Comparison of pulmonary function test results before and after exercise in junior high school students

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Abstract

Background During exercise, bronchoconstriction occurs due to heat loss from mucosal respiratory tract. Exercise test can be performed to evaluate hyper-reactivity of the bronchus. The examination of pulmonary function is beneficial to confirm the diagnosis, to determine precipitating factors, and to evaluate disease severity and therapeutic response.

Objective To compare pulmonary function test values before and after exercise in junior high school students aged 13 to 15 years.

Methods Experimental study of 60 junior high school students from Bilah Hulu was performed using spirometry to evaluate pulmonary function before and after eight minutes of exercise.

Results Functional vital capacity (FVC) values before and after eight-minute exercise were 2.20 (SD 0.52) and 2.18 (SD 0.42), respectively. There was no significant difference between FVC values before and after exercise (P>0.05). The mean forced expiratory volume in 1 second (FEV₁) values before and after eight minutes of exercise were 2.21 (SD 0.42) and 2.13 (SD 0.50) respectively. There was no significant difference between FEV₁ before and after the exercise (P>0.05).

Conclusion Eight-minute exercise does not influence the pulmonary function test results in healthy children. [Paediatr Indones. 2010;50:176-80].

Keywords: exercise, pulmonary function test, spirometry

Close relationship between exercise and asthma has been known for a long time. This relationship is now used to assess the long-term effects of asthma, to study of new drugs and their efficacy in treating exercise-induced asthma, and as a diagnostic tool in cases where the diagnosis of asthma is uncertain. Free-running is considered as the most asthma-inducing exercise. Nevertheless treadmill running is considered to be more useful in determining bronchial response to exercise, since the intensity and the conditions in which it is performed can be more thoroughly controlled.¹

There are many reasons why exercise-induced asthma (EIA) is not recognized in children. Firstly, it occurs most commonly after exercise, so it may not exceed normal performance unless the child has moderate to severe asthma. Secondly, children may fail to notice the symptoms of EIA until they take part in organized or competitive sport. Thirdly,
50% of children become refractory to the bronchoconstricting effects of exercise when exercise is repeated within an hour of warm up. Forced expiratory volume (FEV₁) and forced vital capacity (FVC) are simple and relatively cost-effective pulmonary function tests. FVC is the volume of air that can be exhaled in a forced expiration after a maximal inspiratory effort. FEV₁ is the volume of air that can be exhaled during the first second of a forced expiration after a maximal inspiratory effort. These tests are useful for confirming diagnosis, determining exacerbating factors, determining the severity of disease, and measuring treatment responses.

Backer and Ulrik reported that 16% of a random sample of 494 Danish children and adolescents experienced more than 16% reduction in FEV₁ after a standardized exercise test. Anna reported that in 63 children classified as having intermittent asthma, there was no significant relationship between baseline FEV₁ and the decline in FEV₁ after exercise. In childhood, playing with other children and doing sport (physical exercise) are very important to increase self-confidence. However, these activities can induce asthma. Therefore, it is very important to identify EIA in children early to ensure optimal growth and development. De la Rubia found that FEV₁ and FVC are sensitive diagnostic parameters, especially for exercise tests that can induce bronchoconstriction. FEV₁ test can be performed only in children older than 8 years of age.

**Methods**

This study was conducted at PTPN III Hospital in South Aek Nabara Labuhan Batu District, North Sumatera, in the third week of March 2005. Pre-and post-pulmonary function test results were obtained to evaluate the effect of exercise on changes in FEV₁ and FVC. Sixty boys (13-15 years old) were recruited randomly from a population of junior high school students. Baseline data were recorded and each child was examined to assess their physical status.

We included healthy, male, junior high school students between the age of 13 and 15 years. Weight was measured with a Camry® digital weight meter with an accuracy of 0.1 kg. Subjects wore their school uniform without shoes when they were weighed. Height was measured with a Stature Meter Height® device (accuracy of 0.1 cm), placed vertically on the wall. Informed consent was signed by their parents and the study was approved by Ethics Committee of Medical Faculty of North Sumatera University.

The children were guided by an expert coach to take breath as deep as they could (maximal inspiration) and then to exhale as hard as they could through the exhalation pipe, which was connected to spirometer Spiro Lab II®. This process was done three times. The highest FEV₁ and FVC values were recorded. Next, the child exercised on a treadmill (Series 2000 treadmill, Marquet Medical System Inc) for 8 minutes then the second measurement of FEV₁ and FVC values were recorded using the same procedure described above.

Results produced from a suboptimal maneuver can give a misleading information. Therefore, both the individual coaching the child during the test and the physician interpreting the results must be able to recognize and reject an inadequate effort. Children who did not complete the entire study and who were not cooperative during the examination were excluded from analysis. Data were analyzed using SPSS version 10.0. A paired-\( t \) test was used to compare pulmonary function test values before and after exercise.

