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Exercise-Induced Bronchospasm, Prevalence and Associated Factors in University Students in STAPS

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Abstract

Background: There are links between physical exercise, fine particles and the prevalence of exercise-induced bronchospasm (EIB). **Objective:** The aim of this study was to assess the prevalence of exercise-induced bronchospasm in students of sciences and techniques of physical activities and sports (STAPS) exercising in a hot, humid and relatively polluted environment. **Methods:** Twenty-two first-year undergraduate students, including 11 in PE and 11 in SPORT, aged 21.64 ± 1.80 years, participated in a football match. Resting spirometry was performed before and 5 minutes after the match. During the match, particulate matter (PM2.5 and PM10) was measured every 10 minutes around the football pitch. Ambient temperature and relative humidity were recorded. The diagnosis of EIB was based on a decrease in FEV1 of at least 10% after the match. If there was a decrease, the participant was considered susceptible to EIB. **Results:** Five subjects were positive for exercise-induced bronchospasm, a percentage of 22%. Ambient temperature and relative humidity were 34.22˚C ± 1.38˚C and 52.2% ± 4.97%, respectively. Concentrations of PM2.5 and PM10 were between 53.3 - 115.5 μg/m^3 and 75.5 - 168.2 μg/m^3, respectively, exceeding WHO limits. **Conclusion:** These results show a high incidence of exercise-induced bronchospasm in students without a history of asthma but exercising in a hot, humid and environment polluted by fine particles.

Keywords

Bronchoconstriction, Air Pollution, Sports Health, Respiratory Asthma, Athlete

1. Introduction

Exercise-induced bronchoconstriction (EIB) is the transient narrowing of the airways after exercise. This phenomenon is common in athletes who may have no diagnosis of asthma or even no respiratory symptoms [1]-[4]. The child, athlete or atopic patient is prone to exercise-induced bronchoconstriction. Rhinitis or respiratory infection during exercise may predispose to exercise-induced bronchoconstriction [3] [5]. Johansson *et al.* [6] reported a prevalence of EIB in the general population of approximately 5% to 20%. Study by Burnett *et al.* [7] has shown that the prevalence of EIB is relatively high (18% to 34%) in athletes participating in both individual and team sports. It also varies according to the type of sport, the ventilatory demands and the environmental conditions in which the sport is performed.

Boulet & O'Byrne [2] showed a higher prevalence of EIB in elite athletes compared to the general population (21% vs. 10%). Similarly, studies by Anderson & Kippelen [8] and Carlsen *et al.* [5] have shown that the prevalence of EIB in athletes trained for high-level endurance events ranges from 10% to 55%. It is, therefore, not surprising that high performance endurance athletes who train in a hot, humid and polluted environment have an increased prevalence of several respiratory diseases such as asthma, rhinitis and EIB compared to non-athletes [9] [10].

While Exercise-induced bronchoconstriction is strongly correlated with hot, humid conditions and exercise levels, it should also be noted that EIB can be triggered by pollutants such as fine particles. The Higher Institute of Physical and Sports Education is a university facility located near major roads with dust-covered playing fields. It is also close to the largest market in the capital, where the unhygienic environment and garbage odors can cause respiratory problems.

The aim of this study was to assess the prevalence of bronchospasm in students of sciences and techniques of physical activities and sports exercising in a hot, humid environment relatively polluted with fine particles. We hypothesized that football, which is a long-duration, intermittent sport played in a hot, humid environment, might affect lung function and induce bronchospasm in students.

2. Material and Methods

2.1. Study Participants

Twenty-two students (age: 21.62 ± 0.62 years, weight: 63.91 ± 3.09 kg, height: 173.27 ± 1.92 cm) participated in this study. In this nonprobability sampling method, the subjects are selected by the choice of the investigators among 110 students. Participants were first-year undergraduate students, including 11 in

Physical Education and Sports (PE) and 11 in SPORT, practicing at the Higher Institute of Physical and Sports Education (HIPSE) of Marien Ngouabi University, Congo. All practical courses are held outdoors. Measurement of forced expiratory volume in L/seconds ($l·s^{-1}$) enabled us to determine positivity to exercise-induced bronchospasm. None of the subjects had a respiratory antecedent, nor did they suffer from any restrictive or obstructive ventilatory disorder. Exclusion criteria were: recent upper respiratory tract infection, a history of chronic lower respiratory disease, a history of allergic disease, and history of bronchodilator drugs consumption during the 24 hours prior to the study. They had been working near road traffic for one year. The study was approved by the Scientific Council of the Higher Institute of Physical and Sports Education of University in accordance with the Helsinki declarations on ethics. Written informed consent was obtained from all study participants.

