

THE EFFECTS OF MAXIMAL AND SUB MAXIMAL AEROBIC EXERCISE ON BRONCHOSPASM INDICES IN NON ATHLETIC PEOPLE

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ABSTRACT

Background: Exercise-induced bronchospasm (EIB) is a transient airway obstruction that occurs during and after the exercise. Exercise-induced bronchospasm is observed in healthy individuals as well as the asthmatic and allergic rhinitis patients. **Research question:** The study compared the effects of one session of submaximal aerobic exercise and a maximal one on the prevalence of exercise-induced bronchospasm in non-athletic students. **Type of study:** An experimental study, using human subjects, was designed. **Methods:** 20 non-athletic male students participated in two sessions of aerobic exercise. The prevalence of EIB was investigated among them. The criteria for assessing exercise-induced bronchospasm were 10% fall in FEV1, 15% fall in FEF25-75%, or 25% fall in PEF. **Results:** The results revealed that the maximal exercise did not affect FEF25-75% and PEF, but it led to a meaningful reduction in FEV1. Contrarily, the submaximal exercise affected none of these indices. That is, in both protocols the same result was obtained for PEF and FEF25-75. Moreover, the prevalence of EIB was 15% in the submaximal exercise and 20% in the maximal one. Actually, this difference was significant. **Conclusion:** This study demonstrated that in contrast to the subjects who performed submaximal exercise, those who participated in the maximal protocol showed more changes in the pulmonary function indices and the prevalence of EIB was greater among them.

Keywords: EIB, pulmonary function indices, sub maximal, maximal.

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INTRADUCTION

Exercise-induced bronchospasm (EIB) is a transient and reversible airway obstruction associated with physical exertion [30] and occurs during and after the exercise [42,35,21]. Intense and prolonged physical exercise induces stress in the respiratory system because of the hyperventilation [26]. That activates an accumulation of the inflammatory cells and mediator release triggering EIB [4,20,6]. The heat and water loss from the airway surface caused by hyperventilation are the main factors in the pathophysiological mechanism of EIB [9,19,48,54]. Dry and cold air is the strongest cause of bronchospasm in the people predisposed to EIB [54,5,24,34]. The clinical symptoms are coughing, wheezing, dyspnea, and excessive mucus [18]. A mismatch between fitness level and performance “heavy legs” [42] muscle cramps, headache, abdominal pain and fatigue [49] May also be observed.

Self-reported symptoms are not reliable in identifying EIB [15,41,42]. So it is advisable to diagnose it with pulmonary function measurements before and after the exercise [41]. EIB frequently goes undiagnosed [30]. The lack of high sensitivity or specificity demonstrates that self-reported symptoms are poor indices of pulmonary dysfunction [42]. It is important to take care of the effects of individual and environmental factors on the prevalence of EIB. Such factors include exercise intensity [16] Duration and type of exercise [29,16,2,7,22] and also provocative effect of substances in the environment [2]. The wide range is due to the nature of the sports performed (e.g., high-ventilation or low-ventilation sports) differences in the test protocols used for bronchoprovocation, the

environmental conditions where the tests are performed [43] And the variable criteria for diagnosing EIB [42,49,41,22,13].

Although it is believed that EIB occurs 30 minutes after the exercise, most commonly it occurs 5 to 10 minutes following the exercise [55]. EIB is observed in healthy individuals, preadolescents, children, military recruits, elite athletes as well as asthmatic and allergic rhinitis patients [50,1,39,51,23,38,56]. Practically this trouble is reported in different people performing different exercise protocols but a few researches have examined the prevalence of such trouble in non-athletic people using two exercise methods.

Therefore the aim of this study was to make a comparison between the effects of one session submaximal aerobic exercise and another maximal one on the prevalence of exercise-induced bronchospasm (EIB) in non-athletic male students of Shahid Chamran University in Ahvaz with VO_{2max} less than 30 ml/kg/min.

Materials and methods

Subjects

The aim of this study was to make a comparison between two sessions of aerobic exercise namely maximal and submaximal and to investigate the effects of both on the prevalence of exercise-induced bronchospasm (EIB) in non-athletic male students of Shahid Chamran University in Ahvaz with VO_{2max} less than 30 ml/kg/min. The criteria for assessing EIB in this study was 10% fall in FEV1 15% fall in FEF25-75% or 25% fall in PEF. The result showed that the prevalence of EIB among non-athletic male students in submaximal and maximal aerobic exercises was 15% and 20% respectively.

