Effect of Temperature, Relative Humidity and Physical Activity on Bronchospasm Responses in Adolescent Athlete Males

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Abstract: Temperature and relative humidity are as major factors that stimulate exercise-induced bronchospasm (EIB). The purpose of this study was to investigate the effect of environmental temperature and relative humidity on the EIB in the pre-test and 5, 10, 15 and 60 minutes (1 hour) after the activity in the exercise (EXEG) and control (CONG) groups. Among 60 adolescent male students of Sport and Physical Education School after performing a standard test, 24 subjects which had maximal oxygen uptake $2.4 \pm 55.6$ ml.min$^{-1}$ G selected as the study group. Then the subjects were randomly divided into two exercise (n=12) and control (n=12) groups. One hour after facing with temperature and relative humidity, peak Expiratory Flow Rate (PERF) of groups taken before and 5, 10, 15 and 60 minutes after performing the test. Dependent and independent t-test used to comparing PERF at pre-test and post-test also between two groups. EIB occurrence rate calculated according to 15% dropping on PEFR after exercise. Results showed that the most rate of EIB observed 5 and 15 minutes after exercise test in training group (58% and 41.66% respectively). In addition, no significant differences observed between PEFR before and after performing the test in two groups ($P>0.05$). The minimum correlation of PEFR observed 10 minutes after exercise in the EXEG. Thus, exercise at temperature of 15 Celsius degrees and relative humidity 50% causes occurrence of EIB in 29.8% athletes and 12.49% in non-athletes only to be faced with this situation. It was concluded that exercise activity in abnormal conditions(cool conditioning) by normal children can cause pulmonary abnormalities(EIB). Therefore, we recommended the implementation of activities under these conditions to be avoided.

Abbreviations: EIB: Exercise-Induced Bronchospasm- EXEG %Exercise Group -CONG %Control Group - VO$_{2\text{max}}$ %Maximal Oxygen Uptake-VO$_{2\text{peak}}$ %Peak Oxygen Consumption-PERF %Peak Expiratory Flow Rate-NS %No Significant

Key words: Exercise-Induced Bronchospasm %Temperature

INTRODUCTION

Exercise-induced asthma is a common disease that has no difference from EIB which causes by maximum physical activity. In various studies, the main causes of asthma have introduced sports [1]. EIB has been repeatedly observed occurred in young adults and children and its prevalence has reported 40 to 90 percent [2]. EIB presents through airways and may accrue after physical activity [2, 3] and causes disorder and chronic infection in airway [4]. Epidemiological studies showed that the prevalence of asthma is increasing and mainly occurred in industrialized countries [5-7]. Perhaps the main causes of this disorder are factors such as dust particles, pollutants and high ventilation rate during exercise [8]. ASMir Hojat Mousavi (2012) said "he higher the workplace air pollution, the lower the respiratory capacity" [9]. Other reasons which can be mentioned are exposing to cold and dry air, intensity of exercise and chronic asthma [10] especially exercise in cold weather may lead to presence pathological and physiological responses such as narrowing in airways [11]. Probably Prevalence of EIB in exercise deepening on two important factors: first, increasing in ventilation and decreasing tidal volume [12] second factor is association between activated T lymphocytes and eosinophils play a major role in the development of airway inflammation and in the accompanying bronchial hyperreactivity [13].
Prevalence of EIB in elite athletes has been reported 10 to 50% [14]. Cross-sectional studies have reported a prevalence of EIB 3 to 13% among young athletes [15, 16]. It may the physical activity levels of children is limited due to decreasing in their lung function [17, 18]. The incidence of EIB is different between complications various sport fields; such as it’s much greater in skiers than other sport fields [3, 19]. The most possible common reason for asthma symptoms is physical activity and it’s assumed that it results in restrictions in the airways in children and young people [20]. Which occurs 3 to 10 minutes after intense physical activity and 5 to 15 minutes after the end of moderate intensity exercise [21, 22].

EIB is identified through a reduction in lung function, usually is characterized through a 15% reduction in Peak Expiratory Flow Rate (PEFR) after exercise [21,23]. The spirometry test is performed using a device called a spirometer which predicted normal values based on age, weight, sex and height and obtained values in rest and exercise situation. Thus, In clinical practice pulmonary function testing is used most commonly to estimate prognosis, follow the course of the disease or the response to therapy, detect untoward reaction to drugs and to assess functional impairment or disability [24-26].