**Results**

The mean age of the subjects was 14 years, while the mean weight, height and BMI were 47 kg, 157 cm and 19 kg/m², respectively. The mean FEV₁ value before exercise was 2.21 L and became 2.13 L after exercise. The mean FVC values before and after exercise were 2.20 L and 2.18 L, respectively. The FEV₁ and FVC values before and after exercise decreased, but the differences were not statistically significant.

**Table 1. Subjects’ characteristics**

<table>
<thead>
<tr>
<th></th>
<th>n = 60</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
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<td>13</td>
<td>16</td>
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<tr>
<td>Weight (kg)</td>
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<td>6.49</td>
<td>33</td>
<td>64</td>
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<tr>
<td>Height (cm)</td>
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<td>7.22</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>19</td>
<td>1.72</td>
<td>15</td>
<td>25</td>
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</tbody>
</table>
Discussion

This study measured pre- and post-pulmonary function test in order to evaluate the effect of exercise on changes in \( \text{FEV}_1 \) and FVC. De la Rubia\(^1\) found that \( \text{FEV}_1 \) and FVC are sensitive diagnostic parameters, especially for exercise tests that can induce bronchoconstriction.\(^1\)

There are more useful numerical parameters derived from forced expiration consisted of forced vital capacity (FVC), peak flow (PF), forced expiratory volume (\( \text{FEV}_1 \)) and forced expiratory flow between 25\% and 75\% of vital capacity (\( \text{FEF}_{25-75} \)). The volume exhaled from the deepest inspiration possible to the end of exhalation (FVC) is usually nearly identical to vital capacity measured during a slow exhalation but may be slightly smaller in individuals with airway obstruction.\(^9,18\)

The volume exhaled during the first and second of exhalation (\( \text{FEV}_1 \)) is the most dependable indicator of airway obstruction. Values of \( \text{FEV}_1 / \text{FVC} < 80\% \) or \( \text{FEV}_1 / \text{FVC} < 80\% \) indicate an airway obstruction. An \( \text{FEV}_1 / \text{FVC} \) ratio greater than 80\% indicate normal airway function.\(^9,18,19\)

Spirometry is a simple method that can measure most components of lung volume and capacity; the tool used for measurement is called a spirometer.\(^9\) An electronic spirometer can measure various parameters of lung function, such as forced expiratory volume (\( \text{FEV}_1 \)) or forced vital capacity (FVC) \(^{14,16,17}\).
Exercise test was performed to evaluate bronchus hyperactivity. The principle is that bronchoconstriction occurs because of heat loss from respiratory tract mucous during exercise. According to the literature, bronchoconstriction develops after six to eight minutes of vigorous exercise. In this study, we wanted to evaluate whether there were any differences of pulmonary function test results (FEV<sub>1</sub> and FVC) before and after exercise in junior high school boys aged 13 to 15 years.

There are some reasons why EIA is difficult to identify:
1. It occurs after exercise, therefore it is not so bothersome to a child during normal activities, unless the child suffers from moderate to severe asthma.
2. A child does not show any symptom of asthma until they engage in competitive exercise.
3. As many as 50% of children become refractory to the effects of bronchoconstriction when exercise is repeated within a few hours or if they warm up beforehand. Resistance to the effects of bronchoconstriction shows that asthmatic symptoms do not always occur every time a child exercises.

This study was performed on healthy children (there was no prior history of bronchial hyper-reactivity or the hyper-reactivity was difficult to identify).

Asthma is defined as chronic inflammation of the respiratory tract, with many cell involved - especially mast cells, eosinophils, and T lymphocytes. Cabral et al found that there was no significant relationship between FEV<sub>1</sub> values before exercise in children with different severities of asthma. This was probably because differences in responses to intense exercise would be found between children with mild asthma and children with severe asthma, but not in children with persistent asthma.

Similarly, in this study, it was very difficult to compare the effect of exercise on children with mild and severe asthma due to research ethics. The exercise used in this study was running on a treadmill. Another study by De la Rubia compared treadmill and free-running in children aged 6 to 14 years old. The result was that there was no significant difference in FEV<sub>1</sub> and FVC values between subjects who ran on a treadmill and those who did the free running. This is an important finding since most people believe that running is more asthmagenic than cycling, walking, swimming or treadmill running.

In conclusion, there is no significant difference in pulmonary function test values (FEV<sub>1</sub> and FVC) before and after 8 minutes exercise in healthy boys aged 13 to 15 years.

References
12. Aditama TY, Mangunnegoro H, Fachrurodji H, Depari,