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Are asthma-like symptoms in elite athletes associated with classical features of asthma?

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‘INFORMATION BOX’

When diagnosing asthma most guidelines still recommend symptom scoring. Exercise-related asthma-like symptoms are poor predictors of asthma in elite athletes and it seems that elite athletes have an increased number of airway inflammatory cells but our knowledge about this is still limited. Further, the role of asthma-like symptoms in elite athletes remains somewhat unclear.

This study brings knowledge about management of asthma-like symptoms and asthma in elite athletes. Asthma-like symptoms in elite athletes alone should not be relied upon to make a diagnosis of asthma and use of objective measurements for diagnosing asthma is recommendable.
ABSTRACT

Background: Asthma is frequent in elite athletes and clinical studies in athletes have found increased airway inflammation.

Objective: To investigate asthma-like symptoms, airway inflammation, airway reactivity (AR) to mannitol and use of asthma medication in Danish elite athletes.

Methods: The study group consisted of 54 elite athletes (19 with physician-diagnosed asthma), 22 non-athletes with physician-diagnosed asthma (steroid naïve for 4 weeks before the examination), and 35 non-athletes without asthma; all aged 18-35 years. Examinations (one day): questionnaires, exhaled nitric oxide (eNO), spirometry, skin prick test, AR to mannitol and blood samples. Induced sputum was done in subjects with asthma.

Results: We found no difference in values for eNO, AR and atopy between 42 elite athletes with and 12 without asthma-like symptoms (NS). Elite athletes with physician-diagnosed asthma had less AR (Response Dose Ratio 0.02 (0.004) vs. 0.08 (0.018) p < 0.01) and fewer sputum eosinophils (0.8% (0-4.8) vs. 6.0% (0-18.5), p < 0.01) than non-athletes with physician-diagnosed asthma. Use of inhaled corticosteroids was similar in the two groups (NS). Forty-two elite athletes had asthma-like symptoms but only 12 had evidence of current asthma. Elite athletes without asthma had asthma-like symptoms more frequently than non-athletes without asthma (68.6% vs. 25.7%, p < 0.001).

Conclusion: Asthma-like symptoms in elite athletes are not necessarily associated with classic features of asthma and alone should not give a diagnosis of asthma. More studies are needed to further investigate if and how the asthma phenotype of elite athletes differs from that of classical asthma.
INTRODUCTION
Elite athletes have a high prevalence of physician diagnosed asthma compared with non-athletes.[1, 2] Exercise-related asthma-like symptoms are poor predictors of exercise-induced bronchoconstriction (EIB) and asthma in elite athletes;[3, 4] furthermore, respiratory complaints during exercise can occur independently of asthma.[5] Elite athletes have a higher prevalence of airway hyperresponsiveness (AHR) to methacholine than non-athletes[6] and an increase in airway inflammatory cell numbers, with neutrophils being the dominant cell type.[7-9] It has been suggested that chronic endurance training might increase the number of neutrophils in the airways.[7, 10] This may reflect airway injury, and more studies are needed to investigate whether airway inflammation of elite athletes with ‘asthma’ differs from that seen in patients with classical asthma. The use of asthma treatment in elite athletes is also currently under scrutiny in order to reduce the risk of undertreatment,[11-13] or over treatment.[14-16]

The objective of the study was to identify the prevalence of asthma-like symptoms and examine them in relation to airway inflammation, to airway reactivity to mannitol and to use of asthma medication in Danish elite athletes and non-athletes.

METHODS
Subjects
The study group consisted of three groups: 1) 54 elite athletes, 2) 22 non-athletes with asthma, and 3) 35 non-athletes without asthma. All volunteered to participate and all met the inclusion criterion of being between 18-35 years and the exclusion criterion of not having had a recent chest infection (past month). All participants lived in Copenhagen or in a radius of 80 km of Copenhagen (Zealand). All gave their written informed consent, and the local ethics committee approved the study (No KF262958 and KF262754). None of the non-athletes was involved in active competitive sports.

Group 1: Elite athletes who were financially supported by Team Denmark (N = 145) were invited and 54 (37%) volunteered to participate in the study. They were identified from a previous study[13] in which willingness to participate in further investigations was assessed. Group 1 was divided in two subgroups: elite athletes with asthma (n = 19) and elite athletes without asthma (n = 35).