Children with EIB tend to show lesser Maximum oxygen consumption (VO_{2max}) levels than healthy people [27]. This can result in reducing changes in active lifestyle of children [28]. A study showed that the high school athlete students with EIB ran less time in free running test rather than coeval matched subjects [29]. In general, young people with asthma showed lower peak oxygen consumption (VO_{2peak}) levels and ventilation threshold than healthy controls people [30].

In fact, EIB may occur in any athlete and in any environment. Those athletes who participate in endurance sports or prolonged aerobic activities or those exercises that much increase ventilation rates may increase the risk of the EIB (3). It is important to recognizing the effects of environmental and individual factors such as exercise intensity, height and nature of exercise [31-33], cold and dry air breathing [34-36]. As well as stimulating environmental effects on accelerating EIB. Cold weather can lead to accruing the EIB in several processes. It is believed that at first increases the airways drying caused by hyperventilation [8,32] or leads to changes in the central temperature of airways caused by cold air breathing [38]. Cold air affects the skin, as well as respiratory airways. Irritation the sensitive to temperature-receptors of skin [39,40] or other body regions [41], can irritate airway narrowing reflex [23].

The purpose of this study was to assessing the effect of air temperature and relative humidity on EIB in elite athlete children. In this study, the subjects carried out an incremental aerobic test (Astrand protocol) to exhaustion phase at the temperature of approximately 15 degrees Celsius and relative humidity of approximately 50 percent on attached to the treadmill Ergo spirometer. The temperature and relative humidity measured carefully during the whole process of the study.

**MATERIALS AND METHODS**

**Subjects:** Among the sixty teenagers from Sport and Physical Education School, after performing 12-minutes Cooper test, thirty subjects who ran more distance were selected as the study participants. Then, after completing the CONG sent form by their parents, these people call to Laboratory of Physiology and Sports Medicine Clinic of Shahid Chamran University of Ahwaz to accurately determining of VO_{2max} level and lack of abnormalities. Afterwards, 24 subjects who have 50 ml.kg. minG level of VO_{2max} based on the bicycle ergometer Astrand protocol were selected and were randomly assigned into two EXEG and CONG. The mean age, height and weight of EXEG were 17.81±0.51 years, 173.16±6.17 cm and 60.90±8.36 kg, respectively and the mean age, height and weight of CONG were 17.74±0.62 years, 171.58±4.35 cm and 57.23±7.35 kg, respectively. All these characteristics are presented in Table 1.

After sampling, based on health and physical activity questionnaires, which were distributed to the subjects, none of them had lung and heart disease and did not consume tobacco, drugs and alcohol. All the sample have participated 8 to 10 hours in physical activity programs in fields (soccer, volleyball, running and taekwondo) per week. All declared that none of them didn’t expose to warm, cold and infected environments at least a month before and they didn’t have trained in too much hot and cold or the infected environments. During second recalling to the lab, all were informed about the purpose, requirements and the experimental protocol of the investigation. Experimental procedures (running on the treadmill and spirometer) were demonstrated to all subjects and they were advised and asked that 24 hours before the test, do not exercise and expose to the hot and cold weather.

**Experimental Procedures:** Subjects were randomly divided into exercise group (EXEG, 12 subjects) and control group (CONG, 12 subjects). The EXEG have performed 12 minutes of Cooper test in the vitro at
temperature 2.5±15°C and relative humidity of 1.5±50 percent. The CON G should only be exposed to the similar air temperature and humidity and they should not be performed any physical activity. Subjects' covers were only sport shorts. The spirometer tests to measuring PEFR were taken 5 minutes before the test and 5, 10, 15 and 60 minutes after the running test in the EXEG, while, the spirometer tests to measuring PEFR were taken at same periods for CONG. Laboratory temperature was set by cooler device (air conditioning) and the thermal condition was identical for all subjects and the environment humidity was measured by humidity and temperature gauges in vitro and recorded in all phases of testing. The test was conducted in winter according to the Figure 1. Dropping values of PEFR were calculated according to the following formula (formula 1):

\[ \text{Formula 1: Percent Change in PEFR} = \frac{\text{PEFR PRE} - \text{PEFR POST}}{\text{PEFR PRE}} \times 100 \]

**Statistical Analyses:** Paired t-test was used for determining within-group differences from pre-test to post-test phases and the correlation of the paired data was calculated through this test. Independent t-test was used for assessing between-groups differences. To measurement?? of PEFR, the formula 1 was used. Data are shown as mean and standard deviation. Values of p<0.05 were found significant. Statistical analyses were performed using the SPSS version 16 for Windows.

