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Managing respiratory problems in athletes

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ABSTRACT – Respiratory problems are common in athletes of all abilities and can significantly impact upon their health and performance. In this article, we provide an overview of respiratory physiology in athletes. We also discuss the assessment and management of common clinical respiratory conditions as they pertain to athletes, including airways disease, respiratory tract infection and pneumothorax. We focus on providing a pragmatic approach and highlight important caveats for the physician treating respiratory conditions in this highly specific population.

KEY WORDS: asthma, athlete, cough, dyspnoea, exercise

Introduction

Respiratory problems are common in athletes of all abilities and, although it is recognised that regular physical activity promotes health and well-being, there is legitimate concern that frequent, repeated periods of high ventilation in certain environmental conditions (eg indoor swimming) might be detrimental to an individual's respiratory health.[1]

When athletes do present with respiratory symptoms, it is not uncommon for them to present to the general physician in either the setting of primary care (eg chronic cough), the acute medical take (eg chest pain) or via referral to a non-respiratory specialist (eg referred to cardiology with dyspnoea). Indeed, even in specialist respiratory medicine training, there is no component within the programme dedicated to provide expertise in this area. Therefore, a basic understanding of the key physiological and pathological respiratory conditions as they pertain to athletes is important to ensure that optimum care is delivered to this population.

Overview of respiratory physiology in athletes

An appreciation of differences in respiratory physiology between athletically trained individuals and non-athletic individuals is important to enable meaningful comparison of any physiological measures obtained. It is often expected that athletes will have supra-normal resting lung physiology values. However, studies reveal that lung volumes generally reflect genetic influences and body-size characteristics of an individual. Indeed, there is limited evidence to suggest that exercise training alters the structural parameters of the respiratory system (Table 1). However, lung volume is related to aerobic capacity; therefore, in a group of athletes for whom aerobic capacity is an important component of success, average lung volumes will tend to be higher than in the general population.

In healthy individuals, the demands placed on the respiratory system during exercise do not stress the limits of capacity within the system. Indeed, Dempsey and colleagues[2] described how the respiratory system adapts during exercise to maintain performance and minimise airway resistance, despite significant increases in ventilation. This process involves synchronous sequences of activation and deactivation of respiratory skeletal muscles and bronchial smooth muscle to facilitate the increase in tidal volume and optimise elastic work performed by the respiratory muscles.

A proportion of athletes demonstrate oxygen desaturation on exercise. This condition, termed 'exercise-induced arterial hypoxaemia' (EIAH), is defined as a reduction in the blood oxygen level (ie oxygen saturation (SaO_2) ≤95%, or 3–4% fall from rest) during exercise. To date, there have been no studies of EIAH with

Table 1. Principal physiological adaptations to athletic training

System	Physiological measure	Exercise adaptation
Cardiac	Cardiac output	↑
	SV max	↑
	Heart rate max	None
	Resting heart rate	↓
	Aerobic capacity (VO_2max)	↑
Blood	Hb	↑
	Plasma volume	↑
Muscle	Mitochondrial density	↑
	Oxidative enzyme activity	↑
	Capillary density	↑
Respiratory	FVC	None
	FEV_1	None
	PEFR	None
	Tidal volume	None
	Peak exercise minute ventilation	↑
	Ventilatory efficiency	↑

FEV_1 = forced expiratory volume in 1 sec; FVC = forced vital capacity; Hb = haemoglobin; PEFR = peak expiratory flow rate; SV = stroke volume.

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sufficiently large sample sizes to enable the appraisal of the true prevalence of EIAH. However, a recent study found a prevalence of 35% in a cohort of moderately fit athletes.[3] Several mechanisms have been proposed to explain the phenomenon of EIAH, including inadequate ventilation, V/Q mismatch, diffusion limitation and impact of right to left shunts.[4] Although EIAH might impact upon athletic performance, it does not have clinical implications for treatment in a healthy asymptomatic athlete.