2.2. Experimental Design

This experimental study was conducted using a repeated measures design at the Higher Institute of Physical and Sports Education (HIPSE), of University, in February 2024. The students were familiar with spirometry tests before entering a two-phase protocol that took place (1) before the soccer match and (2) 5 minutes after the match. They performed a general warm-up followed by specific stretching for 15 minutes. Each phase included measurements of spirometry and particulate matter. Subjects performed a forced expiratory volume measurement in $1·sec^{-1}$ (FEV1) before and 5 minutes after exercise, which allowed us to determine positivity for exercise-induced bronchospasm. If the FEV1 fell to 10%, the subject was considered positive for exercise-induced bronchospasm. This allowed us to create two groups in the statistics: the non-bronchospasm positive group (EIB−) and the exercise-induced bronchospasm positive group (EIB+). The match lasted 90 minutes, divided into two periods of 45 minutes each, with a 15-minute break in between. The football match was played from 12 noon to 2 pm at the HIPSE. It was played in accordance with national and international football regulations. During the match, particulate matter (PM2.5 and PM10) was measured every 10 minutes around the pitch, and ambient temperature and relative humidity were measured before and after the first half and before and after the second half of the match. The ambient temperature was 34˚C with a maximum of 35.7˚C and the relative humidity was 52% with a maximum of 59%. Subjects were instructed not to consume alcohol, drugs or caffeine and not to exercise in the 24 hours prior to the protocol. They were allowed to go for a short jog on the day of the experiment. Verbal encouragement was given during the tests.

2.3. Pulmonary Function Test

The football match with two periods of 45 minutes, played from 12 to 2 pm, acting as indirect challenges that release the entire repertoire of mediators representative of EIB and asthma was used raver than direct challenges (methacholine challenge), which are sensitive but nonspecific [11]. Spirometric parameters were measured in the sitting position. Forced expiratory volume in one second (FEV1), forced vital capacity (FVC) and peak expiratory flow rate (PEFR) were measured using a portable Spirobank G-type spirometer manufactured by Medical International Research (Spirobank G USB, MIR, ROMA, Italy) (volume precision: ± 3% or 50 ml and flow rate precision: ± 5% or 200 ml/s) according to standard techniques and procedures. The Spirobank G consists of a central unit, monitor and turbine with Winspiro PRO software installed in the central unit. The Spirobank G was connected to a portable Dell microcomputer with a USB cable so that the measurements of the spirometric variables and the flow-volume curve of the spirometry test could be displayed on-screen.

2.4. Environmental Measures

Measurements of fine particles (PM2.5 and PM10) were carried out from 12 a.m. to 14 p.m. every 10 minutes using a "Temtop Airing-1000" portable particle detector (China). Ambient temperature and relative humidity were also measured from 11:00 a.m. to 14:00 p.m. using an electronic "SUNROAD" type hygrometer (Japan). Only the minimum and maximum values of PM 2.5, PM 10, ambient temperature and relative humidity recorded during the day were taken into account.

2.4. Statistical Analysis

Results are expressed as means ± standard deviations. The diagnosis of EIB was based by a decrease in FEV1 by at least 10% after the soccer match. If there were reduction in FEV1, the participant was considered as prone to EIB. T-test and chi-square were used for comparing variables. Descriptive statistics were used to generate means and standard deviations for fine particles (PM2.5 and PM10) and ambient temperature and relative humidity. Mean values of lung function variables recorded before the match and 5 minutes after the end of the match were compared by Student's t-test for repeated measures. The non-parametric Man Whitney test was used to compare anthropometric and spirometric parameters between subjects in the EIB-sensitive group (EIB+) and those in the non-EIB-sensitive group (EIB−). Variable data were recorded and processed using SPSS version 25 (IBM Corp., Armonk, New York, USA), and the significance level was set at $p < 0.05$.

3. Results

The general characteristics of the students in both groups (EIB− vs. EIB+) are presented in **Table 1** (age, height, weight and body mass index (BMI) and forced expiratory volume in the first second (FEV1). The comparison of the FEV1 and PEFR values before the football match and 5 minutes after the match showed a 10% decrease in FEV1 in 5 students (**Table 1**). This result allowed us to divide the students into two groups: EIB+ group (n = 5) and EIB− group (n = 17) (**Table 1**).

Table 1. Anthropometric characteristics of the study population and exercise-induced bronchoconstriction (EIB) with 10% fall in FEV1.

Parameters	EIB− (n = 17)	EIB+ (n = 5)	P Value
	mean ± SEM	mean ± SEM	
Age (yr)	21.64 ± 1.80	20.40 ± 1.94	0.21
Height (cm)	171.35 ± 5.26	175.20 ± 3.83	010
Weight (kg)	60.82 ± 8.40	67.00 ± 6.89	0.06
BMI (kg/m^2)	20.66 ± 2.04	21.79 ± 1.57	0.19
FEV_1 before (l)	3.63 ± 0.54	3.71 ± 0.23	0.272
FEV_1 after (l)	3.53 ± 0.45	3.05 ± 0.34	0.021*✟

Notes: EIB−, non-bronchospasm-positive subjects; EIB+, bronchospasm-positive subjects, SEM, standard error of the mean; BMI, body mass index; FEV1, forced expiratory volume in the first second; *Significant difference, between before-exercise versus after exercise ($p < 0.05$). ✟, fall of 10% or more of FEV1, expressing positivity to exercise-induced bronchospasm.