Issuing a summons in Shahid Chamran University in Ahvaz, non-smoking healthy students were asked to participate in the study. European community respiratory health survey [10, 32] with some additional questions was adopted to gather the participants' personal information. The volunteers gave written informed consent, the additional questions asked about some issues like smoking cigarette or any other drug, affliction to heart and any other pulmonary disease, living or working in polluted environments, being imposed to contaminants stimulating respiratory system, and having a background of physical activity in the whole life or in the recent years. Among the 521 volunteers who filled out the questionnaire, 56 ones were accepted as the preliminary participants of the study. A bicycle Ergometer (Monark E893 Sweden) which was connected to a computer was applied for carrying out the 6-minute Astrand test. The purpose of the test was estimating VO_{2max} . Among the 34 persons who had VO_{2max} lower than 30 ml/kg/min 22 ones were randomly selected as the final subjects. Using a body composition set (Olympia 3.3 Jawon Company, Korea) BMI rate and the body fat percentage of these subjects were measured. Two subjects who could not continue the other phases were withdrawn from the study. Ultimately the sample population became 20 persons. Their mean age, height, weight, BMI, body fat percentage, and VO_{2max} were 20.6 ± 1.39 , 176.2 ± 5.23 cm, 80.61 ± 10.59 kg, 25.84 ± 3.9 kg/m², $24.61 \pm 5.9\%$, and 26.26 ± 2.83 ml/kg/min, respectively. They were asked not to have any physical activity or regimen from the commencement of the treatment to the end of the study.

Procedures

The study included two exercise protocols, namely a maximal and a submaximal one. Of course, there was a recovery period of one week between them. The criteria range for the assessment of EIB were 10% fall in Forced Expiratory Volume in 1 second (FEV₁), 15% fall in Forced Expiratory Flow at 25-75% of forced vital capacity (FEF_{25-75%}) or 25% fall in Peak Expiratory Flow Rate (PEFR) [22]. Using a digital Spirometer (H1-601 Japan), standard spirometry evaluations were performed prior to and five minutes after the exercise protocols. Spirometry was done in accordance with The American Thoracic Society's and European Respiratory Society's (ERS) recommendations [31,12]. The spirometer was calibrated according to the manufacturer's protocol using a 1Lit syringe before the pulmonary function test every day. The spirometry evaluations were done three times for the pulmonary function indices; FEV₁, FEF_{25-75%}, and PEF. The highest observed value for each of these indices was registered for further analysis.

In order to avoid any interference or influence of the VO_{2max} test on the experiment protocols, the exercises were conducted one week after the former. Before commencement of the treatment, the subjects' rest heart rates were estimated by a digital Pulse oximeter (Beurer-PM80, Germany). Following that, the baseline spirometry was performed for the pulmonary indices. Then, the subjects performed light stretching exercises for five minutes. Following that the submaximal test that is the Balk protocol was performed. The subjects walked on a treadmill (J880 Finland) until they were

exhausted. The test was performed in an air-conditioned room. The highest heart rate was registered for each participant. After a rest period of five minutes the spirometry evaluations were performed three times for each of the pulmonary function indices and the highest values were registered [42,54,14,53]. After a one-week recovery period, the maximal test that is the Astrand protocol was performed. The procedures conducted for this protocol were the same as the former one. The criteria range for the assessment of EIB in this study were 10% fall in Forced Expiratory Volume in 1 second (FEV), 15% fall in Forced Expiratory Flow at 25-75% of forced vital capacity (FEF25-75%), or 25% fall in Peak Expiratory Flow Rate (PEFR) [22].

All the tests were performed between 4 pm to 6 pm because of some previous studies

RESULTS

As said formerly, 20 non-athletic male students were recruited for the study. Their mean age, height, weight, BMI, body fat

percentage, and VO₂max are mentioned in Table 1. (Pressure 760 mmHg)

Statistical Analysis

Data were expressed as mean ± standard deviation (SD). Percentage values were also calculated for specific variables. For statistical comparisons, the level of significance was set as P<0.05. Statistical analyses were done using the statistical software program SPSS 16.0 for Windows. Paired sample T-test was applied for comparing the mean values of the pre- and post-tests in each exercise protocol. Comparing the results of the maximal and submaximal protocols and EIB, the same program was used.