**RESULTS**

The means of anthropometric characteristics of both group subjects are presented in Table 1. Comparison of age variables showed that there weren't any significant differences between mean age of EXEG and CONG. As well as age means, there weren't any significant differences between means of other indicators between CONG and EXEG except in means of height and weight of EXEG that 0.91 kg and 1.66 cm respectively were more than CONG, but this differences were not statistically significant.

Table 2 shows the results of EIB in both groups at minute 5, 10, 15 and 60 min periods (for the EXEG after performing of the protocol at temperature 15±2.5 and humidity 50±1.5 percent and CONG at the similar times without performing the protocol). Number of practicing subjects at all stages in both groups was 12. At 5 minutes after exercise at temperature 15±2.5 and humidity 50±1.5 percent, incidence of EXEG's EIB, based on the rate of 15% reduction in PEFR, was 58% that included 7 subjects which indicated the most presence of EIB in all the measurements. But the level of CONG's EIB at the same time was 16.66% that included 2 cases. At minute 10,
Table 1: Comparison of age, height, weight, BMI, number of subjects in two groups (mean ± standard deviation)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>BMI</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M±SD</td>
<td>EXEG</td>
<td>CONG</td>
<td>EXEG</td>
<td>CONG</td>
</tr>
<tr>
<td>Age</td>
<td>17.81±0.51</td>
<td>173.16±6.17</td>
<td>60.90±8.36</td>
<td>19.65±1.60</td>
<td>12</td>
</tr>
<tr>
<td>Height</td>
<td>17.74±0.62</td>
<td>171.58±4.35</td>
<td>57.23±7.35</td>
<td>19.64±1.96</td>
<td>12</td>
</tr>
<tr>
<td>Weight</td>
<td>16.80 ± 165.00</td>
<td>49.90</td>
<td>48.20</td>
<td>179.00</td>
<td>23.10</td>
</tr>
<tr>
<td>BMI</td>
<td>18.70 ± 188.00</td>
<td>7.645</td>
<td>22.83</td>
<td>116.32</td>
<td>72.83</td>
</tr>
</tbody>
</table>

CI=99.8%, BMI=Body Mass Index, NS=No Significant.

Table 2: Incidence of EIB in temperature and relative humidity

<table>
<thead>
<tr>
<th>Time</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>n</td>
<td>EXEG</td>
<td>CONG</td>
<td>EXEG</td>
<td>CONG</td>
</tr>
<tr>
<td>Positive occurrence</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Negative occurrence</td>
<td>5</td>
<td>11</td>
<td>7</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>Occurrence percentage</td>
<td>EXEG</td>
<td>%58</td>
<td>%8.33</td>
<td>%41.66</td>
<td>%8.33</td>
</tr>
<tr>
<td></td>
<td>CONG</td>
<td>%16.66</td>
<td>%16.66</td>
<td>%8.33</td>
<td>%8.33</td>
</tr>
</tbody>
</table>

Table 3: Comparison of PEFR before and after test in EXEG and CONG in incidence of EIB at temperature and humidity

<table>
<thead>
<tr>
<th>Period+ (Mean±SEM)</th>
<th>P Value</th>
<th>%Decrease</th>
<th>M0/Mrest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>5min</td>
<td>&lt;0.001</td>
<td>16.8% Decrease</td>
</tr>
<tr>
<td>(5.20±5.19)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10min</td>
<td>&lt;0.001</td>
<td>4.14%</td>
<td></td>
</tr>
<tr>
<td>(4.99±1.56)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXEG</td>
<td>15min</td>
<td>&lt;0.001</td>
<td>11.55% Decrease</td>
</tr>
<tr>
<td>(4.60±4.07)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONG</td>
<td>1hour</td>
<td>&lt;0.001</td>
<td>5.79%</td>
</tr>
<tr>
<td>(4.90±4.94)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Correlations of PEFR before and after the test and exposing with temperature and humidity in the EXEG and CONG

<table>
<thead>
<tr>
<th>Period</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test of EXEG</td>
<td>5 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td></td>
<td>15 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>60 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pre-test of CONG</td>
<td>5 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>15 min</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>60 min</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 5: Also shows differences of PEFR of EXEG and CONG between all stages of the test. None of the stages show significant differences.

