown that EIB occurs in a significant number of non-asthmatic school children, and it is more frequent in the early adolescent age-group. School children with allergic conjunctivitis

and rhinitis are more likely to manifest exercise induced bronchospasm.

4.1. Limitation

We did not do skin prick test nor estimated serum Immunoglobulin E (IgE) in the determination of allergic sensitization in our participants.

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Disclosure statement

The authors have no conflict of interest to declare.

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