BTS clinical statement for the assessment and management of respiratory problems in athletic individuals

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INTRODUCTION

This British Thoracic Society (BTS) Clinical Statement addresses the diagnosis, evaluation and management of respiratory problems in athletic individuals. The overall recommendations issued in this document are built on a synthesis of the best available published evidence, where available and appropriate, but are largely based on expert opinion, with emphasis on providing readers with pragmatic clinical advice, when faced with respiratory problems in exercising individuals.

Participation in vigorous exercise or sport plays an important role in many people's lifestyle and is associated with a broad range of benefits, including for cardiovascular, metabolic and mental health. For some individuals, however, the ability to participate in and enjoy sporting activities may be curtailed by the presence of respiratory symptoms. Indeed, it is estimated that at least one in four individuals report troublesome exercise-related respiratory issues, such as breathlessness, cough and/or wheeze.[1] Moreover, in competitive athletes, asthma is the most prevalent medical condition and encountered in approximately a quarter of those partaking in endurance sport.[2 3]

Although athletic individuals can develop any cardiorespiratory illness and thus general clinical guideline documents are broadly applicable, studies over the past three decades have highlighted issues that are particularly relevant when assessing respiratory problems in athletic individuals or in certain sporting scenarios. For example, in the sports medicine world, it is now widely accepted that a clinical-based diagnosis of exercise-induced bronchoconstriction (EIB) in athletic individuals is often inaccurate and that symptoms of EIB poorly relate to objective test findings, such as from bronchoprovocation testing.[4 5] This may be explained by the presence of 'sport-specific' differential diagnoses, including highly prevalent conditions, such as exercise-induced laryngeal obstruction (EILO) and breathing pattern disorder (BPD). This highlights the need for a modified approach to ensure a robust and accurate diagnosis and thus appropriate treatment.

There are also some clinical presentations and scenarios that are unique and specific to sport, for example, swimming-induced pulmonary oedema (SIPE).[6] Thus, while the broad principles of clinical assessment of the respiratory system apply, there are several caveats and considerations when assessing the athletic population.

Scope

The purpose of this document was to provide concise and pragmatic guidance to help clinicians from all aspects of the multidisciplinary team (ie, including doctors, physiotherapists, speech and language therapists, pharmacists, physiologists, psychologists and specialist nurses), in both primary and secondary care settings, in assessing and managing respiratory problems in athletic individuals. While it is important to acknowledge that symptoms in many common cardiorespiratory conditions (eg, heart disease) will be exacerbated by vigorous exercise, the intent of the document is to largely provide guidance regarding the clinical approach to an individual presenting with sport-associated respiratory symptoms. The statement does not address exertional breathlessness, wheeze on exertion or other symptoms in the non-athletic, general population, where the differential is broad and beyond the scope of this work. The statement also does not cover high altitude or extreme sport, given the CSG felt these issues would typically necessitate experienced and highly specialist input and as such would be beyond the scope of this general guidance document.

For the purposes of this document, an athlete (paediatric or adult) is defined as an individual who regularly partakes in physical activity that could be classified as sport. When relevant, we further classify athletic status, based on level of competition, as either amateur, national or international (elite)±professional. The statement, however, aims to be inclusive of 'athletes' of all levels of aptitude, and while some issues will be particularly pertinent in the elite or professional setting (section 5), the approach to any specific issue is broadly applicable across all athletic individuals. This acknowledged, some of the diagnoses described in the statement will be relevant, even in this context. When appropriate, reference is made to cardiac diagnoses, and other clinical conditions in athletes and readers are signposted to other sources of information. A supplementary file with tables is available online, including details on recommended areas for future research (online supplemental table S4).

Methodology

The clinical statement group (CSG) was chaired by Dr James Hull, with membership drawn from experts in respiratory medicine (adult and

paediatric), sports medicine, primary care, physiotherapy, speech and language therapy, physiology and lay/patient input. The CSG identified key areas requiring clinical practice points, and the overall content was developed to reflect the scope approved by the BTS Standards of Care Committee (SOCC). Following discussions of broad statement content, individual sections were drafted by group members. A final edited draft was reviewed by the BTS SOCC before posting for public consultation and peer review on the BTS website June–July 2021. The revised document was reapproved by the BTS SOCC in October 2021 before final publication.