Group 2: Non-athletes with asthma (n = 22). They were recruited through advertisements in the local newspaper and they met the additional inclusion criterion of already having physician-diagnosed asthma.

Group 3: Non-athletes without asthma. A random population sample of 585 subjects aged 18-24 years was drawn from the civil register. This group was part of a population study by A Sverrild. In the present study, the first 35 examined subjects with no history of physician-diagnosed asthma and no current or previous use of asthma medication were included.

Study design
A cross-sectional study. All participants were asked to refrain from taking short-acting beta2-agonists (SABA) for 6 h, long-acting beta2-agonists (LABA) for 12 h, and antihistamines for 3 days before the visit. No inhaled corticosteroids (ICS) were taken on the day of the study. Further, all non-athletes with asthma were asked to refrain from taking ICS for four weeks before their visit; this was, however, not practical for the elite athletes. Nine elite athletes used ICS on a daily basis. All participants visited the research unit once and all elite athletes were asked not to train
on the day of examination. The study was carried out from autumn 2006 to spring 2007. The non-athletes with asthma were examined from autumn 2005 to spring 2006.

All subjects answered a questionnaire; all were interviewed by one of the authors and all had a measurement made of exhaled nitric oxide. Then spirometry was measured at rest and in response to a mannitol challenge test. Skin prick tests were performed and blood samples were taken. Sputum induction was carried out only in athletes and non-athletes with physician-diagnosed asthma or current asthma.

**Questionnaire and interview**

All participants received two questionnaires; one had four question groups: (a) sport and training hours (only for athletes), (b) asthma-like symptoms, (c) physician-diagnosed asthma, family history of asthma and childhood asthma, and (d) smoking habits. This questionnaire was a non-validated standard questionnaire for athletes used in Bispebjerg Hospital, Copenhagen, Denmark.

To determine physician-diagnosed asthma the following question was used: “Has a doctor diagnosed you with asthma?” Questions on asthma-like symptoms in groups 1 and 2 were in accordance with the GINA guidelines:[17] “Do you experience wheezing, breathlessness, chest tightness or cough” (a separate question for each symptom): 1) never, 2) less than once a week, 3) more than once a week but less than once a day, 4) daily, 5) daily with limitation of physical activities? Asthma-like symptoms in group 3 were documented by two questions: 1) “Have you ever experienced wheezing, breathlessness, chest tightness or cough at rest?” and 2) “Have you ever experienced wheezing, breathlessness, chest tightness or cough related to exercise?” The other questionnaire was a validated asthma control questionnaire.[18] All participants were interviewed about their use of asthma medication.

**Spirometry, blood samples, skin prick testing and exhaled nitric oxide**

Spirometry was performed according to the ATS/ERS recommendations.[19] The forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC) were measured using a 7-L dry wedge spirometer (Vitalograph, Buckingham, UK). Predicted values of FEV₁ and FVC were based on reference values according to Nysom et al.[20] Blood samples were taken and a differential cell count was done. A skin prick test to ten aeroallergens (birch, grass, mugwort, horse, dog, cat, house dust mites (D. pter. and D. far.) and molds (alternaria and cladosporium) (ALK-Abello, Hoersholm, Denmark)) was performed in duplicate according to the EAACI recommendations. A positive result was defined as a wheal of at least 3 mm in diameter to one or more allergens.[21] Exhaled NO (eNO) was measured according to ATS guidelines[22] using the Nitric Oxide Analyzer (NIOX®, Aerocrine AB, Solna, Sweden).

**Mannitol challenge test**

Bronchial provocation with mannitol powder (Aridol™, Pharmaxis, Frenchs Forest, Australia) contained in capsules and inhaled from a dry powder inhaler (RS 01, Plastiape, Osnago, Italy) up to a cumulative dose of 635 mg was performed.[23-25] Airway reactivity to mannitol is expressed as the response dose ratio (RDR). This value allows evaluation of all subjects not only those with a 15% fall in FEV₁. The RDR is the percentage fall in FEV₁ measured after the final dose of mannitol, divided by the cumulative dose in milligrams administered to induce that percentage fall in FEV₁. For those having a negative or 0% fall in FEV₁ a value for FEV₁ of 0.1% was assumed in the equation.
Induced sputum
Sputum induction was conducted after the mannitol challenge and according to ERS recommendations using a nebulizer (Easyneb II, Flaemnuova®, Brescia, Italy). After inhalation of 1 mg terbutaline, sputum was induced by inhalation of hypertonic saline in increasing concentrations (3%, 4% and 5%) for 3 periods each of 7 minutes. Sputum plugs were selected and processed within two hours of collection, and cytospins were prepared using standard methods, and a differential cell count was performed.[26, 27] The cells were expressed as a percentage of the total non-squamous cells (100-400 cells).

