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The Prevalence of Exercise-Induced Bronchoconstriction among Symptomatic Sportsmen

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SUMMARY Exercise-induced bronchoconstriction (EIB) is a transient airflow obstruction that usually occurs 5 to 15 minutes after physical exertion. Although this condition is preventable, it is still underrecognized and affects the quality of life. The purpose of this study was to evaluate the prevalence of EIB, to find out whether self-reported symptoms were enough to establish the diagnosis of EIB and to define related symptoms and risk factors among symptomatic students of a Sports Academy in our city, which is situated at about 2,000 meters altitude and experiences a long winter period. A questionnaire was sent to students of the Sports Academy. After its evaluation, symptomatic students were invited to perform a pulmonary function test (PFT) before and after a six minute exercise test. Two hundred and seventy-seven students (205 males and 72 females, mean age: 20 ± 4) from 12 different types of sport replied to the questionnaire. Of these subjects, 43% were symptomatic. Out of the 119 symptomatic students, 63 accepted our invitation. Three of them were excluded. After performing a six-minute exercise test, EIB was observed in 5 (8%) of them, whose symptoms were aggravated by cold weather. Our results suggest that EIB may be common among symptomatic sportsmen. Screening is important, since EIB could be prevented with appropriate diagnosis and treatment. Although respiratory symptoms during exercise may give important clues, only these symptoms are not sufficient to establish the diagnosis of EIB. Symptomatic patients should undergo further tests for EIB.

Exercise-induced asthma (EIA) and exercise-induced bronchoconstriction (EIB) are often used as synonymous terms to describe the airway narrowing that follows vigorous exercise. However, the exact relationship of EIB with asthma remains unclear, but up to 90% of known asthmatics report EIB,[1] and EIB is found in up to 35% of the population with no asthma history.[2,3] EIB is a transient airflow obstruction usually occurring 5 to 15 minutes after physical activity. Although it is easy to prevent, it is still underrecognized and affects aerobic fitness and quality of life.[4]

The diagnosis is based on a detailed history, including assessment of asthma triggers, symptoms suggestive of EIB, and a normal forced expiratory volume at one second at rest. The confirmation is done by a recorded fall in the peak expiratory flow rate or an FEV_1 of 15 percent or more after a thermal challenge (exercise and hyperventilation).[1]

The purpose of this study was to evaluate the prevalence of EIB, to find out whether the self-reported symptoms were enough to establish the diagnosis of EIB, and to define related symptoms and risk factors among the symptomatic students of a Sports Academy in our city, which is situated at about 2,000 meters altitude and experiences a long winter period lasting approximately 6 months.

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METHODS

Study design

A questionnaire was sent to 380 students of the Sports Academy. The questionnaire included questions about age, sex, type of sport, history of atopy or allergy, smoking habit, respiratory symptoms (cough, shortness of breath, wheezing, chest tightness, chest pain, stomach upset, sore throat and/or sputum production) in relation to exercise and cold climate.

Symptomatic students were invited to perform a pulmonary function test before and after a six minute exercise test, done at room temperature under laboratory conditions. Subjects who did not have an asthma diagnosis, a recent history of respiratory tract infection and did not take any medication were included in this study. Sixty-three students accepted our invitation. None of them had a history of previously diagnosed asthma or of asthma medication use. The cases with a history of a recent upper respiratory tract infection (n = 2) or drug intake (n = 1) were excluded.

Informed consent was obtained before the study. The study was approved by the Ethics Committee of the Medical Faculty of the Atatürk University.

Pulmonary function test and bronchial challenge test

All tests were conducted between 8:00 a.m. and noon with a relative-humidity of 35% and an average temperature of 19°C. Flow volume spirometry was carried out with a computerized spirometer (Sensor Medics, Vmax22). The forced expiratory volume in one second (FEV_1) and the forced vital capacity (FVC) were measured and the values of the best effort were used in each case. The values were expressed as a percentage of predicted values. Measurements were made immediately before and at 1, 3, 5, 7, 10, 15, 20 and 30 minutes after exercise. Because of the unavailability of a methacholine challenge test, only free running tests were used. A positive EIB was defined as a 15% reduction or more in the post-exercise FEV_1 compared to the pre-exercise FEV_1 value.

Statistical analyses

Data were analyzed using SPSS for Windows 9.0 software. Pearson's Chi-square test and Mann Whitney U test were used for the analysis of categorical variables and continuous variables, respectively. Correlations between parameters were analyzed with Pearson's correlation coefficient. Data were expressed as the mean ± SD and a probability of less than 0.05 was considered to indicate significance.