Table 1. Basic characteristic of the subjects (n=20)

Demographic data	mean ± SD	minimum	maximum
Age (years)	20.6±1.39	19	24
Height (cm)	176.2±5.23	165	184
Weight (kg)	80.61±10.59	62.60	96.60
BMI(kg/m ²)	25.84±3.9	20.30	33.80
Body fat percentage (%)	24.61±5.9	13.80	23.60
VO ₂ max(ml/kg/min)	26.26±2.83	19.66	29.78

Also, the mean value and the standard deviation of the pulmonary function indices prior to and after the sub-maximal and maximal aerobic exercise protocols are mentioned in Table 2.

Table 2. Pulmonary functions, environmental conditions and specific properties of subjects (n=20)

Parameters and steps	Submaximal protocol	maximal protocol
Pre-test FEV1 (Lit)	4.30±0.58	4.47±0.55
Post-test FEV1 (Lit)	4.31±0.52	4.29±0.52
Pre-test FEF25-75% (Lit/s)	5.30±1.27	5.39±1.21
Post-test FEF25-75% (Lit/s)	5.54±1.26	5.73±1.27
Pre-test PEF (Lit/s)	6.82±2.14	7.57±1.54
Post-test PEF (Lit/s)	7.41±2.04	7.47±1.71
Exercise duration (min)	17.35±4.57	9.54±2.32
Rest heart rate(bpm)	77.7±2.95	76.9±3.01
Heart rate after exercise(bpm)	193.25±10.75	199.3±9.27
Temperature (°C)	26±1.69	27.8±0.49
Humidity (%)	40.27±2	41.03±1.93

Considering table 2, the mean values related to the pulmonary indices FEV1, FEF25-75%, and PEF increased in the submaximal exercise protocol but it had not

been meaningful. The P-value of these indices from the pre-test to the post-test phases had been 0.95, 0.159, and 0.057 correspondingly.

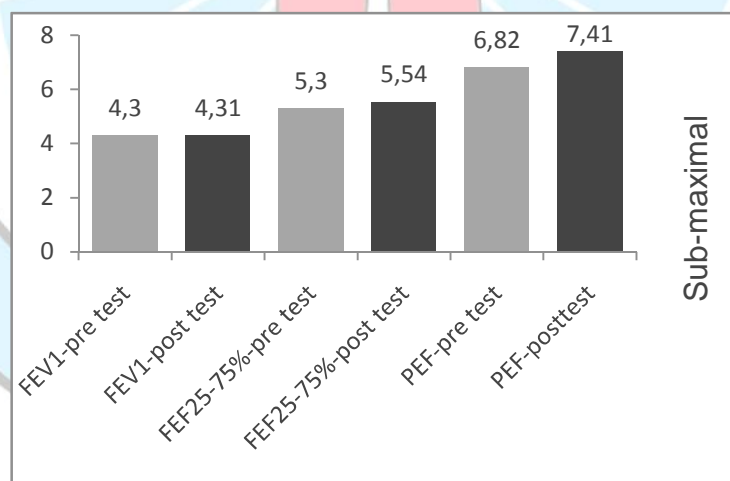


Figure 1. Mean pulmonary functions before and after the sub-maximal exercise

Although a decrease was observed in the mean values of both FEV1 and PEF indices. it was meaningful just in the case of FEV1. The increased mean value in FEF25-75% was not significant and from

the pre-test to the post-test phases the P-values of FEV1, FEF25-75%, and PEF indices were 0.002, 0.19 and 0.65, respectively

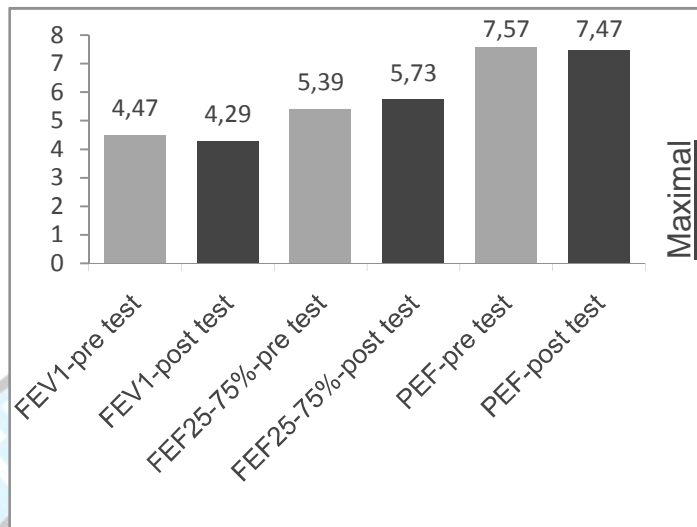


Figure 2. Mean pulmonary functions before and after the maximal exercise

According to Figure 3 and the analyzed data, from the pre-test to the post-test phases, no significant difference was observed for both protocols among the

FEV1, FEF25-75%, and PEF indices. The P-values for comparing the pre-test values of these indices were 0.068, 0.35, and 0.06 correspondingly.