Assessing respiratory symptoms in athletes

Respiratory symptoms are common in athletes of all abilities, with primary care physicians in the UK reporting that they encounter the presentation of an amateur athlete with dyspnoea at a frequency of approximately one case per month.[5] Moreover, in a questionnaire study of 700 athletes, nearly a quarter reported the presence of regular, troublesome respiratory symptoms.[6]

The most frequently reported symptoms included breathlessness, phlegm production and wheeze.[6] Cough is also commonly reported[7] and up to a quarter of athletes reported cough regularly following exercise.[6] Exercise-associated cough is particularly prevalent in swimmers and winter sports athletes, and occurs more frequently during winter training.[7] It is also the most commonly reported symptom in athletes subsequently found to have airways disease (see below).[6,8]

A key problem for the physician encountering an athlete with respiratory symptoms is differentiating between those indicating underlying cardiorespiratory pathology from symptoms or 'sensations' that fall within a spectrum of what could be considered 'physiologically normal' or appropriate in the setting of intense exercise. In this respect, Turcotte and colleagues[6] found that respiratory symptoms in athletes are frequently non-specific and often described with nociceptive terminology; for example, 'I feel that my breathing is rapid' or 'I feel that I am breathing more'. This might explain, at least in part, the poor relation between the presence of 'asthma-type' symptoms and objective evidence of airways disease in athletes.[8,9] Indeed, it is important for physicians to recognise the poor predictive value of symptoms to avoid misdiagnosing athletes with airways disease based upon an appraisal of clinical features alone (see discussion below).

Respiratory conditions in athletes

Athletes can present with any of the commonly encountered acute or chronic respiratory conditions and, in general, approach to management should proceed as with the non-athletic individual. However, certain conditions are more commonly encountered in this population and, in the following section, we focus on these specific conditions and highlight management considerations.

Airways disease

Background

The most frequently encountered chronic respiratory condition in athletes is airways disease. However, the terminology used to describe airways disease in athletes is not straightforward. The term 'exercise-induced bronchoconstriction' (EIB) is used to describe a transient and reversible narrowing of the airways that occurs in association with exercise. It is often used interchangeably with exercise-induced asthma (EIA) however, EIB is favoured given that exercise triggers bronchoconstriction but does not induce the clinical syndrome of asthma.[10]

Studies consistently demonstrate a higher prevalence of EIB in athletes (up to 50–70% in some reviews) than in the general population.[11,12] The prevalence of EIB appears to be particularly high in swimmers and cold weather endurance athletes, although it is not infrequently encountered in amateur-level athletes.[12]

An approach to the assessment and management of airways disease in athletes is described in Fig 1 and Table 2.

The differential diagnosis for EIB in athletes is broad and includes anaemia, deconditioning and other respiratory and cardiac conditions (see reference 10 for a detailed discussion). An important differential or mimic of EIB is exercise-induced laryngeal obstruction (EILO), in which clinical features of dyspnoea and wheeze are generated from a transient obstruction of the upper airways during exercise (Table 3).[13]

Bronchial provocation challenge is often necessary to establish definitive evidence of variable airflow obstruction (ie to demonstrate airway narrowing in response to a provocative substance, such as exercise). Specifically, an athlete performs serial spirometry tests before and following a challenge; typically looking for a 10% fall in forced expiratory volume (FEV_1) from baseline values. The International Olympic Committee favour provocation challenge test with cold, dry gas, termed 'eucapnic voluntary hyperpnoea' (EVH).[14] However, an alternative test includes the Mannitol bronchial challenge. Direct nasendoscopy during exercise might be necessary to rule out the presence of EILO.[13]

Treatment

Both pharmacological and non-pharmacological interventions should be considered when treating airways disease in athletes (Fig 1). Performing a high-intensity, interval warm-up (ie bursts of high-intensity exercise interspersed with periods of low-intensity exercise) takes advantage of a phenomenon termed the 'refractory period' (Table 2) and should be encouraged. Dietary interventions and strategies to humidify inspired air (eg face muffle) can also prove beneficial.

An inhaled short-acting beta-2 agonist administered 15 min before exercise is usually effective in negating EIB and forms the mainstay of pharmacological treatment.[11] Further treatment should be guided by the frequency of requirement of beta-2 agonist therapy and the presence of additional symptoms. It has been recommended that an athlete who has asthma symptoms outside the setting of exercise or who is frequently using beta-2 agonist medication (ie more than three times per week) should be treated with anti-inflammatory agent (eg a regular inhaled corticosteroid).

