Comparison of pulmonary function and pulmonary inflammation in professional mid-endurance female runners and non-athletes

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Abstract

Introduction: Pulmonary functioning has a close and significant relationship with general health and mortality rate. Given the few studies conducted in Iran on the pulmonary functioning of semi-endurance Iranian female athletes, this study aimed to investigate the effects of physical activity on pulmonary function of professional semi-endurance female runners.

Materials and methods:
This semi-experimental study with pre-test and post-test design recruited 15 semi-endurance female runners and 15 non-athletes who were selected randomly and matched each other. Pulmonary volumes were measured before, right after, and 10 minutes after Couper’s test. Half an hour later, a sputum sample was taken to examine inflammatory leukocytes. Repeated measures test was used to analyze the volumes and independent t test was used to analyze inflammatory cells. Significance level was set as p<0.05.

Results:
Intragroup FVC level was found significant (p<0.003), (p<0.000), but changes were not significant between groups. Furthermore, the intragroup and intergroup differences were not significant for FEV1 and peak expiratory flow rate. The frequency of exercise-induced bronchospasm was 6.66% in the athletes and 13.33% in non-athletes based on the 15% and more decrease in FEV1. No significant difference was found in the number of inflammatory leukocytes before and after the exercise in both groups.

Conclusion:
Mean FEV1/FVC ratio was higher than the favorable amount (over 70%) in both groups, which indicates relatively good respiratory functioning in mid-endurance female athletes, and the low rate of exercise-induced bronchospasm in them.

Keywords: Semi-endurance Runners, Pulmonary Function Test; Exercise-Induced Bronchospasm; Pulmonary Inflammation, Females

Introduction

Exercise increases metabolic activities, ventilation and cardiac output. This and in response, both cardiopulmonary system should act to concurrently increase breath rate, heart rate, flow volume and stroke volume (1). Some
studies have shown that aerobic exercise can improve function of the respiratory system and significantly increase Inspiratory Reserve Volume (IRV), Expiratory Reserve Volume (ERV), Maximum Voluntary Ventilation (MVV), Forced Vital Capacity (FVC), and forced expiratory volume in 1 second (FEV1) (2). However, exercise can sometimes cause bronchial hypersensitivity and inflammation of the airways and asthma. Association of exercise and asthma in aerobic exercise is manifested as dyspnea and respiratory problems. Many studies have reported high prevalence of asthma among athletes, especially endurance athletes (3). The prevalence of asthma in winter sports athletes is higher than in summer sports athletes (4). A significant percentage of athletes with no history of asthma experience asthma-like respiratory symptoms during exercise activities (5 and 6). The prevalence of exercise-related bronchospasm has been reported between 5% and 20% in healthy people, 30% and 70% in endurance athletes, and 90% in asthmatic people (7 and 8). Intensity and duration of exercise are also key parameters. Continuous aerobic exercise requires a huge amount of minute ventilation. Sports such as athletics, skiing, orienteering, and cycling are among sports that cause inflammation of the lungs, while intermittent anaerobic exercise causes fewer attacks (4 and 9). Environmental factors predisposing to exercise-induced asthma (EIA) include dry and cold weather, low humidity, air pollution and bad climate, pollen, and concomitant respiratory infection. Healthy people that intensely exercise for long periods of time in cold dry weather are more likely to experience EIA (7, 8, 10, and 11). Some studies conducted on distance and sprinting runners have reported greater prevalence of EIA in endurance runners than in sprinters (17% V 8%) (3). A number of similar studies conducted on distance runners have reported significant reductions in FVC, FEV1 and peak expiratory flow (PEF) induced by activity (5 and 12). Asthma is a reversible disease that can be prevented from turning into permanent and chronic asthma with early diagnosis, control and treatment. Therefore, diagnosis of exercise-induced bronchospasm (EIB) is highly important (8 and 13). Since very few studies have been conducted on EIA in semi-endurance runners, and most of them have examined the effects of dry cold weather on the incidence of lung inflammation, the present study was conducted with the aim to investigate EIA and pulmonary volume changes in these athletes in a warm and dry region.

Materials and Methods
The present pretest-posttest quasi-experimental study recruited 15 semi-endurance professional female runners with mean sporting experience of 5 years and 15 randomly selected non-athletes that matched the runner group (Table 1). Both groups lived in the Kerman Province and no respiratory diseases or history of use of anti-asthma medication in the three weeks before test. Non-athletes had no activities other than the routine daily life. Both groups signed consent forms for participation in the present study. After measurement of body dimensions, all participants completed the standard EIA questionnaire for diagnosing EIB, which included symptoms such as coughing, dyspnea, wheezing, chest pain, digestive symptoms (nausea and vomiting), history of asthma and allergy. This standard Persian questionnaire was developed according to previous studies (14 and 15). Participants with two concomitant symptoms after activity or diagnosis of physician were considered to have bronchospasm symptoms.