RESULTS

Two hundred and seventy-seven students (205 males and 72 females) from 12 different types of sport including football, basketball, volleyball, handball, athletics, wrestling and others (Table 1) replied to the questionnaire. The age range was 13-33 years (mean age: 20 ± 4). Of these subjects, 31.8% were smokers. The ratio of smoking was higher in men than in women (34.6% versus 23.6%). The average beginning age of smoking was 18 ± 3 years. Forty of them (14.4%) had a history of allergy

Table 1 The types of athletes who replied to the questionnaire

Types of Sport	N	Smoking history	Allergy history	Having symptoms	Symptom aggravation by cold
Football	108	43	17	43	17
Basketball	36	12	8	20	7
Volleyball	33	7	6	13	6
Handball	21	11	2	10	4
Athletics	28	4	4	11	6
Wrestling	32	6	2	16	8
Others*	19	5	1	8	2
Total	277	88	40	121	50

*Boxing, tennis, taekwondo, skiing, weightlifting and cycling.

mostly to egg and dust. Other allergic histories were to spicy foods, tomato, pollens and smoke. Of these subjects, 43% were symptomatic after exercise. The most frequent symptoms were coughing, chest tightness and dyspnea (Table 2).

Considering demographics, respiratory symptoms were higher in females, in older ages, in smokers and in those with a history of allergy. A significant relationship was only determined between smoking and respiratory symptoms ($p < 0.05$). Also, the amount of smoking significantly correlated with the symptoms ($p < 0.05$). The most frequent symptoms in smokers were wheezing and dyspnea. Aggravation of the symptoms by cold air was significant ($p < 0.001$). The timing of the appearance of the symptoms was different between the different types of sport, and the mean time interval between the end of their exercise and the onset of their symptoms was 21 ± 19 minutes.

Attempts were made to compare the features of indoor and outdoor sports (Table 3). Dyspnea was more prominent in indoor sports, however, wheezing and chest tightness were significantly higher in outdoor sports ($p < 0.01$ and $p < 0.05$, respectively).

Sixty subjects underwent the tests. No significant relationship was found between initial pulmonary function tests and age, sex, smoking, type of symptoms and allergy history. All subjects tolerated the free running test well. EIB was observed in 5 (8%) of 60 subjects. The characteristics of the subjects with and without EIB were summarized in Table 4. The mean maximal percentage falls in FEV_1 after exercise were 29.42 and 6.13% in subjects with EIB and without EIB, respectively. Initial lung functions in subjects with EIB did not significantly differ from those in subjects without EIB. Of the subjects with EIB, three were female (2 athletes and 1 volleyball player) and two were male (1 athlete and 1 football player). While three of them had a smoking history only, one had an allergy history only (male footballer), and another one

Table 2 Symptoms during exercise

Symptom	N	Smoking history	Allergy history	Symptom aggravation by cold
Coughing	50	20	6	27
Chest tightness	50	20	13	21
Dyspnea	49	23	9	18
Chest pain	35	15	4	18
Wheezing	29	17	8	14

Table 3 Comparison of indoor and outdoor sports

	Indoor sports (%) N = 137	Outdoor sports (%) N = 140	*p*-value
Symptomatic	67 (48.9%)	54 (38.6%)	NS
Symptom aggravation by cold	27 (19.7%)	23 (16.4%)	NS
Coughing	25 (18.2%)	25 (17.9%)	NS
Chest tightness	22 (16.1%)	28 (20.0%)	< 0.05
Dyspnea	30 (21.9%)	19 (13.6%)	NS
Chest pain	19 (13.9%)	16 (11.4%)	NS
Wheezing	8 (5.8%)	21 (15.0%)	< 0.01

NS, not significant

Table 4 The baseline characteristics of 60 study subjects who performed a free running test

	EIB-positive (N = 5)	EIB-negative (N = 55)
Age (years)	19 ± 1	20 ± 3
Female/male	3/2	15/40
FEV1 (% predicted)*	104.07 ± 6.57	105.38 ± 4.83
FEV1/FVC (% predicted)*	90.18 ± 16.43	93.45 ± 12.07
Indoor/outdoor sports	1/4	19/36
Allergy history	2	20
Smoking history	4	30

Values are expressed as means (SD; EIB, exercise-induced bronchospasm;
*, not significant statistically.

had both, an allergy and a smoking history (female athlete). The symptoms of these 5 cases aggravated in cold weather.

DISCUSSION

EIB afflicts many people worldwide. While generally self-limiting, it can hinder performance and reduce activity levels, thus it is an important condition to diagnose and treat. In this study, we found the prevalence of EIB at 8% in symptomatic students who performed an exercise challenge. Although the results did not exactly reflect the true prevalence, they suggested that EIB was more common than expected.

Some previous studies have investigated the incidence of EIB in college and high school athletes with varied results.[2,5] For example, while Rice *et al.*[2] initially reported a 2.8% incidence of EIB in college athletes, Huftel and colleagues[6] reported a 17% incidence of EIB in athletes without a history of asthma. Rupp *et al.*[7] stated this rate as 29%. On the other hand, in asthmatic patients, the prevalence of EIB has been reported to be ranging from 40 to 90 percent.[8-10] This wide range for the incidence of EIB may be attributed to some exogenous factors, such as differences in the intensity of the exercise, lack of uniformity in the methods used to detect the response, and failure to standardize the environmental variables that control the magnitude of the obstruction.[11]

The diagnosis of EIB is mainly based on a detailed history suggestive of shortness of breath, decreased exercise endurance, chest tightness, cough, or wheezing during or immediately following sustained exercise.[14] The most frequent respiratory symptoms in our study were coughing and chest tightness. Although patients elsewhere also reported an upset stomach or a sore throat,[4] our cases did not have such complaints.