General physicians might encounter athletes with an acute exacerbation of asthma on the medical take. In this situation, it

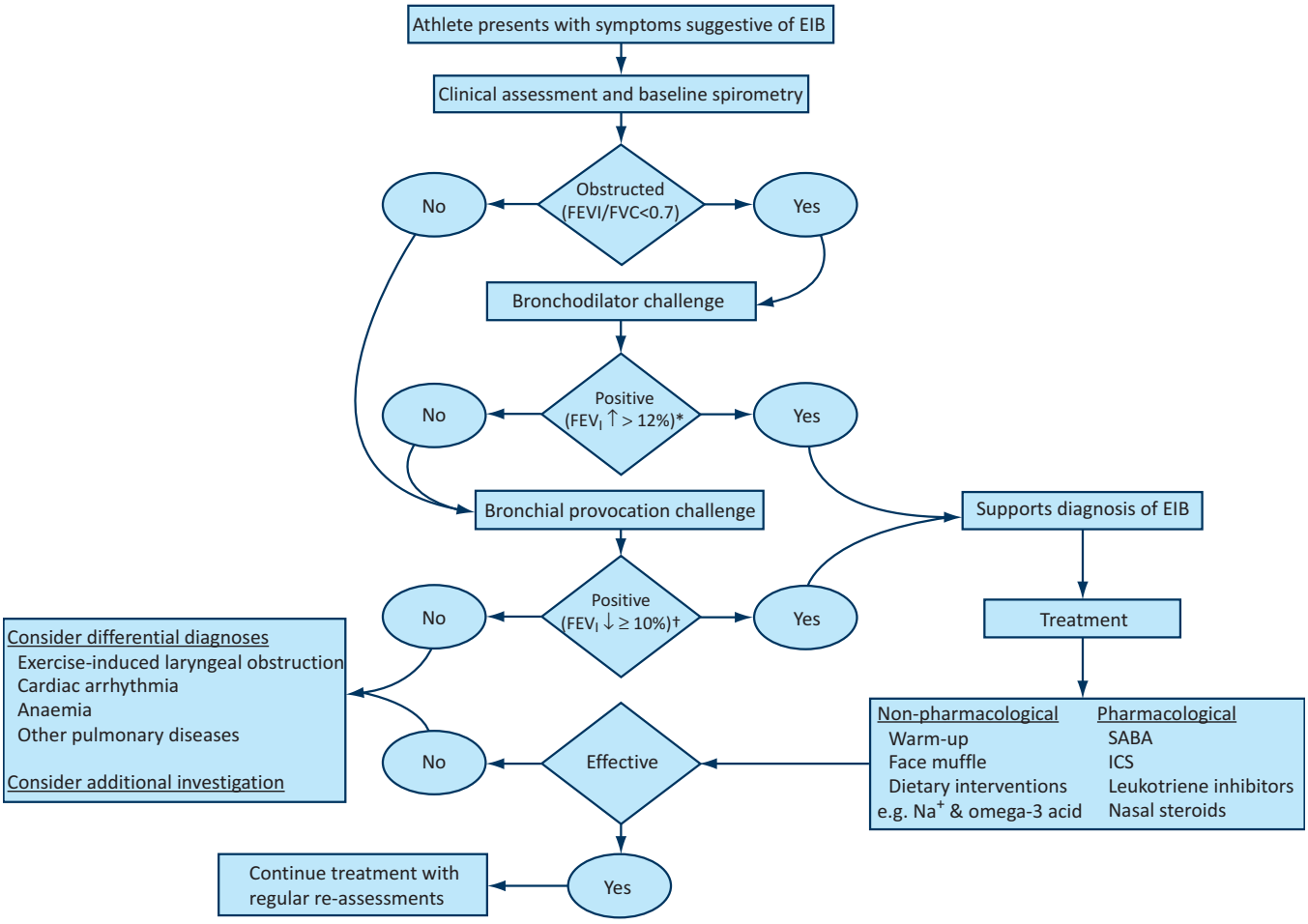

Fig 1. Algorithm for the assessment and treatment of an athlete with suspected airways disease. *FEV$_1$>12% from baseline value in response to inhaled beta-2 agonist; †positive if FEV$_1$ falls by >10% from baseline value (check guidelines for more detail). EIB = exercise-induced bronchoconstriction; FEV$_1$= forced expiratory volume in 1 sec; FVC = forced vital capacity; ICS = inhaled corticosteroid; SABA = short-acting beta-2 agonist.

is important to treat athletes as per guideline recommendations and not to withhold treatment for fear of anti-doping restrictions. As discussed below, emergency treatment can be sanctioned retrospectively providing sufficient supporting clinical evidence for its use is provided.