Pulmonary function test
First, participants were given practical training on the stages of pulmonary function test with emphasis on maintaining concentration and fervor in applying utmost effort in maneuvers or pulmonary
Comparison of pulmonary function and pulmonary Leili Zeiaadini Dashtkhaki et al


tests. Spirometry test was performed three times for each participant with 1 to 2 minutes interval using spirometry device (I-00041 COSMED, Italy) and the best maneuver was recorded. Pulmonary function test was carried out in standing position, where participants held spirometry mouth piece in their mouth such that the edges of the mouth piece was completely covered, and immediately after a strong inhalation, exhaled most vehemently for 6 seconds, when respiratory nomogram and value of each parameter would recorded by the device. Pulmonary volumes of interest included FVC, FEV1, and PEF. A reduction of 15% or more in FEV1 was regarded as EIA in participants. After initial measurement of pulmonary volumes, participants were asked to perform Cooper test. This test involves 12 minutes of running between 9 am and 11 am at 80% to 90% of maximum heart rate in an outdoor athletics track. Maximum heart rate was calculated according to "Age-220" formula, and intensity of running was controlled by measuring heart rate using a Polar heart rate monitor attached to participants' wrists. During the test, mean atmospheric temperature in Kerman was 23.5 °C, with 31.5% humidity. Prior to Cooper test, participants gently ran for 2 minutes to warm up. Then, at the sounding of a whistle, they ran at maximum speed for 12 minutes, and pulmonary function test was performed immediately afterwards. Participants were asked to rest for 10 minutes and then repeat the test. After this activity and the last stage of pulmonary function test, participants were given 30 minutes' rest. Then, to induce sputum discharge, they were asked to breathe nebulized hypertonic sodium solution (5 ml) attached to an oxygen tank for 15 minutes to vaporize the solution. Breathing this solution stimulates the lungs and brings mucus to the mouth. Then, they were asked to remove the mask, rinse their mouths to minimize saliva, take a deep breath and hold for a few moments, clear their throat (by sounding Chi-Chi), cough intensely, and spit mucus sample into a sterile dish. These samples were immediately sent to the laboratory for counting inflammatory cells, lymphocytes, monocytes, and neutrophils, where inflammatory cell counts were recorded after preparation of slides and Giemsa staining (16).

**Statistical analysis**

Normal distribution of data was confirmed using Kolmogorov-Smirnov test. Pulmonary volumes including FVC, FEV1, and PEF were assessed in athlete and non-athlete groups using t-test with repeated measures, and inflammatory cell counts were compared using independent t-test in SPSS-16 at significance level of α<0.05.

**Results**

A total of 30 people, including 15 female members of Kerman track and field team and 15 non-athletes were studied. According to the standard asthma questionnaire, of the 15 semi-endurance runners, 2 (13.33%), and of the 15 non-athletes, 3 (20%) had symptoms of asthma. Changes in pulmonary test parameters before, immediately after and 10 minutes after exercise in all participants are presented in Table 2. Intragroup changes in FVC were significant (P<0.003) and (P<0.000), but intergroup changes were not (P=0.244). There were no significant differences in FEV1 and PEF between before and after exercise in both groups and between the two groups. Based on the criterion of reduction of more than 15% in the FEV1 after exercise, the prevalence of EIB was 6.66% in the athletes group (1 person) and 13.33% in the non-athlete group (2 persons). Mean FEV1/FVC ratio was reported 89% in athletes and 85% in non-athletes. Independent t-test showed no significant differences in lymphocyte, neutrophil, or monocyte inflammatory cell counts before and after exercise (Table 3).
Table 1: Body dimension indices

<table>
<thead>
<tr>
<th>Feature</th>
<th>Athletes (n=15)</th>
<th>Non-athletes (n=15)</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>24.5±14.47</td>
<td>26.6±31.61</td>
<td>0.51</td>
<td>0.481</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>55.7±43.07</td>
<td>63.7±38.64</td>
<td>0.09</td>
<td>0.763</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.5±0.84</td>
<td>162.4±85.22</td>
<td>2.59</td>
<td>0.124</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.2±91.02</td>
<td>22.3±71.06</td>
<td>2.01</td>
<td>0.168</td>
</tr>
</tbody>
</table>

Table 2: Statistical results of FVC, FEV1, and PEF before, immediately after and 10 minutes after exercise in the two groups (P<0.05)