Post-match FEV1 decreased significantly by at least 10% in 5 subjects, or 22% and PEFR decreased significantly by at least 15% in 8 subjects, or 36% in EIB+, without however showing a significant decrease in EIB− subjects (Table 2).

Table 2. Spirometric parameters and percentage fall in FEV1 and PEFR and positivity to exercise-induced bronchospasm.

Spirometric parameters	Fall of 10% or more (EIB+)		No drop or insignificant drop (EIB−)	
	n	%	n	%
FEV_1 (l)	**5**	**22.7**	**17**	**77.3**
FVC (l)	5	22	17	78
PEFR ($l \cdot s^{-1}$)	**8**	**36**	**14**	**63**

Notes: EIB+, bronchospasm-positive subjects; EIB−, non-bronchospasm-positive subjects; n, number of subjects; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; PEFR, peak expiratory flow rate.

The comparison between values for FEV1, FVC, peak expiratory flow rate (PEFR) decreased significantly after compared to before the soccer match in EIB+ ($P < 0.002$) (Table 3). There was no significant change before and after the match in EIB− ($P > 0.05$) (Table 3).

The results in Table 4 show that PM2.5 and PM10 concentrations measured in the vicinity of the pitch throughout the soccer match were well in excess of WHO 24-hour limits. It appears that the ambient temperature recorded at the start of the first period was 32.4˚C and increased to 35.3˚C at the end of the second period with a mean standard deviation of 34.22 ± 1.38 and the relative humidity recorded at the start of the first period was 48.3% and increased to 59.3 % at the end of the match with a mean standard deviation of 52.2 ± 4.97.

Table 3. Mean spirometric values measured before exercise and 5 min after soccer match and comparison between EIB− and EIB+. Values are expressed as mean ± SEM.

Parameters	EIB−	EIB+
	mean ± SEM	mean ± SEM
FEV1 before (l)	3.63 ± 0.54	3.71 ± 0.23
FEV1 after (l)	3.53 ± 0.45	3.05 ± 0.34*
FVC before (l)	4.21 ± 0.64	4.51 ± 0.54
FVC after (l)	3.96 ± 0.49	3.76 ± 0.58*
PEFR before ($l \cdot s^{-1}$)	7.46 ± 1.25	7.75 ± 2.08
PEFR after ($l \cdot s^{-1}$)	7.24 ± 1.23	6.62 ± 1.40*

Notes: SEM, standard error of the mean; EIB−, non-bronchospasm-positive subjects; EIB+, bronchospasm-positive subjects; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; PEFR, peak expiratory flow rate; *Significant difference, between before-exercise versus after exercise ($p < 0.05$).

Table 4. Concentration of fine particles (PM2.5 and PM10) recorded during the match.

Sampling site	Sampling time	PM2.5 concentration measured (μg/m³)	WHO recommended 24-hour threshold (μg/m³)	PM10 concentration measured (μg/m³)	WHO recommended 24-hour threshold (μg/m³)
Around the ISEPS soccer field	90 minutes	78.79 ± 23.11 [53.3; 115.5]	15	109.33 ± 29.67 [75.5; 168.2]	45

Notes. WHO, World Health Organization; PM2.5, Particulate matter or fine particles with a diameter of less than 2.5 μm; PM 10, Particulate matter or fine particles less than 10 μm. The results in Table 4 show that PM2.5 and PM10 concentrations measured in the vicinity of the pitch throughout the soccer match were well in excess of WHO 24-hour limits.

4. Discussion

The main results of this study show a prevalence of exercise-induced bronchospasm of 22% in students. We also showed a decrease in forced vital capacity and peak expiratory flow. The decrease in these last two parameters is due to airway obstruction, a disturbance in lung function and supports the idea of exercise-induced bronchospasm. There was also an increase in the concentrations of PM2.5 and PM10 measured around the pitch throughout the match. These parameters are above the values set by the WHO.

The prevalence of EIB is estimated to be between 5% and 20% in the general population [12], reaching 90% in asthmatic subjects [2]. In the present study, non-asthmatic students were susceptible to EIB, with a prevalence of 22% (**Table 2**).