<table>
<thead>
<tr>
<th>Period</th>
<th>Pre-test</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
<th>60 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>(EXEG and CONG)</td>
<td>P-Value</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td>0.07</td>
<td>0.7</td>
<td>0.1</td>
<td>0.006</td>
</tr>
</tbody>
</table>

CI=0.999, NS=Non significant p<0.00

Fig. 2: Means of PEFR of EXEG and CONG at different times.

the incidence of EIB for EXEG and CONG at temperature 15±2.5 and humidity 50±1.5 percent were 8.33% (1 case) and 16.66% (2 cases) respectively. The percentage of EIB for EXEG and CONG in minute 15 were 41.66% (5 cases) and 8.33% (1 case) respectively and after 1 hour, the incidence of EIB at temperature 15±2.5 and humidity 50±1.5 percent in EXEG and CONG were 8.33% in both groups (1 case per group).

Table 3 shows the differences of PEFR between before and after performing the test which compared values of PEFR before test and after exercise measurements in EXEG and states that the mean PEFR in the minute 5 and 1 hour after exercise have significant difference (P<0.001), but between minutes 10 and 15, there was no significant difference. Column 4, based on the formula M0/Mrest (MD: average difference between before and after test, M0: the mean of pre-test), shows the most reductions in PEFR were occurred in 5 and 15 minutes and the lowest decreases in PEFR were occurred 10 minutes and 1 hour after the test.

Table 3 shows comparison of PEFR of CONG in different phases. A significant difference (P<0.001) was observed only between minute 15 and 1 hour after test (P<0.002); but between minutes 5 and 10, any significant differences wasn’t observed. All reductions were approximately equal in column 4.
Table 4 also shows the correlations of PEFR between pre-test and post-test in both groups. The highest correlation (r=0.96) was observed between the pre-test and 1 hour after test in EXEG and the lowest correlation (r=0.79) was observed between the pre-test and 10 minutes after test in EXEG. Correlation between the mean PEFR were approximately identical at all stages than the initial measurements.

**DISCUSSION**

EIB is common among elite athletes and some studies also have been shown that the prevalence of EIB is 30% or slightly more in children, but it seems that its prevalence is lower in athletes than normal people [4]. Immediate response of bronchus stenosis usually occurs 5 to 12 minutes after exercise. People with EIB may show a maximum reduction in lung function 15 minutes after exercise. Some people may be able to exercise with mild obstruction of airways, but show EIB in 30 to 90 minutes after activity and during recovery time. According to the previous studies, 50 percent of the people experience EIB in the first 4 hours after the activity [42]. So, the selection measuring times in the present study have done based on previous study of Anderson SD et al. [43].

Since the exact pathology of EIB is not known yet; some assumptions have been made which is associated with high osmolarity (Hyperosmolarity) of bronchial epithelium that causes releasing of chemical mediators and reducing the amount of water and heat contained in the airway. Thereby, cooling the airways is considered as one of the most important mechanisms in the occurrence of EIB. Thus, the incidence of EIB is more in winter athletes and those who exercise in the cold air [44].

Cold air breathing in patients with shortness of breath is caused stenosis in bronchi. It has been proven that the parasympathetic nerves stimulates the mucous layer and airway smooth muscle and will cause shortness of bronchi [45- 48]. Since, so far there are a few studies have been done to investigation the effect of activity in the winter on prevalence of EIB in elite athlete children, this study aimed at assessing the effect of temperature 15 degrees Celsius and humidity 50 percent on the incidence of EIB in elite athlete children after performing physical activity. Some researchers such as Msalaty Like Adil Mughal et al have studied 9-16 years old children or CABRAL et al have investigated 7-17 years old children [15,49]; so, we trend to assess 16 to 18 years children.

According to the present study results, the incidence of EIB 5 minutes after exercise was 58 percent in the EXEG (Table 2) that included 7 subjects of 12 subjects and in the control group at the same time and exposing with this temperature was equal to 16.66 percent that included 2 subjects. Therefore, these results showed that in 5 minutes after exercise the incidence of EIB of the EXEG is 3 times more that CONG that was only exposed to the environmental temperature and relative humidity.

The results also showed significant differences between pre-test and 5 minutes after implementation of environmental temperature and relative humidity in the CONG (p= 0.001) (Table 3). According to the formula $M_r/M_{BEST}$, PEFR in the EXEG and CONG, decreased 16 and 5.93 percent compared to the pre-test phase in both groups (Figure 1).