Respiratory tract infection

Upper respiratory tract infection (URTI) is the most commonly reported acute illness in athletes and is widely reported to relate to periods of heavy training and prolonged exercise bouts. This association has been attributed to a suppression of immune system function with exercise. However, there is little evidence to support a temporal relation between altered immune response following exercise and incidence of URTI.[15] Moreover, infective pathogens are infrequently identified in nasopharyngeal and throat swabs taken from athletes reporting URTI.[16] Therefore, other non-infectious causes of URT symptoms should be considered, particularly in athletes with recurrent symptoms.

URTI symptoms in athletes should be treated as in the non-athletic individual with antipyretic and analgesic agents. Decongestants agents can also be used topically, but are often prohibited in oral format (eg pseudoephedrine-containing agents).

Occasionally, athletes might present with lower respiratory tract infection. There is no evidence to suggest that assessment and management should differ from standard recommendations. However, appropriate consideration should be given to covering bacterial pathogens deemed more common in young individuals (eg *Mycoplasma pneumoniae*) and the possibility of serious bacterial pathogens reported in individuals living in training environments (eg Panton-Valentine leukocidin (PVL)-associated *Staphylococcus aureus*).

Allergy and rhinitis

Current research has led to the development of the 'non-infectious' hypothesis for URT symptoms in athletes. It is likely that

Table 2. A clinical approach to airways disease in athletes

Assessment of EIB

History and examination

- Symptoms of EIB include dyspnoea, chest tightness, wheeze and/or cough. These symptoms classically occur following a bout of high-intensity exercise (eg fast jogging) that is sustained for longer than a few minutes.
- The key differential diagnoses (eg cardiac dysfunction, anaemia or physical deconditioning) typically cause symptoms that are maximal during exercise and improve with exercise cessation.
- Symptoms typically remit spontaneously within 30 min and approximately half of athletes display a refractory period during which respiratory symptoms do not recur with further exercise challenge.
- Clinical examination usually provides little additional information to secure or refute a diagnosis of EIB; however, it is important to rule out other pathology (eg cardiac valvular disease).

Investigation

- A diagnosis of EIB might be strongly suspected by an appropriate history; however, exercise-related respiratory symptoms in athletes have poor diagnostic value for diagnosis of EIB when compared with objective testing.[26] Therefore, secure diagnosis depends on confirmatory investigation (Fig 1).
- A diagnostic trial of therapy (eg with a short-acting beta-2 agonist) without confirmatory objective testing is not recommended, given the poor diagnostic value of symptoms; an athlete might not respond to first-line therapies and there might be overlap between EIB and other causes of exercise-related dyspnea, for example exercise-induced laryngeal obstruction.

EIB = exercise-induced bronchoconstriction.

many symptoms reported post-exercise, including itchy and running nose, sneezing and ocular symptoms, are more likely to be allergic than infectious in origin.

The prevalence of atopy (approximately 40%) in trained athletes is higher than nonathletic controls[17] and it has recently been reported that allergy questionnaires are predictive of URT symptoms in marathon runners.[17] In addition, topical anti-inflammatory nasal spray has been shown to significantly reduce self-reported episodes of URT symptoms in runners following an ultra-marathon.[18] However, only a small proportion of athletes with self-reported allergies undergo specific clinical allergy tests to confirm the diagnosis[19] or optimally manage symptoms.[17]

Therapy for allergic rhinitis in elite athletes should follow recommended guidelines, with consideration for allergen avoidance, regular intranasal corticosteroids and second-generation non-sedating anti-histamines (Fig 2).[19]

Pneumothorax

Young, tall individuals are susceptible to the development of primary spontaneous pneumothorax and therefore it is not unsurprising for physicians to encounter athletes with pneumothorax. Furthermore, certain contact athletic activities (eg soccer or ice-hockey) have been associated with the direct development of pneumothorax.[20]

In case series evaluating pneumothorax in athletes, it is noteworthy that athletes might not present with classic clinical symptoms. Indeed, there are reports of athletes presenting with atypical chest pain attributed to injury and deconditioned status.[20] As such, it is important for the physician assessing an athlete to