The DEP is also one of the criteria for determining the EIB. It decreased by 36%, confirming the EIB in these athletes (**Table 2**). This prevalence is higher than in the general population (5% - 20%), but lower than the EIB prevalence reported in elite athletes [9]. Our result corroborates that of the study carried out by Nsompi *et al.* [13], reporting a prevalence of 33% among athletes in hot and humid environments. Athletes who train in cold air environments and/or a dry atmosphere may be more susceptible to bronchoconstriction and have a higher prevalence [14]. On the other hand, due to the significant circulation of air during exercise, the respiratory tract of these athletes is often exposed to numerous allergens and particles (PM2.5 and PM10). Indeed, the concentrations of PM 2.5 (78.79 ± 23.117 $\mu g/m^3$) and PM10 (109.33 ± 29.672 $\mu g/m^3$) measured near the student's property were much higher than the reference values in 24 hours (**Table 3**). The WHO recommends levels of 15 $\mu g/m^3$ for PM 2.5 and 45 $\mu g/m^3$ for PM 10 in 24 hours. The studies by Weiler *et al.* [9] showed that the prevalence of EIB varies depending on the environment in which the sport is practiced, the type of sport and the maximum intensity achieved.

It should be noted that the environment in which the match took place in our study was polluted. In fact, the land is located near major roads and a large market. This causes the air to be polluted by combustion engines, in particular fine particles and detritus, considered to be very harmful to the respiratory tract [15]. Giles *et al.* [16] and Rundell *et al.* [15] claimed that pre-exposure to diesel exhaust significantly attenuated the respiratory effects of physical activity on lung function. In the present study, the ambient temperature and relative humidity were 34˚C and 54%, respectively, with values of 35˚C and 59% at maximum. Our results are consistent with those reported by Maughan *et al.* [17], who demonstrated that in a warm environment (30˚C) with relative humidity levels of 24%, 40%, 60% and 80%, the ability to exercise at 70% of the Maximum oxygen consumption deteriorates as humidity increases. Although beneficial, exercise requiring intense effort, performed in unfavorable environmental conditions, is also likely to cause respiratory distress and EIB [3]. Indeed, the prevalence of EIB of 22% observed in our subjects is different from that reported by Wilber *et al.* [14]. This can be explained by the fact that bronchoconstriction is influenced by several variables, including environmental and climatic conditions, as demonstrated by the studies of Burnett *et al.* [7]. These authors showed that the prevalence of EIB among athletes practicing individual and team sports varies between 18 and 34%. This variation depends on the type of sport, ventilatory demands and the environmental conditions in which the sport is practiced. In our study, football was played in a hot, humid and polluted environment. These three factors together could explain this high prevalence of EIB.

We showed a significant decrease in post-exercise PEF (7.75 ± 2.08 ($l \cdot s^{-1}$) vs. 6.62 ± 1.40 ($l \cdot s^{-1}$)) and post-exercise FVC (4.51 ± 0.54 (l) vs. 3.76 ± 0.58 (l)) in EIB (+) students (**Table 3**). These results show that football resulted in a reduction in lung function capacity. Our results are consistent with those of Zavorsky *et al.* [18]

and Nsompi *et al.* [13], who showed an acute decrease in FEV1, PEF and FVC after prolonged exercise in amateur runners and professional long-distance runners, respectively. The authors reported that the decreases in these parameters after prolonged endurance exercise suggest ventilatory dysfunction and/or impaired lung function in individuals with of EIB. Furthermore, Smith *et al.* [19] reported that this alteration, associated with air pollution, may lead to respiratory dysfunction and respiratory muscle fatigue.

Physical education and sports classes must be taught very early in the morning, when traffic is less dense. In addition, the state should build schools away from main roads so that pupils and students are not exposed to automobile pollutants. Indeed, the latter are likely to cause respiratory and blood diseases. However, there are some limitations of the method, such as the small sample size, false positives and negatives, reproducibility, signs and symptoms mismatch and safety concerns. Other limitations are linked to the lack of measurement of PM2.5, PM10, temperature, and humidity continuously throughout the match. So, it is worth noting that the differences reported in our study may only be within-group changes. Given the importance of the issue, future studies should include a larger sample.

5. Conclusion

The aim of this study was to assess the prevalence of exercise-induced bronchospasm in first year undergraduate exercise science and technology students working in a polluted environment. In our study, we reported a decrease in FEV1 and PEFR after exercise, *i.e.* a susceptibility rate to exercise-induced bronchospasm of 22 % and 36 % respectively, associated with a decrease in forced vital capacity, suggesting a decrease in pulmonary compliance or small airway closure. The football match took place in a hot and humid environment with high levels of particulate matter, well above the WHO 24-hour standard. These factors are likely to exacerbate the change in lung function parameters and increase the incidence of exercise-induced bronchospasm.

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Ethical Approval and Informed Consent

The study designs were approved by Institutional Ethics Committee of High institute of physical education and sport, Marien Ngouabi University, Brazzaville, Republic of Congo. A letter of consent was obtained from all participants.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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