Definitions
Elite athletes were defined as athletes financially supported by Team Denmark. Team Denmark is an institution charged with the overall planning of elite sports in Denmark, including individual financial support for top-level athletes. Asthma was defined as physician-diagnosed asthma diagnosed before entering the study (ever diagnosed asthma). A diagnosis of current asthma was made on the basis of asthma-like symptoms in combination with a current positive mannitol challenge (15% decrease in FEV₁) and/or current daily use of ICS. Never ICS was defined as no current or previous use of ICS. The athletes’ sports classifications were made according to our previous classification:[13] endurance sports (rowing, cycling, swimming etc), power sports (gymnastics, athletics, wrestling etc), intermediate sports (handball, soccer, ice hockey etc), and other sports (golf, curling, bowling etc).

Statistics
The data were analyzed using SPSS version 14.0 (SPSS Inc., Illinois, USA). Frequencies were calculated for the entire group. Continuous variables were analyzed using ANOVA, followed by t-test for normally distributed data. Results for continuous data are presented in mean and standard error of the mean (SEM) in brackets. Skewed data (induced sputum) are presented in median (range). Differences for skewed data were assessed by the Mann-Whitney U Test. Differences for categorical data were assessed by chi-square tests and Fisher’s Exact Test when appropriate. A p-value < 0.05 was considered to be statistically significant.

RESULTS
Table 1 shows the basic characteristics of the study group. Of the elite athletes, 27 (50%) performed endurance sports, 5 (9%) performed power sports, 18 (33%) performed intermediate sports, and the remaining 4 (7%) were from other sports. The athletes’ weekly training was 23.8 (1.3) hours and the duration of their active sport career at this level was 5.9 (0.4) years, with no difference between elite athletes with and without asthma.

The prevalence of any asthma-like symptoms was higher in the participating athletes (n = 54) than in those athletes invited but who declined to participate (n = 91) (p < 0.05) (data not shown). Table 2 shows the characteristics for elite athletes with (n = 42) and without asthma-like symptoms (n = 12) and we found no differences between the groups in all variables listed.
Nineteen elite athletes had physician-diagnosed asthma but only 12 had evidence of current asthma. Of these 12, one was not aware of asthma before entering the study. No differences in current asthma or use of any asthma medication were found between the elite athletes and non-athletes with asthma (Table 3).

Elite athletes without asthma had a higher prevalence of asthma-like symptoms (p < 0.001) and higher values for eNO (p < 0.05) than non-athletes without asthma (Table 3). The values for eNO were similar in the non-atopic subjects for both groups (12.7 (1.22) vs. 16.9 (1.73) ppb, p < 0.05).

### Table 1: Basic characteristics for elite athletes and non-athletes

<table>
<thead>
<tr>
<th></th>
<th>Elite athletes</th>
<th>Non-athletes</th>
<th>P Between 1 and 3</th>
<th>P Between 2 and 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects, n</td>
<td>19</td>
<td>35</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sex M:F</td>
<td>11:8</td>
<td>25:10</td>
<td>NS</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Age, years</td>
<td>24.0 (0.75)</td>
<td>25.1 (0.70)</td>
<td>&lt; 0.01</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>NS</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>FEV1, L</td>
<td>4.37 (0.19)</td>
<td>4.91 (0.15)</td>
<td>&lt; 0.01</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FEV1, % predicted</td>
<td>98.2 (1.94)</td>
<td>105.4 (2.10)</td>
<td>&lt; 0.001</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>FVC, L</td>
<td>5.51 (0.30)</td>
<td>5.85 (0.19)</td>
<td>NS</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FVC, % predicted</td>
<td>106.2 (2.17)</td>
<td>107.8 (2.45)</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>FEV1/FVC-ratio, %</td>
<td>80.4 (1.71)</td>
<td>84.5 (1.30)</td>
<td>0.052</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Subjects with physician-diagnosed asthma. *Fisher’s Exact Test. FEV1: forced expiratory volume in one second. FVC: forced vital capacity.
## Table 2: Characteristics for elite athletes with and without asthma-like symptoms

