

High prevalence of asthma in Danish elite canoe- and kayak athletes

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ABSTRACT

INTRODUCTION: Asthma is common in elite athletes, but our knowledge of asthma in elite canoe and kayak athletes is limited. The aim of the present prospective cross-sectional study was therefore to investigate the prevalence of asthma, including asthma-like symptoms, exhaled nitric oxide, and airway reactivity to mannitol in Danish elite canoe and kayak athletes.

MATERIAL AND METHODS: The study group consisted of 29 (of 33 eligible) elite athletes aged 17-43 years, and the examination programme consisted of questionnaires, including the Asthma Control Questionnaire, fraction of exhaled nitric oxide ($F_E\text{NO}$), spirometry and airway reactivity to mannitol. Asthma was defined as a history of doctor-diagnosed asthma and/or elevated $F_E\text{NO}$ and airway reactivity.

RESULTS: Seven of the elite athletes (24.1%) were found to have asthma, including four subjects with previously doctor-diagnosed asthma. Of the four athletes (all treated with inhaled corticosteroids) with doctor-diagnosed asthma, all reported asthma-symptoms and two had elevated $F_E\text{NO}$, but none had airway hyperresponsiveness (AHR) to mannitol. All three athletes with previously undiagnosed asthma had elevated $F_E\text{NO}$ and AHR to mannitol, but reported no asthma-like symptoms.

CONCLUSIONS: Asthma is common in elite canoe and kayak athletes, and classical signs of asthmatic airway inflammation are also found in asymptomatic athletes.

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Exercise may increase ventilation up to 200 l/min for shorter or even longer periods of time, and it is, therefore, not surprising that highly trained athletes commonly report respiratory symptoms [1], and that respiratory problems may occur during exercise independently of asthma [2]. Furthermore, previous studies have shown that exercise-related asthma-like symptoms is a poor predictor of exercise-induced bronchoconstriction and asthma in elite athletes [3, 4].

The occurrence of asthma seems to be higher in elite athletes than in non-athletes [5, 6], and use of asthma medication is also highly prevalent in elite athletes [7]. However, there is increasing evidence to suggest that a substantial proportion of elite athletes fail to recognise and report symptoms of exercise-induced

asthma [8], which supports the view that elite athletes should be routinely screened for asthma, not least in order to optimise their performance in competition.

In this cross-sectional study, we assessed the occurrence of asthma-like symptoms and examined these in relation to fraction of exhaled nitric oxide ($F_E\text{NO}$) and airway reactivity to mannitol in Danish elite canoe and kayak athletes in order to provide evidence for the prevalence of asthma in this specific group of elite athletes.

MATERIAL AND METHODS

Subjects and study design

The study population consisted of 29 (of 33 eligible) elite canoe and kayak athletes (both sprint and marathon athletes). All participants volunteered, and all met the inclusion criteria: age ≤ 45 years, non-smoker, elite athlete ≥ 4 yrs (≥ 10 hours of training per week and competition at least at national championship level), and the exclusion criterion of not having had a chest infection/common cold within the past month. Only elite athletes living in the Copenhagen area were invited to participate in the study. All subjects gave written informed consent, and the study was approved by the local research ethics committee and performed in accordance with the ethical standards described by Harris & Atkinson [9].

A cross-sectional study was performed. All participants, if prescribed asthma medication, were asked to refrain from taking short-acting β_2 -agonists for six hours and long-acting β_2 -agonists for 12 hours before the visit,

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A canoe athlete.
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whereas inhaled corticosteroids were continued as prescribed. All subjects visited the research unit once and were asked not to train on the day of examination. The study was carried out in 2010, and in case of known allergy, the examination was performed out of season.

All subjects answered a questionnaire, were interviewed by one of the authors and all had a measurement on the basis of $F_{E}NO$ in parts per billion. Afterwards, spirometry was measured at rest and in response to a mannitol challenge test.

Questionnaire and interview

All participants received two questionnaires; the Asthma Control Questionnaire (ACQ) [10] and a non-validated standard questionnaire with four question groups: a) training hours, b) asthma-like symptoms, c) doctor-diagnosed asthma and d) smoking habits. To determine doctor-diagnosed asthma, the following question was asked: "Has a doctor diagnosed you with asthma?" Questions on asthma-like symptoms included: "Do you experience wheezing, breathlessness, chest tightness and/or cough at rest? Or related to exercise?" [11]. All participants were interviewed about their use of asthma medication. For participants reporting a previous diagnosis of asthma, further information was obtained regarding age at diagnosis, including timing in relation to commencing a career as an elite athlete, and diagnostic procedures performed, including tests for airway hyperresponsiveness, diurnal variability in peak flow and bronchodilator reversibility.

Spirometry and exhaled nitric oxide

Spirometry was performed according to the American Thoracic Society (ATS)/European Respiratory Society recommendations [12]. The forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured using an EasyOne Ultrasonic spirometer (NDD, Zürich, Switzerland). Predicted values of FEV_1 and FVC were based on reference values according to Nysom et al [13].

$F_{E}NO$ was measured before the spirometry and mannitol challenge test, according to the ATS-guidelines [14] and using the Nitric Oxide Analyzer (NIOX, Aerocrine, Solna, Sweden): Briefly, subjects exhaled from total lung capacity to residual volume at an expiratory flow rate of 50 ml/s and against a target resistance of 4-5 cm water with the help of a biofeedback monitor. $F_{E}NO$ was determined as the average of three measurements of the plateau of the exhaled nitric oxide curve.

Mannitol challenge test

Bronchial provocation with mannitol powder (Aridol, Pharmaxis, Frenchs Forest, NSW, Australia) in capsules

(0, 5, 10, 20 or 40 mg) was performed [15]. Consecutive doses of 0, 5, 10, 20, 40, 80, 160, 160, 160 mg to a cumulative dose of 635 mg were administered from a dry powder inhaler and a controlled deep inhalation to total lung capacity with 5 s of breath-holding. Spirometry was performed 60 s after each dose. The test was terminated if the decrease in FEV_1 was 15% or greater of the FEV_1 after inhalation of 0 mg mannitol, or when 635 mg had been inhaled. Salbutamol and ipratropium bromide were administered after the challenge test to aid recovery, and spirometry was performed 10 min post-administration.

Definitions and statistical analyses

Asthma-like symptoms were defined as wheeze, abnormal breathlessness, cough, or chest tightness either on exertion or at rest. Asthma was defined as doctor-diagnosed asthma, based on symptoms and a positive bronchial challenge test/reversibility test and/or elevated $F_{E}NO$ plus airway hyperresponsiveness to mannitol.

Based on the available reference values, elevated $F_{E}NO$ was defined as values ≥ 25 ppb [16, 17]. Airway hyperresponsiveness (AHR) to mannitol was defined as a provocative dose causing a 15% decrease in FEV_1 of 635 mg or less.

Data are expressed as mean \pm standard deviation or percentage values. Differences in subjects' characteristics were analysed with the Student's t-test for normally distributed data and with Mann-Whitney U-test for non-normally distributed data. Correlation coefficients were calculated using Spearman's rank method. Statistical significance was defined as a p value of 0.05 or less. Trial registration was not considered to be relevant for the present study.

RESULTS

Subject characteristics

Thirty-three athletes were invited to participate in the study and 29 accepted the invitation and completed the study. Two subjects declined, and two subjects did not want to participate in the clinical part of the study. Only data on subjects who completed all parts of the study are included in the analyses. The characteristics of the subjects included in the study are given in **Table 1**. All 29 subjects were competing at national to Olympic levels.

Athletes with previously diagnosed asthma

Four of the athletes had asthma diagnosed, based on typical symptoms and presence of airway hyperresponsiveness, before beginning their sport career, were treated with inhaled corticosteroids, and had also been prescribed short-acting β_2 -agonists on demand. All four athletes reported typical asthma symptoms, including exercise-induced wheezing. No differences with regard



TABLE 1

Study population characteristics.

Male:female, n	24:5
Age, mean (range), yrs	25.1 (17-43)
Height, mean (range), cm	181.7 (167-198)
BMI, mean (range), kg/m ²	24.3 (21.9-28.1)
Competitive experience, mean (range), yrs	9.3 (4-28)
Self-reported allergy, yes/no, n	8/21
FEV ₁ , mean (range), l	4.7 (3.6-6.5)
FEV ₁ , mean (range), %pred	107.7 (84-147)
FEV ₁ /FVC, mean (range), %	82 (67-90)

%pred = percentage of predicted; BMI = body mass index;

FEV₁ = forced expiratory volume in one second; FVC = forced expiratory volume.

TABLE 2

Characteristics of asthmatic and non-asthmatic athletes.

	Asthma (n = 7)	Non-asthma (n = 22)
Male:female, n	6:1	18:4
Age, mean (± SD), yrs	25.9 (8.0)	24.9(8.1)
Atopy, yes:no, n	4:3	4:18
Competitive experience, mean (± SD), yrs	10.4 (5.9)	9.0 (7.1)
FEV ₁ , mean (± SD), l		
FEV ₁ , mean (± SD), %pred	4.5 (0.6)	
103.3 (13.3)	4.8 (0.9)	
109.1 (14.8)		
FEV ₁ /FVC, mean (± SD), %	80 (6)	83 (6)
F _e NO, mean (± SD), ppb	38.8 (24.3)	18.5 (9.8)**

%pred = percentage of predicted value; F_eNO = fraction of exhaled nitric oxide; FEV₁ = forced expiratory volume in one second FVC = forced expiratory volume; SD = standard deviation.

**) p = 0.003.

to age, body mass index (BMI), FEV₁ percentage of predicted value (% pred) or competitive experience were found between athletes with known asthma and non-asthmatic athletes. All four athletes had a negative mannitol challenge test, but two subjects had F_eNO above 20 ppb.

Athletes with signs of asthma

Three athletes with no previous diagnosis of asthma had AHR to mannitol (PD₁₅ 205, 320 and 335 mg mannitol, respectively); and all three also had elevated F_eNO (mean F_eNO 53.6 ppb). All three athletes reported breathlessness in relation to physical training, but did not report it as abnormal breathlessness and, likewise, they did not report other asthma-like symptoms. Comparing these three athletes with the non-asthmatic athletes revealed no significant differences with regard to age, BMI, competitive experience, FEV₁ %pred or FEV₁/FVC ratio.

Characteristics of non-asthmatic and asthmatic athletes

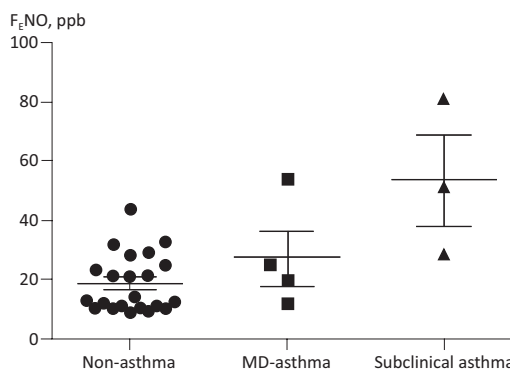
Asthmatic and non-asthmatic athletes did not differ with regard to age, BMI, prevalence of self-reported allergy, years of competitive experience, FEV₁ %pred or FEV₁/FVC ratio (Table 2). However, on average, both athletes with previously diagnosed asthma (n = 4) and asymptomatic subjects with signs of asthma (n = 3) had elevated levels of F_eNO (mean 27.7 ppb and 53.6 ppb, respectively) compared with the non-asthmatic athletes (mean 18.5 ppb; p < 0.001) (Figure 1). The level of F_eNO was not significantly correlated with years of competitive experience.

DISCUSSION

This study showed a high prevalence of individuals who met the criteria for asthma (24.1%) among Danish top-level canoe and kayak athletes, which may be related to the combination of hard physical training, exposure to inhalant irritants and/or allergens, and Danish climate conditions which feature a long autumn-winter season with lots of rain. Furthermore, and perhaps even more interestingly, the present study also revealed that classic signs of asthmatic airway inflammation are frequently found in athletes not reporting abnormal breathlessness or other asthma-like symptoms, and a diagnosis of asthma in elite athletes should therefore not primarily rely on reported respiratory symptoms. However, despite the inclusion of subjects previously diagnosed with asthma, we did not observe an increased prevalence of asthma compared with previous findings among elite athletes [1, 6].

In the present study, we used the mannitol challenge test for assessing airway reactivity. However, as this indirect challenge method has a high specificity, but a relatively low sensitivity [15, 18], it is likely not the optimal test for assessing airway reactivity in individuals already on controller medication for asthma [18]. This may well explain why four athletes with previously diag-

FIGURE 1



Fraction of exhaled nitric oxide (F_eNO) in elite canoe- and kayak athletes without asthma, with previously diagnosed asthma (MD-asthma), and new asthma (defined as elevated nitric oxide and airway hyperresponsiveness to mannitol), respectively.

nosed asthma had a negative bronchial challenge test. However, although it might have been an advantage for the purpose of the present study, we did not consider stopping controller therapy in the four athletes with known asthma, because they were all symptomatic on the currently prescribed dose of inhaled corticosteroids.

Previous studies have shown a poor correlation between asthma symptoms and post-exercise bronchoconstriction in elite athletes [4, 19]. The World Anti-Doping Agency (WADA) and the International Olympic Committee-Medical Commission therefore require the demonstration of airway hyperresponsiveness to confirm the diagnosis of asthma in international-level athletes reporting asthma-like symptoms [18, 19]. None of the elite athletes included in the present study on controller therapy for asthma, i.e. inhaled corticosteroids, had airway hyperresponsiveness to the indirect stimulus mannitol, but had on average elevated NO levels compared with the other included athletes with a negative challenge test, although two of the athletes had NO levels within the reference range, probably as a consequence of the treatment with inhaled corticosteroids. Some of these athletes already on inhaled corticosteroids may therefore benefit from stepping-up their asthma therapy. This would include increasing their daily dose of inhaled corticosteroid and/or adding a long-acting β_2 -agonist, not least in order to improve their performance in competition. Although stepping-up therapy in subjects with good clinical asthma control and no signs of airway hyperresponsiveness may seem controversial, there is nothing illegal in doing so according to the updated version of WADA's list of prohibited substances [19], as inhaled corticosteroids, salbutamol (albuterol) and salmeterol may be used by athletes without a Therapeutic Use Exemption [19]. In these cases, decisions regarding the level of therapy are therefore up to the athlete and the athlete's doctor, where the former is probably likely to choose the step-up option. However, it appears relevant to do further clinical work-up before deciding to increase the level of therapy, for instance by monitoring variability in FEV₁ or peak flow. Future studies will, hopefully, address the potential benefits as well as the risk-benefit relation of these treatment decisions.

The present study revealed that elite canoe and kayak athletes not reporting asthma-like, including exercise-induced, symptoms may have classic signs of asthmatic airway inflammation. This observation raises some important questions. Firstly, should elite canoe and kayak athletes routinely be offered screening for asthma? Secondly, should those elite athletes be considered to have asthma who report no asthma-like symptoms, but who are identified through screening as having both airway hyperresponsiveness to mannitol

and elevated expiratory NO-levels, which strongly suggests eosinophil airway inflammation? Thirdly, will it be justified to treat asymptomatic elite athletes with asthma medication, including inhaled corticosteroids, based solely on laboratory findings? And fourthly, will treatment with inhaled corticosteroids in these athletes improve their performance in competition? And, lastly, is eosinophil airway inflammation in these asymptomatic athletes a by-product of their years of intense endurance training? Based on the current knowledge and our personal opinion, the answer to the first three questions are likely to be yes; and further support for this answer is found in previously reported observations that treatment of asthma with inhaled corticosteroids reduces the annual decline in lung function in individuals with asthma [20, 21]. Hopefully, future studies of elite canoe and kayak athletes will provide us with definite answers, also with regard to last two questions.

CONCLUSION

Asthma with typical symptoms, including exercise-induced symptoms, is common in elite canoe and kayak athletes, but classic signs of asthmatic airway inflammation, including airway hyperresponsiveness, are also found in asymptomatic athletes.

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