Most of our cases (43%) were symptomatic, but EIB was only determined in 8% of those cases. Although all the symptoms were associated with exercise, it is possible that the symptoms were not solely associated with asthma. Although questionnaires provide reasonable estimates of EIB, the use of self-reported symptoms is not sufficient for EIB diagnosis, because of their high frequency of both false positive and false negative results.[12] A similar predictive inability of questionnaires has been reported previously.[2,13] It has also been reported that exercise induced respiratory symptoms are not always associated with asthma.[14] A questionnaire may predict EIB with 36-72% sensitivity and 50-85% specificity.[13,15]

The symptoms appearing during exercise may be affected by different factors such as weather conditions and length and intensity of exercise. Therefore these factors are also important for the prevalence of EIB.[16,17] The mechanism responsible for EIB appears to be evaporative water loss from the airway mucosa leading to airway hyperosmolality, which triggers bronchospasm in susceptible individuals.[18] Airway cooling has also been shown to be a causative factor.[19] Athletes are usually exposed to cold air during winter training and to many pollen allergens in spring and summer. An increased ventilation

rate up to 200 l/minute by exercise for short periods of time in speed and power athletes and for longer periods in endurance athletes, such as long-distance runners and swimmers, is also responsible for EIB.[20]

The fact that the same type of exercise may have different consequences may be due to the season and the activity being performed inside or outside. Fluctuations in temperature and humidity, as well as intensity of exercise may determine the severity of EIB.[11] In a study by Smith *et al.*,[21] a different prevalence of asthma in athletes was reported depending on their sport and training condition, 4.9% in outdoor field sports and 2.9% in indoor court sports. Outdoors sports were prominent in our study, too. Additionally, the high altitude of the city, 2000 meters, may have an important role in restricting physical capacity of those cases where the symptoms were due to hypoxia.

The basis for a diagnosis of EIB in some studies[5-7] was a significant drop in FEV_1 either by exercise provocation or methacholine challenge. However, a commonly used criterion for EIB diagnosis is a 15 to 20% drop in FEV_1 after at least 5 minutes exercise (usually in a controlled, laboratory setting) at 90% of the predicted maximal heart rate.[22] Mannix *et al.*[23] claim that testing for EIB in athletes who train and compete in cold ambient conditions should include exercise testing in cold air plus a bronchial provocation test such as eucapnic voluntary hyperventilation or a methacholine challenge.

In our study, we could only perform exercise testing because of the unavailability of a methacholine challenge test during the study period. Studies examining the utility of exercise testing to investigate asthma prevalence have been hampered by differences in the clinical definition of EIB and varying test protocols.[6,7,13,15,24,25] In addition, the clinical significance of a fall in airflow after exercise for a diagnosis of asthma is not clear. However, Haby and colleagues[26] have shown that a decrease in FEV1 after exercise may correlate with a history of wheezing and histamine-induced hyperresponsiveness in children. Despite other bronchial provocation techniques shown to be better at eliciting EIB than exercise itself,[19] the sensitivities of those techniques were not sufficient to determine all cases of EIB. However, it has been demonstrated that free-running tests can be a useful screening test[27-29] to confirm the questionnaire, as sensitive as 94% in ruling in EIA, but with low specificity (64%) in ruling out EIA.[28]

As we discussed above, the type of sport may also have an effect on EIB due to its duration or its characteristics, either indoor or outdoor. Although our cases who performed the challenge test were from a variety sports, EIB was only determined in three different sports (athletics, football and volleyball) which are mostly outdoor sports.

Another important point is the time when symptoms appear. According to our questionnaire results, the mean duration for symptoms to appear following exercise was 21 ± 19 minutes. Symptoms that occurred during the first five minutes of exercise were mostly not indicative of EIB; however, these symptoms may suggest other changes in pulmonary function, poorly controlled underlying asthma, poor physical conditioning, lack of warm-up exercise or injury to the chest wall muscles. Persons who engage in physical activities that involve only short bursts of exertion may perform well without becoming symptomatic.[4] Although the time range in our study was outside of the recommended period for diagnosis, the onset of symptoms of our cases with EIB was between 5 and 15 minutes.

In conclusion, our results suggest that EIB may be common in the population, and thus warrant extensive screening of sportsmen at risk. With treatment, those who suffer from EIB may be able to participate and compete at the highest levels of performance. Therefore, appropriate diagnosis and treatment of EIB is important. Although respiratory symptoms during exercise may give important clues for EIB, respiratory symptoms alone are not sufficient to establish the diagnosis of EIB. Symptomatic patients should undergo further tests for the diagnosis of EIB.

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