Also, Table 4 shows the correlations are 0.82 in EXEG and 0.94 in CONG between pre-test and 5 minutes after test values. In addition, there isn't any significant difference between PEFR of EXEG and CONG in pre-test phase (P=0.006) also at 5 minutes after test (P=0.1). These findings confirm the results of Adil Mughal et al that studied bronchospasm between the urban and rural children and also found significant differences in this case but they weren't mention the temperature and humidity of environment which their study done in that [50]. The main cause of the difference between the EXEG and CONG could be due to the relatively constant temperature and humidity of exercise, because, according to Bavarian et al the EIB is common among elite athletes. They expressed in their study that the prevalence of EIB is between 17.6 to 26.5 percent and is higher in Iranian children compared to other countries [4].

In our research, 10 min after exercise in EXEG only one subject showed EIB, but at this time in CONG, 2 subjects showed EIB and the results didn’t show any significant differences between pre-test and 10 minutes after test values. Correlations between pre-test and 10 minutes after test phases in EXEG and CONG were 0.72 (P=0.002) and 0.94 (P=0.001) which these results show less correlation in EXEG than the CONG. Rundell et al didn’t observe any significant relationship between the EIB and baseline lung function in female athletes in ice hockey players. In their study, spirometer measurements after exercise showed significant difference between [within] room environment and cold environment that confirm our study results [50].

The results also showed that at 15 minutes after the
exercise, 5 cases (42.66%) of EXEG and 1 case (8.33%) of CONG showed EIB. In the EXEG, mean PEFR in 15 minutes after performing the protocol didn’t show significant difference than pre-test value but in the CONG a significant different was found between pre-test and 15 minutes after the exercise (P=0.001) and these values were reduced significantly 1 hour after the exercise. The reduction was equal to 11.55 percent in the EXEG and 6.83 percent in the CONG. Correlations between these periods were 0.81 (P=0.001) in EXEG and 0.96 (P=0.001) in CONG which indicated less correlation of PEFR in EXEG between pre-test and 15 minutes after the exercise test than the CONG.

In this research, at 1 hour (60 minutes) after the exercise 1 case (8.33%) of EXEG and 1 case (8.33%) of CONG showed EIB. In EXEG, mean PEFR in one hour after the activity showed significant difference than pre-test (P=0.001). In the CONG, also, a significant different was observed between pre-test and 1 hour (60 minutes) after the exercise and these values were reduced significantly 1 hour after the exercise. The reduction was equal to 5.79 percent in the EXEG and 8.5 percent in the CONG. Correlations between these periods were approximately similar for both groups and were 0.94 (P=0.001) and 0.96 (P= 0.001) in EXEG and CONG.

In comparisons between measuring periods, any significant differences didn’t observe in both groups. Penny et al reported 20.7% prevalence of EIB in children 8 to 10 years in the city of Lima that is inconsistent with the obtained results of this study that shows 29.08% of EIB [12, 51]. However, this value is lower than Adil Mughal who reported 35.5 of prevalence of EIB and approximately is equal to Issa (1998) results that found 28% of EIB prevalence [12]. Maybe it causes from both the increasing in minute ventilation during the cooling and drying air airways which results in Lumen contraction of airway [12]or decreasing in inflammatory cells in the airway [13].

Release of histamine like mediators from the mast cell. Stimulating of lumen contractive reflex may be body’s natural defense mechanisms that reduce the volume of breathing air, severity of airway cooling or possibly increases ventilation rate during exercise and heat losing from the airways [2].

When the body becomes cold, constriction of respiratory mucosa vessels and reductions in central body temperature result in cool downing of airways. The main reason for the occurrence of EIB in this study may be due to contamination from the oil industry in Ahwaz or dust pollution in the air or even pollution from steel industry of this city. Because of warm weather of the Ahvaz almost in nine months, these people have not had any environmental compatibility with 15 degrees Celsius weather. In addition, 22 subjects of this study had experienced indoor sport fields and only 2 subjects had experienced outdoor football. Since in most carried out researches, a control group was not used and most previous population weren’t trained athletes and most were asthma people and due to the new procedures of this study, incidence of bronchospasm in EXEG and CONG group at a temperature of 15 degrees Celsius and relative humidity 50 percent, were 29.8 and 12.49 percent, respectively. It can be said that synchronization of mentioned humidity and temperature (cold air in Ahwaz city of IRAN) and physical activity and even facing with the temperature and humidity for athletes who weren't compatible with the activity in this environment caused falling in PERF (impairing in lung function, especially airways) which may affect the executive performance of these people and continuing these activities in these conditions may cause dissatisfaction of teenage athletes and as mentioned in the text possibly will lead to lack of physical activity in young athlete people.

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REFERENCES