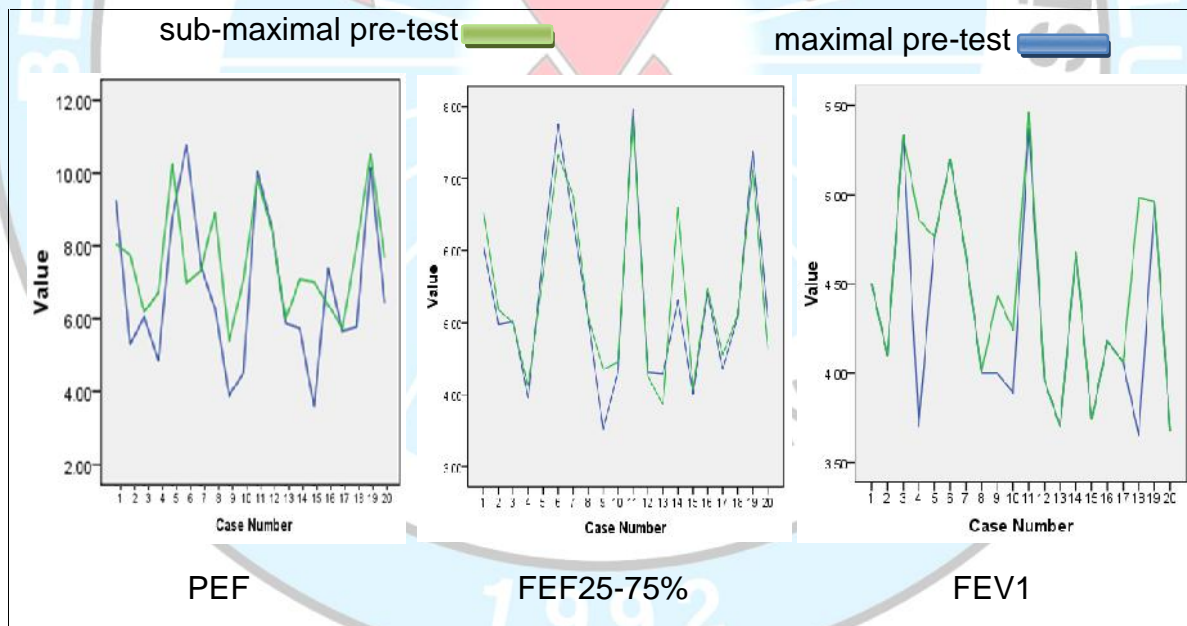


Figure 3. Comparison of the pre-tests of the sub-maximal and maximal exercises (n=20)

Practically with the aim of comparing the results obtained from the protocols the differences in the amount of the changes in the pre- and post-tests were contrasted. This contrast did not reveal any significant difference between the results of the two

protocols in FEV1 and FEF25-75% indices. but a meaningful change was observed for the results of PEF in both exercise protocols. The difference was an increase of 8.25% in the submaximal protocol and a 1.36% decrease in the maximal one. The

P-values for comparing the two protocols in their pulmonary function indices were 0.15, 0.61 and 0.04 respectively.

EIB was observed in 3 subjects in the submaximal exercise and 4 subjects in the maximal exercise (Table 3). The difference

between the two protocols in the prevalence of EIB was significant ($p > 0.05$). Also after performing the test only one symptom of EIB (coughing) was observed in just two subjects.

Table 3. Result of EIB in two protocol (n=20)

	Submaximal exercise	Maximal exercise
10% fall in FEV1	2 (mean of fall 16.4%)	2 (mean of fall 10.93%)
15% fall in FEF25-75%	1 (mean of fall 15.15%)	1 (mean of fall 15.18%)
25% fall in PEF	-----	1 (mean of fall 30.16%)
Participants diagnosed as EIB	3	4
Prevalence of EIB	15%	20%

Based on the data presented in Table 3 it can be concluded that the FEV1 index is hypersensitive in diagnosing EIB in both protocols. The reason is that it shows the highest range of prevalence. The results also revealed that after the exercise the mean value of the maximum heart rate had been more in the maximal exercise with a rate of 6.05 beats in a minute. Moreover