<table>
<thead>
<tr>
<th></th>
<th>No symptoms</th>
<th>All(^1) N = 42</th>
<th>More than 1(^2) N = 23</th>
<th>Daily N = 7</th>
<th>Exercise(^3) N = 12</th>
<th>p(^8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV(_1), % predicted</td>
<td>105.2 (3.44)</td>
<td>102.2 (1.79)</td>
<td>101.2 (2.53)</td>
<td>107.8 (4.83)</td>
<td>103.1 (3.76)</td>
<td>NS</td>
</tr>
<tr>
<td>FVC, % predicted</td>
<td>110.2 (5.14)</td>
<td>106.3 (1.73)</td>
<td>106.6 (2.15)</td>
<td>111.4 (3.54)</td>
<td>107.3 (3.28)</td>
<td>NS</td>
</tr>
<tr>
<td>eNO, ppb</td>
<td>19.2 (2.67)</td>
<td>23.7 (2.57)</td>
<td>30.1 (4.13)</td>
<td>26.7 (4.04)</td>
<td>19.7 (2.55)</td>
<td>NS</td>
</tr>
<tr>
<td>B- eosinophils, 10(^9)/L</td>
<td>0.12 (0.02)</td>
<td>0.15 (0.01)</td>
<td>0.15 (0.02)</td>
<td>0.17 (0.04)</td>
<td>0.13 (0.02)</td>
<td>NS</td>
</tr>
<tr>
<td>Atopy, n (%)</td>
<td>7 (58.3)</td>
<td>22 (52.4)</td>
<td>14 (60.9)</td>
<td>4 (57.1)</td>
<td>6 (50.0)</td>
<td>NS</td>
</tr>
<tr>
<td>Mannitol test,(^#) n (%)</td>
<td>0 (0)</td>
<td>5 (11.9)</td>
<td>5 (21.7)</td>
<td>0 (0)</td>
<td>2 (16.7)</td>
<td>NS</td>
</tr>
<tr>
<td>RDR(^##)</td>
<td>0.0075 (0.002)</td>
<td>0.0116 (0.002)</td>
<td>0.0165 (0.003)</td>
<td>0.011 (0.003)</td>
<td>0.0109 (0.003)</td>
<td>NS</td>
</tr>
<tr>
<td>Current asthma,(###) n (%)</td>
<td>1 (8.3)(^§)</td>
<td>11 (26.2)</td>
<td>9 (39.1)</td>
<td>2 (28.6)</td>
<td>5 (41.7)</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(^1\)All symptoms (exercise + rest). \(^2\)Symptoms more than once a week. \(^3\)Only symptoms after exercise – include athletes from the different symptom groups “less than once a week”, “more than once a week” and “daily”. The group of athletes with asthma-like symptoms “less than once a week” (n = 12) is not shown. \(^4\)A positive mannitol challenge test. \(^#\)Response Dose Ratio. \(###\)Asthma-like symptoms + positive mannitol test and/or current use of daily ICS. \(^§\)P between groups. \(^\##\)Well controlled asthmatic using ICS.
Table 3 also shows that elite athletes with asthma had less reactivity (lower values for RDR) than non-athletes with asthma (p < 0.01). In subjects with asthma who had never used ICS the airways were still less reactive in elite athletes than in non-athletes (0.018 (0.004) vs. 0.095 (0.024), p < 0.01).

Of the 42 subjects with physician-diagnosed asthma and/or current asthma, 26 were able to produce usable sputum samples giving a success rate of 62%. The examination of the sputum differential cell count in subjects with asthma revealed fewer eosinophils in elite athletes than in non-athletes (p < 0.01) and more neutrophils in the elite athletes, although this difference was not significant (Table 4). For subjects with current asthma there was no significant difference in sputum eosinophils between elite athletes and non-athletes (data not shown). Sputum eosinophilia (> 4%) was found in 1 elite athlete and in 7 non-athletes with asthma (p < 0.05).