Table 3. Managing respiratory problems in athletes: key points

Respiratory condition	Key considerations			Refs
	Evaluation	Management	Important to know	
Airways disease	Symptoms typically occur maximally on exercise cessation Symptoms have poor predictive value for diagnosis; therefore, confirm with objective testing (Fig 1)	Consider both pharmacological (eg beta-2 agonist 15 min before exercise) and non-pharmacological management (eg warm up and face muffle in cold weather)	Secure diagnosis is dependent on objective testing Consider anti-doping regulations	10,11
Exercise-induced laryngeal obstruction	Can mimic EIB by causing wheeze and dyspnoea Consider referral for continuous nasendoscopy during exercise	Breathing control techniques and/or physiotherapy referral	Can mimic EIB and lead to inappropriate use of asthma treatment	13
Respiratory tract infection	Consider whether likely to be infective or allergic aetiology	If bacterial community-acquired pneumonia, consider appropriate antibiotic cover	Athletes can often continue to train if symptoms confined to 'above neck'	21
Allergy and rhinitis	Atopy is common in athletes	See Fig 2	Can present as 'recurrent' URTI	19
Pneumothorax	Symptoms might be atypical; therefore have low threshold for CXR	Should proceed as per standard guideline recommendations	Consider surgical intervention and return-to-play criteria	20
Exercise-induced pulmonary oedema	Most commonly encountered in high-intensity immersion sports	Supportive initially; control of hypertension and avoidance of excessive hydration	Requires referral to cardiologist and/or sports specialist	22
Exercise-induced anaphylaxis	Athlete might present with atypical symptoms and/or collapse	Consider food trigger and refer to allergy specialist	Requires referral to allergy specialist	24

CXR = chest radiograph; EIB = exercise-induced bronchoconstriction; URTI = upper respiratory tract infection.

have a low threshold for considering this diagnosis and arranging appropriate investigation.[20,21]

Management thereafter should proceed in line with standard guidelines; however, it might be appropriate to consider additional surgical intervention in scenarios where it is felt that an athlete's sport was causally implicated.

Exercise-induced pulmonary oedema

Exercise-induced pulmonary oedema is most commonly reported in divers and swimmers, although it is occasionally reported in association with non-immersion sports (eg in marathon runners).[22] A recent questionnaire evaluation indicated a prevalence of approximately 1–2% in triathletes.[23]

The phenomenon has been reported to be temporally associated with factors detrimental to cardiac loading, including cold-water exposure, wearing a wetsuit and excessive hydration before swimming. Pre-existing hypertension is also likely to be a relevant risk factor.[23]

The most commonly reported symptoms include dyspnoea, cough and frothy haemoptysis. Swimming-induced pulmonary oedema usually resolves with supportive treatment, including removal of cold clothing and supplemental oxygen. Athletes usually exhibit rapid spontaneous recovery and do not require diuretics. Athletes should subsequently be referred to a specialist cardiologist and/or sports medicine physician.

Exercise-induced anaphylaxis

Exercise-induced anaphylaxis is a rare syndrome previously described in high-performance athletes and in those only undertaking very occasional exercise. It often occurs in association with the ingestion of a food allergen around the time of exercise, when it is referred to as food-dependent exercise-induced anaphylaxis (FDEIA).[24]

Several hypotheses have been proposed to explain the pathophysiology of FDEIA, including alterations in plasma osmolality and pH, tissue enzyme activity and gastrointestinal permeability.[24] More recently, it has been suggested that, at the onset of exercise, the redistribution of blood from the gut, which has specific mast cells, transports recently ingested allergens to areas of phenotypically different mast cells, where a transient loss of tolerance or an intensification of low-grade allergy manifests as anaphylaxis.[24] Athletes with suspected exercise-induced anaphylaxis should be assessed by an allergy specialist and managed as per standard anaphylaxis guidelines, with appropriate consideration for avoidance of food triggers.[24]

