The Incidence of Exercise-Induced Bronchospasm in Competitive Figure Skaters

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ABSTRACT

Pediatric commitment to competitive sports is on the rise. Previous reports of the incidence of exercise-induced bronchospasm (EIB) have investigated high school, college, and Olympic athletes in traditional sports. The purpose of this study was to investigate the incidence of EIB in competitive figure skating, a high-intensity, cold-weather sport performed by young athletes. To investigate the incidence of EIB in skaters, 100 competitive skaters from five Mid-Atlantic rinks completed rinkside pulmonary function tests. Results showed an overall incidence of 30%, signaling the need for education and screening for EIB in youth participating in physically demanding, cold-weather sports.

INTRODUCTION

Asthma is a reversible obstructive airway disease that affects individuals of all ages, genders, races, and levels of fitness. Not only is asthma estimated to affect 10 million Americans, but it is also cited as the leading cause of chronic illness in the United States. Worldwide, prevalence of asthma has been reported to be 2-6% of the population (1). There are many triggers that may lead to an asthma attack. Exercise, however, is one of the most common precipitating factors. Exercise-induced asthma or exercise-induced bronchospasm (EIB) oc-
curs in up to 90% of all asthmatics, in 40% of individuals with allergic rhinitis, and in approximately 3–10% of all athletes (2–4).

EIB is characterized by a transient airflow obstruction that occurs after several minutes of physical exercise (5,6). To assess EIB from a research standpoint, an exercise provocation is usually performed on a treadmill for a minimum of 6 min at an intensity that will elicit a heart rate of 85–90% of predicted maximal heart rate. Exercise at higher intensities with a shorter duration has also been shown to be appropriate for EIB testing. Pre- and post-exercise pulmonary function testing is performed to assess changes in peak expiratory flow rate (PEFR), forced expiratory volume in 1 sec (FEV), forced expiratory flow at 25 and 75% of the vital capacity (FEF25–75). A decrease in FEV of 10% or greater or a drop of ≥25% in PEFR postexercise is associated with hyperreactivity of the large airways that leads to the increased airway resistance demonstrated in EIB. Middle to small airway bronchoconstriction is usually associated with a drop of 20% or more in FEF25–75.

In a survey of the 1984 summer Olympians, 67 of the 597 athletes (11%) reported a history of EIB and/or symptoms suggestive of EIB (7). Of the 67 athletes, 41 (61.2%) were previously undiagnosed with EIB and 26 (38.8%) were diagnosed with EIB. A similar incidence rate has been documented in high school athletes (8). Thus, the purpose of this study was to investigate the incidence of EIB in ice figure skating, a sport characterized by high-intensity exercise performed in a cold environment, both of which are known triggers for EIB (3).

**METHODOLOGY**

This study investigated the incidence of EIB in five Mid-Atlantic ice skating rinks in New York, Pennsylvania, and Delaware. Subjects in the study ranged from juvenile to elite national, international, and Olympic-caliber ice figure skaters. Ages of the skaters ranged from 7 to 25 years with an average age of 14.6 years. Subjects were recruited through communications with ice skating coaches and advertisements within the ice arenas prior to the test date. Consent forms and medical history questionnaires approved by the University of Delaware Human Subjects Review Board and the Medical Center of Delaware Institutional Review Board were completed by each skater prior to the rinkside pulmonary function tests. Of the 100 skaters who completed medical history questionnaires, 14 reported a previous history of EIB with current use of medication. All of these skaters used a metered-dose inhaler, one used a nebulizer treatment in combination with the inhaler, and three of the skaters used an inhaler and steroids in combination with cromlyn sodium or antihistamine medication. Previously diagnosed individuals were instructed to use their metered-dose inhaler approximately 30 min prior to their pulmonary function test. Despite the use of the inhaler prior to testing, 4 of the 13 subjects still experienced a significant drop in FEV and/or FEF25–75. Inhalers were not used by any of the skaters who did not have a previous EIB diagnosis.

To simulate the actual climatic conditions and intensity of exercise that skaters are normally exposed to, pre- and post-exercise spirometry testing was carried out at rinkside following the skater’s long program and two maximal stroking laps around the rink. The duration of the exercise provocation was approximately 4 min. Post-exercise spirometry was performed immediately following the completion of the exercise bout. Air temperatures in the rinks averaged 15.6°C ± 2.5°C with a relative humidity between 75 and 85%. All participants were encouraged to perform a maximal effort, and a subset of the overall group wore Polar wireless heart rate monitors to verify a maximal effort.

After the medical history questionnaire had been completed by the skater and he/she had been interviewed by the researchers to clarify responses, each skater was instructed in and completed resting spirometry. A Science and Medicine portable dry rolling seal spirometer interfaced to an interpretation program (S & M Instruments Screening Software version 120.601.05, Doylestown, PA) was used to measure resting and postexercise FEV and FEF25–75 responses. Flow volume loops were performed in triplicate. The PFT was judged as an acceptable effort if the FEV value was within 5% for two of the three tests. The highest value from
Exercise-Induced Bronchospasm in Figure Skaters

the two pretests and the highest value from the two posttests judged as acceptable were used to determine the FEV$_1$ and the FEF$_{25-75}$ changes. Tests were considered diagnostic of EIB if postexercise pulmonary function testing revealed a decrease in FEV$_1$ of $\geq 10\%$ and/or a decrease in FEF$_{25-75}$ of $\geq 20\%$. This criterion suggested an airway obstruction that was at least two standard deviations below the mean response for nonasthmatics. The percent drop was found by using the Jones Liability Index (9).

RESULTS

Results of EIB screening of 100 highly competitive ice figure skaters demonstrated an overall incidence of 30%. The population identified as positive for EIB consisted of two groups: 16% ($n = 16$) were undiagnosed asthmatics, and 14% ($n = 14$) were prediagnosed with EIB. Of the 30%, 74% reported that one or both parents had a history of asthma, hay fever, and/or allergies and 61% stated that they themselves had allergies. Moreover, 64% of the skaters reported coughing, wheezing, and/or chest tightness during exposure to cold air and 75% responded “yes” to the question “Do you ever cough, wheeze, or feel tightness in your chest after exercise?” Only 7% reported nighttime coughing or wheezing in the absence of illness.

In the previously undiagnosed group with positive spirometry, 47% of the individuals had clinically significant decreases in both FEV$_1$ and FEF$_{25-75}$. 27% had a significant drop in FEV$_1$ only, and 21% experienced a drop solely in FEF$_{25-75}$. Results of the postexercise spirometry are shown in Figure 1. These data demonstrated an average decrease of 15% for FEV$_1$ and 38% for FEF$_{25-75}$.

Tables 1 and 2 depict the incidence of EIB by age group and skating level. Of the skaters tested in the 7–12-year ($n = 50$) and 13–18-year ($n = 39$) age groups, 33% and 34% respectively met the study criteria for EIB. The average age for the asthmatic skater was 12.7 $\pm$ 3.7 years. While juvenile skaters had the highest incidence of EIB (50%), the junior (25%) and the novice (24%) level skaters also demonstrated high incidence rates for EIB.

DISCUSSION

Previous reviews have reported the incidence of EIB in athletes to be between 3 and 10% (2–4). In the 1984 summer Olympics, 11% of the athletes had EIB (7). The incidence of EIB in this group of 100 prejuvenile through elite national and international senior-level competitors was 30%, far in excess of reported incidences in other athletes. The high incidence of EIB documented in this group of skaters is unusual especially since posttesting was not carried out for the 15 min following the exercise provocation.

The increased rate of EIB may be the result of several factors. Possible explanations for the substantially higher incidence of EIB in skaters

<table>
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<th>AGE GROUP</th>
<th>POSITIVE RESPONSES</th>
<th>TOTAL NUMBER TESTED</th>
<th>% EIB BY AGE GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>7–12 years</td>
<td>13</td>
<td>39</td>
<td>33</td>
</tr>
<tr>
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<tr>
<td>19–25 years</td>
<td>0</td>
<td>11</td>
<td>0</td>
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</table>

Figure 1. Exercise-induced bronchoconstriction in competitive skaters.
include the following: the relatively young age of the skaters, the cold-air environment in which ice skating is performed, the possibility of poor air quality and presence of molds in some of the rinks, and the high-intensity, anaerobic exercise performance associated with the long program in skating.

Reports have documented that up to 41% of all children will be affected by conditions that increase bronchial hyperreactivity at some time in their lives and that of these children approximately 90% will experience EIB (3,10). Skaters who tested positive for EIB in this study had an average age of 12.8 ± 3.7 years. The skaters tested in this study represent a younger group than those tested in previous studies that have reported a lower incidence in high school athletes (8) as well as in Olympic athletes (7). Pearson (4) has suggested that childhood asthmatics often outgrow their disease within 7 years of its onset. This may explain the lack of response in the 19–25 year age group in the present study as well as the lower incidence rates among high school and Olympic athletes. In addition, some skaters may self-select to a less demanding sport when breathing difficulties are experienced in the skating environment.

Another plausible explanation for the higher incidence of EIB found in ice skaters compared to other athletes is the environment they are exposed to during training and competitive sessions. Air temperatures in this study averaged 15.6°C ± 2.5°C with relative humidities between 75 and 85% in the rinks during the summer months when testing was performed. Several papers have addressed the correlation between the incidence and severity of EIB and respiratory heat and water loss (11–13). Since a humid environment is one that reduces respiratory heat and water loss, the relatively cold air temperatures in the rinks would be the more likely precipitating factor (14,15). Air temperatures measured in the skating arenas represent a relatively cool environment. This environment combined with the high-intensity exercise effort that skating requires may be a sufficient stimulus to trigger EIB. However, other environmental factors may also play a role in the significantly high incidence of EIB in skaters. Although air quality and the presence of molds were not tested in this study, they should be considered as a possible stimulus for EIB in this group of athletes. The presence of mold due to the high humidity in the rinks and the question of air quality as a result of the zamboni exhaust fumes and/or inadequate ventilation systems warrant further investigation. Previous studies have documented reductions in pulmonary function in the presence of ozone and sulfur dioxide when exercise of relatively low intensities was performed. Nitrogen dioxide has also been implicated as a factor in advancing bronchospasm (16). Therefore, relatively cold air temperatures in combination with the possibility of questionable air quality and the presence of mold may produce a significant environmental trigger for EIB.

In addition, the long program run-through followed by two maximal laps around the rink that acted as the exercise provocation in this study is representative of a high-intensity, anaerobic workout. In this study a subgroup of skaters wore wireless heart monitors with a memory function (Polar Vantage XL, Polar Electro Oy, Finland) that allowed heart rates to be recorded throughout the entire exercise provocation. Heart rates of 185 bpm or higher were achieved within the first minute of the program. The remaining minutes of the exercise provocation were performed at or above this level, with the overall average heart rate response equal to 97% of the age-predicted maximum. Previous studies by Noviski et al. (14) and Deal et al. (15) have shown that high-intensity exercise is a trigger for EIB. Noviski et al. (14) have shown that when exercise was performed under the same respiratory heat loss conditions, the decrease in FEV₁ was two times greater for the higher, more anaerobic exercise
intensity than for lower, aerobic intensity of the same duration. This finding led Noviski and associates to conclude that exercise intensity determines and climatic conditions modify the severity of EIB. In this particular study, it seems that the increased incidence of EIB in skaters is most likely explained by the high-intensity effort associated with the long program but that environmental factors also play a significant role.

SUMMARY AND CONCLUSIONS

With increasing competition in athletics, pediatric commitment to sports is on the rise. The increased prevalence of EIB in this group of adolescent skaters underscores the need for increased education and screening for EIB in young athletes especially in at-risk sports such as figure skating, skiing, and hockey. Athlete, coach, and parental education should focus on diagnostic evaluation and effective treatments that will ultimately enhance sport performance and enjoyment. Moreover, if pulmonary function testing is unavailable, the use of a medical history questionnaire that includes questions regarding the presence of allergies, a history of upper respiratory illnesses, or whether symptoms of chest tightness, coughing, or wheezing are present on exposure to the cold or after exercise would identify a large percentage of the population who have EIB. Thus, results of this study support previous research that has documented high-intensity exercise as well as exercise that is performed in a cold environment to be triggers for EIB. Moreover, these results signal the need for increased education and evaluation of EIB in youth who are participating in physically demanding sports.

REFERENCES