DISCUSSION

Current evidences show that airways infection caused by high intensity activities and hyperventilation and cooling and drying of the airways result in presence of EIB symptoms [21]. Anna and her colleagues investigated EIB before, 5,10 and 20 minutes after 6 minutes pedaling on the ergometer cycle with 80% of maximum heart rate and showed 45.7% prevalence rate among children [21]. Anna concluded that the incidence of EIB in this study didn't lead to a significant correlation between asthma and exercise and it may occur in all children. Also, airway response to exercise is similar to histamine or methacholine responses. They concluded that the use of

the mean of the exercise duration in the maximal protocol was 7.41 minutes less than the same value in the submaximal protocol. The subjects that were diagnosed as showing symptoms of bronchospasm had VO₂max less than 26ml/kg/min, BMI higher than 26 kg/m², and average fat percentage more than 26%.

FEV1 alone cannot prove the presence and absence of EIB [21].

In many studies, only one index is used to identify EIB. But the present research has used two indicators to identify EIB. These indices were used after exercise, because using more than one indicator applies for the patient population. But for the athletes, to get stronger results, two indicators are used [22,23]. The prevalence of EIB is seen in table 6. FEF₂₅₋₇₅ or PEF are used for the EIB diagnosis in the lower airway passages and the FEV1 is used in the upper airways EIB. Pohjantahti and colleagues assessed EIB among athlete and non-athlete students at temperature of 10 and -4 °C. The results showed that, after

performing exercise test, the prevalence of EIB observed 35% in athletes and 11% in non-athletes [9].

The most commonly used criteria for assessing EIB is 10% [2,18,33,41,42,44,45,53]. 10-20% [56]. Or 15% [14,47]. Decrease in FEV1. Post-exercise falls of 15–25% [46] 12.5% [41] 15% [8] or 20% [37]. in FEF25-75% are the criteria for diagnosing EIB. Some other researches also have used 15% [25] Or 25% [27,2,37]. Decrease in PEF for assessing EIB Commonly the prevalence of EIB is 4–20% in the general population [42]. EIB is prevalent in elite athletes [52,17]. With prevalence rate ranging from 10% to 50%. Also 90% of the athletes with asthma may have EIB[42,36,43]. When a subject is atopic or asthmatic the risk of EIB becomes greater [3,11]. In the literature the prevalence of EIB in athletes is greater in contrast to the sedentary and non-athletes [22,37,40].

In contrast to the submaximal protocol the prevalence of EIB in maximal protocol is higher as it needs more ventilation. Proving the same claim Parsons et al. showed that in sports which require high ventilation the prevalence of EIB is higher than those which involve low ventilation. [56]. Investigated the pulmonary functions in athletes and sedentaries they founded no statistical change in the pulmonary functions FEV1, FEF25-75%, and PEF in sedentaries. EIB was observed in none of them as well. Possibly difference in the types of sports performed the criterion for diagnosing EIB and the time of conducting the spirometry test had led to this result [55]. In another study about EIB in athletes and sedentaries, revealed that 7 of 20 athletes and 1 of 19 sedentaries had developed symptoms of EIB. In the present

research the criterion for diagnosing EIB was the same as the one used in Ka an's study. but differences in the time of performing the spirometer test, environmental conditions (cold weather) and varied exercise protocols had led to differences between the two research.

Examined the prevalence of EIB in medical students in Tehran University [28]. The findings identified 16.36% prevalence of EIB in male subjects. Again the type of the exercise, the EIB indices, time of conducting the spirometry test, the number of the subjects and including smoking and allergic participants were the differences between that study and the present one. In another research Huang et al showed that after performing average aerobic exercise for ten weeks no change had happened in the FEV1 index. This result is in accordance with the protocols of the present study, although the number of the subjects was greater in the former study. The protocols applied in the present research were of augmentative nature and were performed on a treadmill. Subject's weight was one of the effective factors in implementing the exercises [28].

CONCLUSION

This study revealed that in contrast to the subjects who performed submaximal aerobic exercise, those who participated in the maximal protocol showed more changes in the pulmonary function indices and the prevalence of EIB was greater among them. Based on the existing theories and evidence, maximal aerobic exercise is usually associated with high ventilation, accumulation of Lactate and excessive exhaustion especially in the respiratory muscles and in this research these factors led to the observed

differences between the two protocols. Additionally low VO₂max, high BMI, weight, and body fat percentage and not having physical activity were among the

important factors provoking EIB in non-athletic students.

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