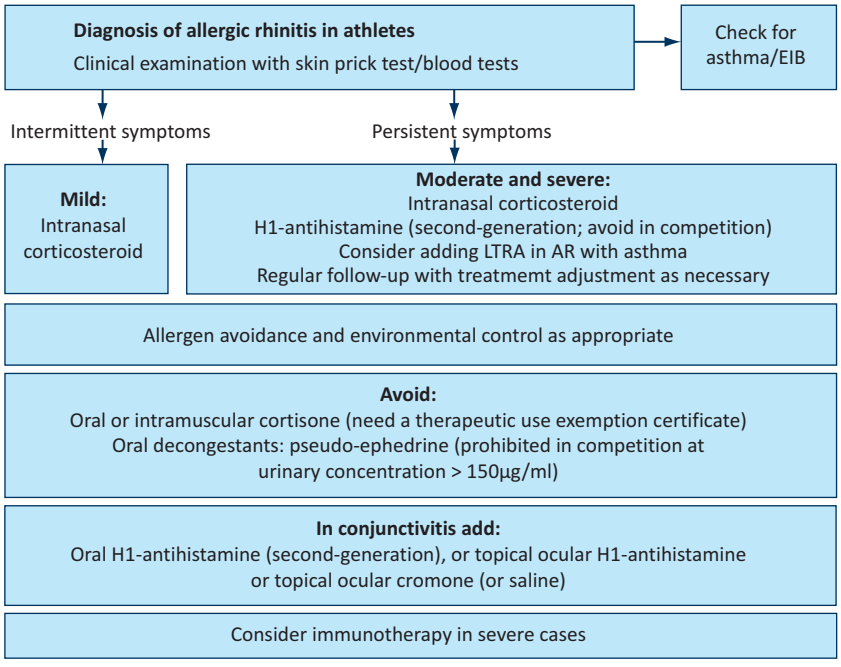

Fig 2. Approach to management of allergic rhinitis in competitive athletes. Adapted with permission.[19] AR = allergic rhinitis; EIB = exercise-induced bronchoconstriction; LTRA = leukotriene receptor antagonist.

Specific considerations when treating athletes

'Return to play'

A unique and important aspect in the management of athletes is deciding when it is safe and appropriate for an athlete to 'return to play' following treatment. It is essential that this process addresses the safety and functional capabilities of the athlete, the functional requirements of their sport, and legal or regulatory requirements.

Unfortunately, there are few clear guidelines addressing 'return to play' criteria in respect of respiratory disease.[21] However, it is clear that decisions regarding 'return to play' should be made in cooperation with the athlete's physiotherapist and/or team doctor (as applicable). It is also generally accepted that an athlete with symptoms of infection that are present 'above the neck' only (ie as found in URTI (eg sore throat)) can continue training uninterrupted.[20] However, it is also advised that if infective respiratory symptoms are accompanied by systemic symptoms (eg myalgia and fever), then an athlete should abstain from further exercise until their symptoms resolve. Under these circumstances, it is important that athletes are advised that short periods of rest (ie 4–5 days) will significantly improve their recovery and have a negligible impact on athletic conditioning.[21]

There is no clear evidence of when an athlete can 'return to play' following treatment for community-acquired pneumonia. Series evaluating symptom resolution suggest that up to a month is necessary in some individuals and thus, 'return to play' should be appraised on an individual basis.

In the case of pneumothorax, it has been recommended that an athlete can resume training immediately following radiological resolution.[20,21] However, it is important that athletes are appropriately counselled regarding the inherent risk of recurrence and other standard precautions.[25]

Anti-doping and/or consideration of prohibited substances

Physicians should be aware that several medications used in the treatment of respiratory disease are prohibited for use by competitive athletes. The list of prohibited substances is updated on an annual basis by the World Anti-Doping Agency and therefore it is advisable to access www.globaldro.com to check the prohibited status of any UK-licensed medication before prescribing to an athlete. Physicians might also want to consult with the relevant national anti-doping agency for specific advice (UK Anti-Doping general enquiries tel: 0207 766 7350).

It is the responsibility of the athlete to ensure that any medication taken is not prohibited within their sport. However, at the same time, physicians should be well informed and consider that alternative effective medications might be permitted and thus could be preferentially selected. Ultimately, physicians should proceed to manage patients according to their usual 'best practice', while diligently recording clinical detail in support of their treatment choice. In circumstances where permitted alternatives do not exist or are unsuitable, athletes can apply for a therapeutic use exemption (TUE) to cover their use of a prohibited substance.

Conclusions

In most cases, the respiratory system is engineered to meet the demands of even the most intense exercise. Respiratory pathologies often present with non-specific symptoms that can make initial diagnosis based solely on history and physical examination difficult and unreliable. Therefore, objective testing is often required and strongly recommended.

In general, the management of respiratory conditions in athletes should proceed as in the non-athletic population, but with important caveats (Table 3). In addition, understanding medication eligibility considerations and 'return to play' criteria for elite athletes is crucial. Improved overall awareness of the key respiratory conditions is important to ensure physicians maintain the respiratory health and performance of this unique population.

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Dr Les Ansley provides exercise-induced asthma testing for athletes using eucapnic voluntary hyperpnoea.

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