No difference in ICS dose (budesonide-equivalent) was found between athletes and non-athletes (622 (91) μg vs 475 (74) μg). The ICS dose for non-athletes was calculated on their regular use of ICS prior to the last four weeks in which they had no ICS. Of the athletes getting ICS and/or FC-ICS (fixed combination of ICS and LABA), 2 were positive to the mannitol test.
Table 3: Clinical characteristics for elite athletes and non-athletes

<table>
<thead>
<tr>
<th></th>
<th>Elite athletes</th>
<th>Non-athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>¹Asthma N = 19</td>
<td>²Non-asthma  N = 35</td>
</tr>
<tr>
<td></td>
<td>³Asthma N = 22</td>
<td>⁴Non-asthma N = 35</td>
</tr>
<tr>
<td>eNO, ppb</td>
<td>25.2 (3.84)</td>
<td>21.3 (2.47)</td>
</tr>
<tr>
<td></td>
<td>43.4 (7.85)</td>
<td>14.7 (1.34)</td>
</tr>
<tr>
<td></td>
<td>NS (0.056)</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Atopy, n (%)</td>
<td>11 (57.9)</td>
<td>18 (51.4)</td>
</tr>
<tr>
<td></td>
<td>22 (100)</td>
<td>10 (28.6)</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.01</td>
<td>0.051</td>
</tr>
<tr>
<td>Mannitol test, # n (%)</td>
<td>4 (21.1)</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td></td>
<td>18 (81.8)</td>
<td>2 (5.7)</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.001</td>
<td>NS</td>
</tr>
<tr>
<td>RDR##</td>
<td>0.0179 (0.004)</td>
<td>0.0067 (0.001)</td>
</tr>
<tr>
<td></td>
<td>0.0825 (0.018)</td>
<td>0.011 (0.004)</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>B- eosinophils, 10⁹/L</td>
<td>0.17 (0.02)</td>
<td>0.12 (0.01)</td>
</tr>
<tr>
<td></td>
<td>0.29 (0.04)</td>
<td>0.12 (0.02)</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.02</td>
<td>NS</td>
</tr>
<tr>
<td>ACQ###</td>
<td>3.7 (1.0)</td>
<td>0.5 (0.2)</td>
</tr>
<tr>
<td></td>
<td>7.4 (1.3)</td>
<td>0.2 (0.2)</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Symptoms, ‡n (%)</td>
<td>18 (94.7)</td>
<td>24 (68.6)</td>
</tr>
<tr>
<td></td>
<td>21 (95.5)</td>
<td>9 (25.7)</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Current asthma, n (%)</td>
<td>11 (57.9)</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td></td>
<td>18 (81.8)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Treatment, §§n (%)</td>
<td>15 (78.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>21 (95.5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

¹²Subjects with physician-diagnosed asthma before entering the study. ³⁴A positive mannitol challenge test. ⁴⁵Response Dose Ratio. ⁶⁷Asthma control questionnaire (mean score). ‡All asthma-like symptoms (rest + exercise). §§Use of any asthma medication. ⁵⁶P between group 1 and 3. ⁷⁸P between group 2 and 4. One athlete with “non-asthma” had a positive mannitol challenge test and asthma-like symptoms and was classified as having current asthma.
Table 4: Sputum differential cell count

<table>
<thead>
<tr>
<th></th>
<th>Asthma subjects#</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elite athletes N = 20</td>
<td>Non-athletes N = 22</td>
<td>p##</td>
<td></td>
</tr>
<tr>
<td>Usable samples n (%)</td>
<td>13 (65)</td>
<td>13 (59)</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Total cell count</td>
<td>430 (248-1307)</td>
<td>518 (212-1252)</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Eosinophils %</td>
<td>0.8 (0-4.8)</td>
<td>6.0 (0-18.5)</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Neutrophils %</td>
<td>39.3 (2.8-89.0)</td>
<td>23.5 (0-98.0)</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Lymphocytes %</td>
<td>1.5 (0-6.0)</td>
<td>1.8 (0-14.1)</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>Macrophages %</td>
<td>39.8 (2.5-87.3)</td>
<td>43.0 (0.5-87.5)</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>Bronchial epithelial cells %</td>
<td>7.8 (0.3-38.8)</td>
<td>8.5 (0.5-45.5)</td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

#Subjects with physician-diagnosed asthma and/or current asthma.
##Mann-Whitney Test (athletes versus non-athletes). Data in median (range).