<table>
<thead>
<tr>
<th>Volume</th>
<th>Group</th>
<th>Before exercise Mean ± SD</th>
<th>Immediately after exercise Mean ± SD</th>
<th>10 minutes after exercise Mean ± SD</th>
<th>Intragroup F</th>
<th>P</th>
<th>Intergroup F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (liter)</td>
<td>Athletes</td>
<td>3.46±0.40</td>
<td>3.31±0.45</td>
<td>3.48±0.43</td>
<td>0.003*</td>
<td>7.43</td>
<td>0.244</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>3.32±0.31</td>
<td>3.13±0.30</td>
<td>3.28±0.33</td>
<td>0.000*</td>
<td>17.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1 (Liter/second)</td>
<td>Athletes</td>
<td>3.06±0.29</td>
<td>3.05±0.32</td>
<td>3.01±0.35</td>
<td>0.35</td>
<td>0.99</td>
<td>0.05</td>
<td>4.16</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>2.87±0.22</td>
<td>2.78±0.21</td>
<td>2.82±0.24</td>
<td>0.154</td>
<td>2.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEF (Liter/second)</td>
<td>Athletes</td>
<td>6.87±0.93</td>
<td>6.97±1.05</td>
<td>6.58±1.05</td>
<td>0.109</td>
<td>2.41</td>
<td>0.67</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>6.88±0.99</td>
<td>6.65±1.09</td>
<td>6.44±0.99</td>
<td>0.149</td>
<td>2.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Mean and standard deviation of inflammatory factors before and after exercise in participants

<table>
<thead>
<tr>
<th>Inflammatory factor</th>
<th>Group</th>
<th>Before exercise Mean ± SD</th>
<th>After exercise Mean ± SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphocyte (%)</td>
<td>Athletes</td>
<td>43.4±7.2</td>
<td>47.4±5.6</td>
<td>0.173</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>49.2±2.1</td>
<td>52.8±2.3</td>
<td></td>
</tr>
<tr>
<td>Neutrophil (%)</td>
<td>Athletes</td>
<td>40.8±1.4</td>
<td>44.8±7.4</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>30.9±5.1</td>
<td>35.2±8.9</td>
<td></td>
</tr>
<tr>
<td>Monocyte (%)</td>
<td>Athletes</td>
<td>8.62±3.4</td>
<td>8.43±5.6</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>Non-athletes</td>
<td>10.1±4.8</td>
<td>12.7±4.6</td>
<td></td>
</tr>
</tbody>
</table>

Discussion

According to the results of standard EIA questionnaire, EIB was 13.3% among semi-endurance runners, which disagrees with the results obtained in a study conducted by Ilkka, which reported EIA 17% in endurance runners and 7% in sprinters (3). The prevalence of bronchospasm in endurance runners, based on the criterion of pulmonary function test (FEV1 reduction ≥15%), which has a greater accuracy, was reported 6.6%, while Lumme (17), Kukafka (18), Pohjantahti (19), and Mehmet Unal (20) reported the prevalence of EIB among athletes in various disciplines between 10% and 15%. In their study, Koh & Choi (21) showed that environmental temperature and humidity affect pulmonary bronchospasm, and humidity is highly important. Through repeated tests, Randolph et al. showed that breathing warm air has less effect on bronchoconstriction than cold air. FVC and FEV1 are among the most important pulmonary function maneuvers. Any factor that changes total pulmonary capacity affects FVC. Obstruction in airways or respiratory muscle weakness, including diaphragm, intercostal muscles, abdominal muscle group change values of FVC and FEV1. The present study results showed no significant difference between semi-endurance runners and non-athletes in pulmonary volumes of FVC, FEV1, and PEF. Despite intangible reduction in the above volumes due to exercise compared to the baseline, all volumes measured in the baseline were higher in runners than in non-athletes. Given the dry and warm climate of Kerman and low inflammatory cell count, this shows that the prevalence of EIB was not high in semi-endurance runners in this region, and highlights the
positive effects of endurance exercises on pulmonary function. This agrees with the results obtained in a study conducted by Atarzadeh et al. in an intermittent aerobic program in inactive girls, reporting a non-significant increase in pulmonary volumes (FVC, FEV1, and PEF) (1). In their study, Khosravi et al. showed that 8 weeks of circular endurance exercise can improve pulmonary function in inactive women (23). Similarly, Moazami et al. showed that two months of aerobic exercise can increase pulmonary volumes (FVC and FEV1) in postmenopausal women (24). In the present study, mean FVC/FEV1 ratio was 89% in athletes and 85% in non-athletes. The high ratio in adults suggests favorable ventilation, and it can be concluded that continuous exercises impose higher workload on inspiratory muscles and strengthen chest expansion forces and their endurance.

Conclusion

Generally, low prevalence of EIA in professional semi-endurance runners in Kerman can be due to the high ventilation threshold in these athletes due to endurance exercises. The physiological adaptability resulting from regular endurance exercises improves cardio-respiratory capacity and endurance and reduces bronchospasm and allergy, and maintains pulmonary function at a desirable level. Undoubtedly, detection and management of this negligible percentage of bronchospasm is necessary to prevent it from turning into severer asthma and allergy.

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Conflict of interest

The Authors declare that there is no conflict of interest in this paper.

References: