

EXERCISE INDUCED BRONCHOCONSTRICTION

Are Former Athletes More Prone to Asthma?

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Objective. We have designed the present study to compare prevalent lifetime cases of diagnosed asthma or exercise-induced asthma, as well as current related respiratory symptoms, across two different levels of former athletes and non-athletes. **Methods.** Demographic, behavioral, and asthma history information, as well as current related respiratory symptoms, were obtained through a questionnaire from 627 subjects (290 former elite and 201 non-elite athletes that competed between 1969 and 2005, and 136 control subjects that had never been athletes). **Results.** Non-athletes presented a higher percentage of subjects reporting the existence of symptoms associated with exercise or vigorous activities. Former athletes who reported having practiced mostly in indoor facilities presented significant lower risk for asthma than outdoor athletes (Odds Ratio = 0.48, 95% CI = 0.25–0.94). Multiple regression analysis (where “B” refers to unstandardized coefficients) showed that former elite ($B = -0.85, p < .001$) and non-elite athletes ($B = -0.70, p < .001$) were less prone to be affected by asthma-related symptoms than non-athletes. Athletes with careers that lasted more than 20 years were more likely to possess asthma-related symptoms than the ones with shorter careers (3–7 years, $B = -0.47, p < .001$; 8–14 years, $B = -0.42, p < .01$; 15–20, $B = -0.32, p < .05$). **Conclusions.** Non-athletes seem to have a higher prevalence of respiratory symptoms. Among former athletes, career characteristics seem to play a crucial role, with special emphasis to its duration, where the most lengthy seem to be more associated with respiratory symptoms.

Keywords adults, exercise-induced asthma, exercise-induced bronchoconstriction, master athlete, respiratory disease

INTRODUCTION

It is known that athletes have frequent upper respiratory tract infections, and this may increase the susceptibility to develop asthma (1).

Respiratory symptoms such as recurrent breathlessness, cough, wheezing, chest tightness, and excessive mucous production are common in athletes and may be suggestive of asthma (2).

The term “exercise-induced asthma” (EIA) is used to describe acute lung airway narrowing occurring during and/or after physical activity. In 2008, the PRACTALL initiative, endorsed by the European Academy of Allergy and Clinical Immunology and the American Academy of Allergy, Asthma and Immunology, defined EIA as lower airway obstruction and symptoms of cough, wheezing, or dyspnea induced by exercise in patients with underlying asthma, but also usual in individuals without asthma (3).

Some patients with EIA only present symptoms with exercise, have no signs or symptoms of asthma at rest, and have a normal physical examination and spirometry (4). It is only with exercise that these patients have respiratory symptoms and a subsequent drop in pulmonary function; they have EIA with no evidence of underlying chronic asthma (4).

Despite most studies aiming to analyze EIA are performed among world class athletes, EIA is a condition that may be found in athletes at any level, from recreational to elite (4). The few studies that have attempted to investigate the prevalence of asthma in former athletes suggest that

changes in lung function and airway responsiveness may be at least partly reversible after cessation of long-term endurance training (5, 6).

However, to our knowledge, no studies exist analyzing the prevalence of asthma and current respiratory symptoms among former athletes, and to investigate the possible association with the athletic background (level and intensity of sport, career length, years since retirement, and typical facilities). This was the aim of our study.

MATERIALS AND METHODS

We identified former elite athletes who represented Portugal in selected sports at least once in the Olympic Games, World or European championships, or other international competitions; former non-elite athletes who competed in selected sports for at least three consecutive years in their adult life, but not representing Portugal; and control subjects randomly selected in the Portuguese population, matched for age, and who were never athletes. All subjects had to be at least 30 years old. Former athletes competed during 1969–2005, and at the time of the study have ended their career for at least 3 years. Sports federations provided and confirmed athlete’s sports history.

We first conducted telephone interviews with former athletes and controls in order to make the study known, describe our goals, and to extend a formal invitation to one of our laboratories for collection of biochemical measures (1378 subjects). After consent to participate (868 subjects), we mailed a questionnaire (preceded by a pilot study that attested the reliability) based on the World Health Organization STEPs approach (7).

The response rate was 78% for former elite athletes, 71% for former non-elite athletes, and 64% for non-athletes.

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Therefore, the study population comprised 341 men and 286 women, totaling 627 subjects (290 former elite athletes; 201 former non-elite athletes; and 136 non-athletes).

Questionnaire

The questionnaire included demographic (age, sex, and occupation), behavioral (smoking status), anthropometric (height and weight), sports career (type of sport, year of beginning and ending), and clinical history information. Regarding asthma and current respiratory symptoms, we used the following questions: a) Have you ever been diagnosed by a physician with asthma or exercise-induced asthma?; b) Are you currently under some medication for asthma treatment/control?; c) Currently, when you exercise or perform vigorous activities, you usually wheeze?; Currently, when you exercise or perform vigorous activities, you usually cough?; d) Currently, when you exercise or perform vigorous activities, do you usually have phlegm?; e) Currently, when you exercise or perform vigorous activities, you usually feel shortness of breath?; f) Currently, when you exercise or perform vigorous activities, do you usually feel a tightness in your chest?; g) Beyond asthma have you ever been diagnosed by a physician with another respiratory disease? If so, what disease?; h) Was any of your first degree blood relatives (parent or sibling) diagnosed with asthma?

To former athletes who were diagnosed with asthma, the following question was applied: "The diagnosis of asthma occurred before, during or after your sports career?"

We scored as positive for asthma any subject diagnosed with asthma, EIA, or currently on an asthma medication. Each symptom reported as currently usual when exercising or doing vigorous activities (that require hard-physical effort and cause large increases in breathing or heart rate) was considered as 1, and the symptoms score was obtained through their sum.

We asked subjects to self-measure height and weight, in order to provide current values. We requested height measurement to be performed by a second person, and instructed the participant to stand barefoot (also for weight measurement), leaning against a wall and looking forward. Through height (m) and weight (kg), we calculated the body mass index (BMI in kg/m^2).

Categorization

We grouped the athletes classifying the sports they have participated according to the Compendium of Physical Activities (8), based on the intensity of exercise performed between each sport, with their respective metabolic equivalent (MET) intensity levels. Sports were categorized according to the model proposed by Pate et al. (9) as moderate (3–6 METs; volleyball, gymnastics, archery, field events—throwing and jumping) and vigorous (> 6 METs; judo, canoeing/rowing, sprint running, middle- and long-distance running, triathlon, decathlon, swimming, basketball, handball, and soccer).

According to each sport typical practice facilities, we divided sports into indoor (gymnastics, judo, volleyball, basketball, swimming, and handball) and outdoor (field

events, archery, sprint running, canoeing/kayaking, triathlon, decathlon, middle- and long-distance running, and soccer). Although this is the most common distribution, we found discrepancies in the responses. For example, some of the former handball athletes stated their typical training as outdoor (in reference to the handball with 11 players). This was taken into account in the distribution of athletes by their categories, and whenever the discrepancy occurred, rather than the sport discipline, the typical training facility was considered.

Socio-economic/occupational groups had the following categories: government employee, non-government employee, self-employed, retired, unemployed-able to work, and unemployed-unable to work.

We have based the subject's smoking status on a detailed smoking history, and classified them into three categories: never, ex, or current smokers.

BMI was categorized as follows: normal weight (BMI $\leq 24.99 \text{ kg/m}^2$), overweight (BMI $25.00\text{--}29.99 \text{ kg/m}^2$), and obese (BMI $\geq 30.00 \text{ kg/m}^2$). Finally, we created categories according to the duration of the sports career (3 to 7 years; 8 to 14 years; 15 to 20 year; and more than 20 years), and years since retirement (less than 5 years; 5 to 10 years; 11 to 20 years; and more than 20 years).

Statistical Analysis

Using cross-tabulations with the Chi-square test and Anova, we examined differences in the demographic and behavioral characteristics between former elite, non-elite, and non-athletes, as well as differences in career between former elite and non-elite athletes. To assess differences across groups of former athletes and prevalence of asthma or EIA, we have also used the Chi-square test. We performed this same analysis to achieve differences between former athlete's total values (with former elite and non-elite athletes as one group only) and non-athletes. Odds ratios (OR) for the presence of asthma and their 95% confidence intervals (95% CI) for each of the categorized variables were analyzed using logistic regression. Through linear regression analysis (where "B" refers to unstandardized coefficients), we have determined the differences in the symptoms score under control of possible confounders. Both linear and logistic regression analysis were performed for each of the variables categorized into two blocks. The first contained age as a possible confounding factor and the second contained age, sex, BMI, family history of asthma, occupation, and smoking status (in the linear regression, lifetime diagnosis of other respiratory diseases and current treatments for asthma were also included as possible confounding factors). Significance was considered to be $p < .05$. All statistical analysis was performed with PASW Statistics 18 for Windows.

RESULTS

The descriptive background characteristics of all the study subjects are shown in Table 1. At the time of this study, there were no significant differences regarding sex and

TABLE 1.—Demographic and behavioral characteristics of the study subjects according to the level of sports participation.

	Former elite athletes (N = 290)	Former non-elite athletes (N = 201)	Non-athletes N = (136)	p
Sex				
Men (%)	51.7	61.2	50.0	0.060**
Women (%)	48.3	38.8	50.0	
Age, mean (SD)	47.7 (12.8)	48.3 (16.0)	50.8 (17.4)	0.133*
<40 years (%)	36.9	35.3	44.1	<0.001**
40–50 years (%)	28.3	42.8	17.6	
>50 years (%)	34.8	21.9	38.2	
BMI, mean (SD)	24.9 (3.1)	25.7 (3.6)	26.4 (4.2)	<0.001*
<25 (%)	46.2	43.8	35.3	0.001**
25–29.99 (%)	46.9	42.3	44.1	
≥30 (%)	6.9	13.9	20.6	
Smoking				
Never smokers	55.2	69.2	20.6	<0.001**
Ex-smokers	9.7	6.0	4.4	
Smokers	35.2	24.9	75.0	

Note: *P-value by ANOVA.

**P-value by Chi-Square tests or Pearson Chi-Square Asymp. (2-sided).

mean age of participants from main groups (former elite, non-elite, and non-athletes). However, former non-elite athletes accounted for a higher percentage (42.8) of subjects between 40 and 50 years old ($p < .001$). Former elite athletes (24.9 ± 3.1) had lower ($p < .001$) mean BMI score than non-athletes (26.4 ± 4.2), which also represented the higher percentage (20.6) of obese subjects ($\text{BMI} \geq 30$). In relation to smoking status, both groups of former athletes had a considerable ($p < .001$) lower percentage (35.2 among former elite athletes, and 24.9 among former non-elite athletes) of smokers, and a higher percentage (55.2 among former elite athletes, and 69.2 among former non-elite athletes) of never smokers than non-athletes (75% were smokers, and 20.6% had never been smokers).

Table 2 shows that, among former athletes, elite ones were clearly those who had a longer career (mean of 16.2 years $\pm$ 6.5). They also retired for fewer years (15.3 ± 11.6) than non-elite ones (19.7 ± 15.1). No significant differences were found among former athletes from

different intensities sports (vigorous and moderate), or across type of facilities typically used for practice (indoor and outdoor).

Among main groups, the analysis regarding prevalence cases of asthma and current medication (Table 3), did not reveal any significant differences. Likewise, we found no significant differences between former elite and non-elite athletes regarding typical symptoms of EIA. However, when this same analysis was performed between former athletes as a whole (former athlete's total) and non-athletes, it was found that non-athletes presented a higher percentage of subjects reporting the existence of symptoms associated with exercise or vigorous activities. Breathlessness ($p = .002$) and chest tightness ($p = .008$) were the symptoms with minor differences, while phlegm, persistent cough, and wheezing were the ones with higher differences ($p < .001$). Regarding the time period in which the former athletes were diagnosed with asthma, was possible to notice that former non-elite athletes had a higher

TABLE 2.—Career characteristics according to the level of sports participation.

	Former elite athletes	Former non-elite athletes	p
Sports intensity			
Vigorous (%)	41.7	58.3	0.435**
Moderate (%)	45.3	54.7	
Typical facilities			
Indoor (%)	66.2	71.1	0.248**
Outdoor (%)	33.8	28.9	
Years as athlete, mean (SD)	16.2 (6.5)	10.7 (5.7)	<0.001*
3–7 (%)	13.8	33.8	<0.001**
8–14 (%)	27.9	42.3	
15–20 (%)	31.7	16.4	
More than 20 (%)	26.6	7.5	
Years since career termination, mean (SD)	15.3 (11.6)	19.7 (15.1)	0.001*
<5 (%)	22.8	12.4	0.025**
5–10 (%)	21.7	23.9	
11–20 (%)	23.4	23.4	
>20 (%)	32.1	40.3	

Note: *P-value by t-test (2-tailed).

**P-value by Chi-Square tests or Pearson Chi-Square Asymp. (2-sided).

TABLE 3.—Lifetime prevalent cases (%) of asthma/EIA and respiratory symptoms.

	Former elite athletes	Former non-elite athletes	<i>p</i>	Former athletes total	Non-athletes	Former athletes vs. Non-athletes <i>p</i>
With Asthma	7.9 (23>)	7.5 (15)	0.849	7.7 (38)	11.8 (16)	0.139
Time of diagnosis						
Before career	34.8 (8)	66.7 (10)	0.049			
During career	34.8 (8)	20.0 (3)	0.326			
After career	30.4 (7)	13.3 (2)	0.226			
Under asthma medication	6.2 (18)	5.5 (11)	0.734			
Total symptoms score, mean (SD)	1.0 (1.0)	0.9 (0.8)	0.093*	0.9 (0.9)	1.7 (1.1)	<0.001*
Wheezing	14.1 (41)	11.4 (23)	0.383	13.0 (64)	31.6 (43)	<0.001
Persistent cough	12.8 (37)	10.4 (21)	0.435	11.8 (58)	27.9 (38)	<0.001
Phlegm	17.6 (51)	16.9 (34)	0.847	17.3 (85)	34.6 (47)	<0.001
Breathlessness	28.3 (82)	21.9 (44)	0.111	25.7 (126)	39.0 (53)	0.002
Chest tightness	26.2 (76)	23.9 (48)	0.560	25.3 (124)	36.8 (50)	0.008

Note: Except for total symptoms score, data are number of cases and percentages.

**P*-value by *t*-test (2-tailed); all the other values were obtained through Chi-Square tests or Pearson Chi-Square Asymp. (2-sided).

percentage (66.7) of subjects diagnosed before their sports career ($p = .049$). Among former elite athletes, only 34.8 % of the subjects were diagnosed with asthma before becoming athletes.

Table 4 presents the results of multivariate logistic regression analysis whereby, adjustments were made for age, and for age, sex, BMI, smoking status, and current treatments for asthma. Within the selected covariates, sex ($p < .05$) and family history of asthma ($p < .001$) were the only ones with statistical significance. Former athletes reporting a typical practice in indoor facilities presented

significant lower risk for asthma than outdoor ones (OR = 0.48, 95% CI, 0.25-0.94). However, after adjustments for age, BMI, smoking status, and current treatments for asthma, that significant risk difference vanished. No significant differences were found among main groups (former elite, non-elite, and non-athletes), different sports intensities, or among categories of time elapsed since the end of the career.

Regarding current symptoms associated with exercise or vigorous activities, even when adjusted for other possible confounding factors than age (age, sex, BMI,

TABLE 4.—Logistic regression analysis for asthma and linear regression analysis for respiratory symptoms score.

	Asthma			Symptoms		
	Age adjusted	Adjusted for age, BMI, sex, family history of asthma, occupation, and smoking	Age adjusted	R^2	Adjusted for age, BMI, sex, family history of asthma, occupation, smoking, other respiratory diseases, and current asthma medication	R^2
Athlete level						
Elite	0.69 (0.35/1.37)	0.89 (0.37/2.14)	−0.85 (−1.06/−0.63)***	0.100	−0.53 (−0.75/−0.31)***	0.213
Non-elite	0.63 (0.30/1.33)	0.90 (0.35/2.31)	−0.70 (−0.90/−0.50)***		−0.45 (−0.65/−0.24)***	
Non-athletes	Reference	Reference	Reference		Reference	
Sports intensity						
Vigorous	Reference	Reference	Reference	0.002	Reference	0.113
Moderate	1.20 (0.62/2.34)	0.85 (0.38/1.90)	0.07 (−0.10/0.24)		0.04 (−0.12/0.20)	
Typical facilities						
Indoor	0.48 (0.25/0.94)*	0.64 (0.29/1.40)	−0.10 (−0.28/0.08)	0.003	−0.11 (−0.28/0.07)	0.115
Outdoor	Reference	Reference	Reference		Reference	
Years as athlete						
3–7	0.65 (0.30/1.40)	0.64 (0.25/1.64)	−0.48 (−0.71/−0.24)***	0.038	−0.47 (−0.69/−0.24)***	0.144
8–14	0.62 (0.27/1.44)	0.95 (0.36/2.53)	−0.46 (−0.71/−0.21)***		−0.42 (−0.67/−0.18)**	
15–20	0.57 (0.23/1.42)	0.93 (0.33/2.66)	−0.28 (−0.54/−0.02)*		−0.32 (−0.58/−0.07)*	
More than 20	Reference	Reference	Reference		Reference	
Years since career termination						
<5	Reference	Reference	Reference	0.011	Reference	0.121
5–10	0.66 (0.23/1.92)	0.71 (0.21/2.38)	−0.32 (−0.60/−0.03)*		−0.30 (−0.57/−0.02)	
11–20	1.09 (0.38/3.12)	1.38 (0.37/5.19)	−0.31 (−0.69/0.06)		−0.17 (−0.53/0.20)	
>20	0.37 (0.07/2.02)	0.53 (0.06/4.51)	−0.15 (−0.41/0.11)		−0.13 (−0.38/0.12)	

Note: For the “dependent variables” on logistic regression, data is presented as OR (95% CI); for the “dependent variables” on linear regression, data are presented as non-standardized regression coefficient B for symptoms score and (95% CI); sum score with range 0–5; model fit presented as unadjusted R^2 .

* $p < .05$; ** $p < .01$; *** $p < .001$.

occupation, smoking status, current asthma medication, and family history of asthma), multiple regression analysis showed that former elite ($B = -0.85, p < .001$) and non-elite athletes ($B = -0.70, p < .001$) were less prone to be affected by asthma-related symptoms than non-athletes. Among the predictors selected for inclusion in the adjustment, family history of asthma ($p < .001$), smoking status ($p < .001$), and currently on asthma medication ($p < .01$) were the ones statistically significant. Between former athletes of different sports intensities, as well as between indoor/outdoor sports, we found no significant differences. We noticed that athletes who have had careers that lasted more than 20 years were most likely to possess asthma-related symptoms than the ones with shorter careers (3–7 years, $B = -0.47, p < .001$; 8–14 years, $B = -0.42, p < .01$; 15–20, $B = -0.32, p < .05$). Despite the fact that the widening of confidence intervals remains increasing as the years since retirement were higher, after adjustment for other possible confounding factors than age, the significance of differences within these categories vanished.

DISCUSSION

A consistent body of evidence has shown that elite athletes have an increased risk for asthma (3). Most studies focus on elite athletes due to the very high effort associated with their sporting careers. A few studies that have looked at non-elite athletes have not encompassed comparisons with athletes from other levels (10–12). This raises the question of whether all types of athletes (regardless of the differences in the respective careers) are at similar risk of developing asthma, or whether the elite are at higher risk. Furthermore, to our knowledge, only two studies have analyzed asthma on the post-career of these athletes (5, 6).

It is known that exercise is the most frequent trigger of bronchospasm in those who are known to be asthmatic, and 50 to 90% of all individuals with asthma have airways that are hyper-reactive to exercise (13). Furthermore, manifestation of related respiratory symptoms occurs in up to 90% of asthmatic patients, and is estimated to occur in >10% of the general population (13). It is possible that in subjects who are not known to be asthmatic, the disease may be overlooked (14).

We have analyzed both asthma and EIA as one, and found no significant differences regarding its prevalence between former elite, non-elite, or non-athletes. However, there may have been selection bias at the beginning of our study as subjects with sub-optimal ventilatory function as young adults may have been incapable of becoming elite athletes, thus, reducing the prevalence of later asthma subjects in this group. Furthermore, exercise may have several benefic effects on asthmatic subjects (e.g., a decrease in the intensity of wheezing attacks or an increase in the aerobic fitness) (15). Therefore, it is also plausible that, as in other studies (16), our 18 identified cases of asthma diagnosed before sports career may have selected sports activities because of their condition, which can also bias both the prevalence of asthma and later symptoms results.

Although some asthma studies have suggested associations with obesity (17–21) and occupation (6), we found no significant association between these factors and both asthma or symptoms. On the other hand, both asthma and respiratory symptoms were associated with family history of asthma. Moreover, although the smoking status was not significantly associated with the prevalence of asthma, it was associated with current symptoms. Effectively, smoke is one of the recognized factors influencing both the onset of acute respiratory symptoms and the progression of chronic bronchial inflammation (22). Likewise, the prominence of family history among asthma risk factors has long suggested a significant role for genetics (23). Available data regarding elite athletes suggest that asthma results not only from genetic predisposition but also from complex interactions between genetic and environmental factors (2). Furthermore, asthma has no clear pattern of inheritance and heritability estimates of asthma vary between 36% and 79% (2). Therefore, we believe that the revealed association between subjects who reported family history of asthma and their later symptoms, even when accounting for some environmental factors (e.g., typical training facility) can also be a relevant finding suggesting a strong role of genetics.

Asthma is a long-term disease that may initially manifest during childhood or adult life (24). As mentioned, while no significant differences were found regarding the time period when asthma had been diagnosed, almost twice the percentage of former non-elite athletes were diagnosed with the disease before their sports career. This may also contribute to the fact that EIA (those whose diagnosis was made during sporting career) does not seem to be a differentiating element between the prevalent cases of asthma among former and non-athletes. However, another highlight of the conclusions to be drawn from our study is that, among current symptoms, a significant difference exists between those who have and those who have not been athletes in the past, reinforcing the possibility of the disease being neglected or not properly diagnosed.

Despite having disappeared after adjustments, we also noticed a lower likelihood of asthma among subjects from indoor sports. The Summary of the International Olympic Committee's Consensus Conference (2) states that the outdoor air pollution may play a crucial interactive role in determining whether susceptible individuals develop asthma or not. Athletes inhale large amounts of allergens and irritants both outdoors and indoors. In countries such as Portugal with four distinct seasons, during winter athletes train outdoors in cold temperatures or indoors, where air quality may be poor. Although there are risks in both the training environments, during spring and summer, athletes who train outdoors are exposed to many pollen allergens (25). These, along with the probability that athletes who participate in colder environment sports have more asthma than those who participate in sports in warmer environments (26) may help to explain our results. Indeed, this is quite an ambiguous factor with respect to the risk of asthma. There are studies suggesting that, despite training indoor arenas around the year, athletes report more exercise-induced respiratory symptoms during indoor training than outdoor

training (25). Others suggest that the environment in which athletes regularly train, their age, and the duration of their training did not affect perception of their respiratory symptoms (11). Several factors may be behind these dissimilar results, however, it seems clear that, much increased ventilation during exercise, combined with exposure to cold air and to a mixture of allergens and irritating agents, seems to induce symptoms and airway inflammation in athletes (27). Furthermore, the occurrence of symptoms during former elite athlete's cold weather training appears to be the justification for the use of medication to improve performance (26). The use of inhaled asthma drugs, particularly inhaled β_2 -agonists, became increasingly widespread among elite athletes which is disconcerting (2, 3).

Our data show that duration of sports career seems to be related to both asthma and current respiratory symptoms risk, and athletes who have had shorter careers are suggested to have a lower risk. A study aiming to investigate the occurrence of and risk factors for increased bronchial responsiveness and asthma in elite athletes with summer events, and to compare their results with those of control subjects, concluded that the mean time from the beginning of active competition sports to the physician diagnosed asthma was 4 years in speed and power athletes, 7.3 years in long-distance runners, and 5.7 years in swimmers (28). Nevertheless, another study concluded that there were no differences in the proportion of athletes presenting current respiratory symptoms according to the number of years (mean: 8.8 years) they trained (11). The results of the first mentioned study are based on a descriptive analysis of the subject's characteristics. Since it was not the primary goal of their analysis, we have no more information, making it more difficult to make comparisons. Furthermore, the mean duration of career from the subjects of the second referred study is considerably lower than ours, also biasing a comparison. Nevertheless, in interpreting our results it is possible to suggest that EIA is not as likely to manifest early in a career. Naturally, this will increase the risk of association with longer careers. Identically, we were able to verify that current respiratory symptoms are also common among former athletes with longer careers. Once more, this leads us to wonder if some of these symptoms were already present in the course of their career, without them being diagnosed with asthma mostly due to a non-recognition or underreporting of exercise-induced respiratory symptoms, which may be considered as normal consequences of high intensity training by athletes (11). Considering that the elapsed time since career termination did not reveal a clear association with the asthmatic symptoms and prevalent cases of asthma, it may also suggest that the likelihood of a remission is little. In fact, the asthma remission is poorly understood. Variable remission rates have been reported (29–31). Nevertheless, in children with mild to moderate persistent asthma, a general decrease in asthma morbidity can be expected in adolescence, yet complete remission is infrequent (32), especially in adulthood (33).

Methodological issues must be addressed in our study. Questionnaires are useful tools when evaluating the

prevalence of respiratory symptoms in a population. However, they do not consider the varying levels of perception and/or tolerance to symptoms among individuals. Furthermore, another limitation associated with using questionnaires is their validity and reliability. Therefore, a complete history and physical examination should be performed to make results as ours more reliable.

CONCLUSION

In summary, although the lifetime prevalence of asthma does not seem to be higher among former athletes than non-athletes. However, asthma symptoms appear to be more prevalent among non-athletes than former athletes. Furthermore, we suggest that athletes with a shorter career are less likely to experience respiratory symptoms.

DECLARATION OF INTEREST

There are no potential conflicts to declare.

REFERENCES

1. Langdeau JB, Boulet LP. Prevalence and mechanisms of development of asthma and airway hyperresponsiveness in athletes. *Sports Med* 2001; 31 (8):601–616.
2. Fitch KD, Sue-Chu M, Anderson SD, Boulet LP, Hancox RJ, McKenzie DC, Backer V, Rundell KW, Alonso JM, Kippelen P, Cummiskey JM, Garnier A, Ljungqvist A (2008) Asthma and the elite athlete: Summary of the International Olympic Committee's Consensus Conference, Lausanne, Switzerland, January 22–24, 2008. *J Allergy Clin Immun* 122(2):254–260.
3. Schwartz LB, Delgado L, Craig T, Bonini S, Carlsen KH, Casale TB, Del Giacco S, Drobnic F, van Wijk RG, Ferrer M, Haahtela T, Henderson WR, Israel E, Lötval J, Moreira A, Papadopoulos NG, Randolph CC, Romano A, Weiler JM. Exercise-induced hypersensitivity syndromes in recreational and competitive athletes: A PRACTALL consensus report (what the general practitioner should know about sports and allergy). *Allergy* 2008; 63(8):953–961.
4. Storms WW. Review of exercise-induced asthma. *Med Sci Sports Exer* 2003; 35(9):1464–1470.
5. Helenius I, Ryttilä P, Sarna S, Lumme A, Helenius M, Remes V, Haahtela T. Effect of continuing or finishing high-level sports on airway inflammation, bronchial hyperresponsiveness, and asthma: A 5-year prospective follow-up study of 42 highly trained swimmers. *J Allergy Clin Immun* 2002; 109(6):962–968.
6. Kujala UM, Sarna S, Kaprio J, Koskenvuo M. Asthma and other pulmonary diseases in former elite athletes. *Thorax* 1996; 51(3):288–292.
7. Bonita R, De Counter M, Dwyer T, Jamrozi K, Winkelmann R. Surveillance of Risk Factors for Noncommunicable Disease: The WHO STEPwise Approach. Geneva: World Health Organization, 2001.
8. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. 2011 Compendium of physical activities: A second update of codes and MET values. *Med Sci Sports Exer* 2011; 43(8):1575–1581.
9. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 1995; 273(5):402–407.
10. Robson-Ansley P, Howatson G, Tallent J, Mitcheson K, Walshe I, Toms C, DU Toit G, Smith M, Ansley L. Prevalence of allergy and upper respiratory tract symptoms in runners of the London marathon. *Med Sci Sports Exer* 2012; 44(6):999–1004.

11. Turcotte H, Langdeau JB, Thibault G, Boulet LP. Prevalence of respiratory symptoms in an athlete population. *Respir Med* 2003; 97 (8):955–963.
12. Parsons JP, Kaeding C, Phillips G, Jarjoura D, Wadley G, Mastronarde JG. Prevalence of exercise-induced bronchospasm in a cohort of varsity college athletes. *Med Sci Sports Exer* 2007; 39(9):1487–1492.
13. Parsons JP, Mastronarde JG. Exercise-induced bronchoconstriction in athletes. *Chest* 2005; 128(6):3966–3974.
14. Haahtela T, Malmberg P, Moreira A. Mechanisms of asthma in Olympic athletes - practical implications. *Allergy* 2008; 63(6):685–694.
15. Lucas SR, Platts-Mills TA. Physical activity and exercise in asthma: Relevance to etiology and treatment. *J Allergy Clin Immunol* 2005; 115 (5):928–934.
16. Goodman M, Hays S. Asthma and swimming: A meta-analysis. *J Asthma* 2008; 45(8):639–647.
17. Biring MS, Lewis MI, Liu JT, Mohsenifar Z. Pulmonary physiologic changes of morbid obesity. *Am J Med Sci* 1999; 318(5):293–297.
18. Ricciardolo FLM. Mechanisms of citric acid-induced bronchoconstriction. *Am J Med* 2001; 111:18–24.
19. Schachter LM, Salome CM, Peat JK, Woolcock AJ. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. *Thorax* 2001; 56(1):4–8.
20. Tantisira KG, Weiss ST. Complex interactions in complex traits: Obesity and asthma. *Thorax* 2001; 56:64–73.
21. Visser M, Bouter LM, McQuillan GM, Wener MH, Harris TB. Elevated C-reactive protein levels in overweight and obese adults. *JAMA-J Am Med Assoc* 1999; 282(22):2131–2135.
22. Bonini S, Bonini M, Bousquet J, Brusasco V, Canonica GW, Carlsen KH, Corbetta L, Cummiskey J, Delgado L, Del Giacco SR, Haahtela T, Jaeger S, Moretti C, Palange P, Passalacqua G, Passali D, Pedersen BK, Popov T, Rasi G, Ventura MT, Vignola AM. Rhinitis and asthma in athletes: An ARIA document in collaboration with GA2LEN. *Allergy* 2006; 61(6):681–692.
23. London SJ. Gene-air pollution interactions in asthma. *Proc Am Thorac Soc* 2007; 4(3):217–220.
24. Xuan W, Marks GB, Toelle BG, Belousova E, Peat JK, Berry G, Woolcock AJ. Risk factors for onset and remission of atopy, wheeze, and airway hyperresponsiveness. *Thorax* 2002; 57(2):104–109.
25. Tikkanen HO, Helenius I. Asthma in Runners. *Brit Med J* 1994; 309 (6961):1087.
26. Weiler JM, Ryan EJ. Asthma in United States Olympic athletes who participated in the 1998 Olympic Winter Games. *J Allergy Clin Immunol* 2000; 106(2):267–271.
27. Helenius I, Lumme A, Haahtela T. Asthma, airway inflammation and treatment in elite athletes. *Sports Med* 2005; 35(7):565–574.
28. Helenius IJ, Tikkanen HO, Sarna S, Haahtela T. Asthma and increased bronchial responsiveness in elite athletes: Atopy and sport event as risk factors. *J Allergy Clin Immunol* 1998; 101 (5):646–652.
29. Limb SL, Brown KC, Wood RA, Wise RA, Eggleston PA, Tonascia J, Hamilton RG, Adkinson NF Jr. Adult asthma severity in individuals with a history of childhood asthma. *J Allergy Clin Immunol* 2005; 115(1): 61–66.
30. Phelan PD, Robertson CF, The Melbourne OA. Asthma Study: 1964–1999. *J Allergy Clin Immunol* 2002; 109(2):189–194.
31. Sears MR, Greene JM, Willan AR, Wiecek EM, Taylor DR, Flannery EM, Cowan JO, Herbison GP, Silva PA, Poulton R. A longitudinal, population-based, cohort study of childhood asthma followed to adulthood. *New Engl J Med* 2003; 349(15):1414–1422.
32. Covar RA, Strunk R, Zeiger RS, Wilson LA, Liu AH, Weiss S, Tonascia J, Spahn JD, Szeffler SJ; Childhood Asthma Management Program Research Group. Predictors of remitting, periodic, and persistent childhood asthma. *J Allergy Clin Immunol* 2010; 125(2):359–366.
33. Bronnimann S, Burrows BA. Prospective-study of the natural-history of asthma - remission and relapse rates. *Chest* 1986; 90 (4):480–484.