DISCUSSION

This study included Danish top-level athletes competing at an international level. The results of this study showed no difference in lung function, eNO, airway reactivity to mannitol and atopy between elite athletes with and without asthma-like symptoms. Moreover we found that elite athletes frequently had asthma-like symptoms but further investigation did not confirm a diagnosis of current asthma. Forty-two elite athletes had asthma-like symptoms but only 12 had evidence of current asthma. These findings confirm the recent suggestion by the International Olympic Committee—Medical Commission (IOC-MC) consensus statement on asthma (www.olympic.org) that asthma-like symptoms alone should not be relied upon to diagnose asthma. Our findings suggest that symptoms are independent of the levels of eNO, airway reactivity to mannitol and atopy in elite athletes. Earlier studies have demonstrated that exercise-related asthma-like symptoms in elite athletes are not predictive of EIB and that they are also poor indicators of asthma in this group of patients.[3, 4]

We found that elite athletes with asthma had less airway reactivity and fewer sputum eosinophils than did non-athletes with asthma. Others have also examined airway inflammation in elite athletes.[2, 8, 9, 28] Lumm et al.[2] made the interesting observation that there was no difference in sputum differential cell counts of eosinophils and neutrophils between athletes with and without asthma-like symptoms and AHR to methacholine, suggesting that symptoms are independent of sputum eosinophils and neutrophils as well. It seems that a “healthy” group of elite athletes have some kind of airway inflammation possibly related to airway injury that is independent of asthma. We found that this group of “healthy” elite athletes without asthma had increased eNO compared with “healthy” non-athletes without asthma, even in the non-atopic subjects. The difference was small and the healthy athletes had more atopy than the healthy non-athletes (p = 0.051). A recent study has confirmed earlier suggestions from studies in children that eNO is an index of atopy.[29]

Studies on the effects of asthma medication, such as montelukast[30] and budesonide,[31] on asthma-like symptoms in elite ice hockey players and cross-country skiers have reported no beneficial effect on asthma-like symptoms, AHR or airway cellular inflammation. All these findings support the concept that many athletes with symptoms simply do not have classical asthma or respond to classical.
asthma treatments. We think there might be a difference in the asthma phenotype of some elite athletes compared to non-athletes, but this area needs further investigation.

Karjalainen et al[8] examined bronchial biopsies from 40 elite skiers without a diagnosis of asthma, 12 subjects with mild asthma and 12 healthy controls; they found lower cell counts of eosinophils, mast cells and macrophages in skiers with and without AHR than in subjects with asthma. Furthermore, the skiers were found to have higher neutrophil counts than subjects with asthma. Undiagnosed asthma in the skiers could, however, not be excluded and Karjalainen et al[8] suggested that the inflammatory process in these athletes was different from that in subjects with asthma. This may relate to airway injury.[32]

Helenius et al[28] and Lumme et al[2] examined induced sputum of elite swimmers and ice hockey players. These studies concluded that the athletes had higher sputum eosinophil and neutrophil cell counts than did controls. In both studies, however, athletes had increased atopy, AHR and asthma compared to controls.

Some studies have indicated a high use of asthma medication among elite athletes[14, 16, 33] but they did not indicate whether they thought that the athletes were over treated. We found minor signs of undertreatment in elite athletes with asthma. Four of the 12 athletes with current asthma had a positive mannitol test, despite treatment with asthma medication (2 on ICS and 2 on SABA only), and one had sputum eosinophilia. Further, four athletes without current asthma were taking asthma medication (SABA only). Undertreatment and inappropriate treatment of elite athletes with asthma has been discussed in earlier studies.[12, 34, 35]

Limitations; we found less airway reactivity and fewer sputum eosinophils in elite athletes with asthma compared with non-athletes with asthma. This may to some extent be accounted for by the greater level of atopy in the non-athletes with asthma, a finding that might have increased the general level of airway inflammation in this group. Further the non-athletes had their treatment with ICS discontinued for four weeks before the examination. It was not practical to discontinue ICS in elite athletes as they had a busy schedule with competitions and training. This may have accounted for the findings of a reduced general level of airway inflammation in the athletes.

In conclusion, asthma-like symptoms in elite athletes are not necessarily associated with classic features of asthma and alone should not be relied upon to make a diagnosis of asthma. This indicates that the athletes’ care needs further attention and more studies are needed to further investigate if and how the asthma phenotype of elite athletes differs from that of classical asthma.

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COMPETING INTERESTS

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PhD Sandra D Anderson is the inventor of the mannitol test although it is owned by her employer the Sydney South West Area Health Service (SSWAHS). She owns shares in Pharmaxis Ltd that she purchased herself in 2001. She does not own any options. She may benefit from royalties in the future. In her capacity as an employee of SSWAHS she acts as a consultant and invoices are issued by SSWAHS.

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