SUMMARY OF CLINICAL PRACTICE POINTS

Section 1: general approach to assessment

- The initial appraisal of respiratory symptoms in athletes should not differ from the approach used in the general population; obvious causes/red flag/warning features should not be overlooked by virtue of an individual's athletic status.
- A thorough history should characterise the precise nature of exercise-related clinical features (eg, breathlessness and wheeze) and their relationship with exercise intensity and recovery.
- A thorough clinical assessment should include details about psychological stress, concerns regarding competitive level, changes in training load, concern regarding medications and anti-doping considerations.
- Avoid making a diagnosis of asthma±EIB on a clinical evaluation alone. Clinical features of airways disease (eg, wheeze, cough and breathlessness) are poorly predictive of airway disease in athletic individuals and should always be supported by objective testing.
- If possible, attempt to evaluate the athlete when they are symptomatic or use a surrogate means of evaluating this scenario; for example, with a 'selfie-type' video file or collateral/witness evaluation.
- Cardiorespiratory examination, when performed in the clinic, is nearly always normal in an athletic individual (other than revealing good cardiovascular conditioning, eg, bradycardia) and may be falsely reassuring.
- Simple investigations, such as a full blood count and ECG, are important initial tests. A chest radiograph should only be performed if there are abnormal clinical findings, persistent cough or clinical suspicion of an infiltrative or pleural-based process.

Section 2: investigation

- Objective physiological testing is recommended to ensure a robust diagnosis in any athlete with suspected airways disease.
- Physiological tests are best applied and interpreted in conjunction with a robust evaluation of the pretest probability or likelihood of a given diagnosis.
- Peak flow is not a reliable indicator of airflow obstruction in athletes and can be affected by fatigue and impaired inspiratory flow from coexisting laryngeal or breathing pattern problems.
- In the interpretation of pulmonary function tests in athletes, application of general population normative ranges is appropriate.
- Exercise testing or indirect bronchoprovocation testing (eg, eucapnic voluntary hyperpnoea or mannitol challenge test) is recommended to establish a diagnosis of EIB.
- Cardiopulmonary exercise testing (CPET) may help identify cardiorespiratory pathology, a BPD or deconditioning.
- Continuous laryngoscopy during exercise (CLE) testing, requiring placement of a flexible laryngoscope during exercise, is the gold-standard test in the assessment of exercise-related laryngeal issues.

Section 3: common clinical conditions

Exercise-induced bronchoconstriction

- EIB is prevalent in individuals with asthma but can be present in athletes in the absence of other clinical or inflammatory features of classical asthma.
- EIB most commonly develops following intense exercise, especially in cold air.
- EIB is best assessed with spirometry showing a reduction in forced expiratory volume in 1 s after a suitable challenge test.
- Exercise-associated cough may arise for various reasons and should not be automatically attributed to asthma/EIB.
- EIB in the presence of asthma can be a feature of undertreated and uncontrolled disease and thus should prompt a standard asthma review and escalation in anti-inflammatory treatment, if indicated.
- Athletes with asthma should be afforded high-quality asthma care, including regular assessment and optimisation of inhaler technique.
- Management of EIB should include discussion and consideration of adjunctive non-pharmacological treatments.
- The treatment of an acute attack of asthma in an athlete should not differ from standard guidelines, but document all aspects of care carefully, as the athlete may need to justify medication use in elite sport (see section 5).

Exercise-induced laryngeal obstruction

- EILO symptoms are typically maximal during intense exercise and resolve when exercise intensity is reduced or stopped.
- Classical symptoms include noisy breathing, upper chest/throat discomfort or restriction and difficulties when breathing in. Obtaining a video recording of an athlete's wheeze on exertion may be helpful diagnostically.
- The mainstay of EILO management is behavioural therapy and breathing retraining. Surgical intervention may be considered for some forms of EILO and when conservative therapeutic techniques have failed.

Breathing pattern disorder

- BPD is a common yet often overlooked cause of unexplained breathlessness and should be considered in athletes with variable symptoms, in the presence of normal investigations. It can coexist with EIB and EILO and act to amplify symptoms.
- Assessment at rest and ideally during a provoked attack through sport-specific testing is required to diagnose BPD.
- If BPD is suspected, a referral to a specialist physiotherapist for breathing education and retraining is recommended.

Section 4: athlete-specific considerations in general respiratory problems

Respiratory tract infection (RTI)/pneumonia

- Pneumonia in athletes should generally be managed as per national guidelines, but risk scores may underestimate severity in fit young people.
- Travel history should be considered with regard to risk of antibiotic resistance and potential pathogens.
- Precounsel athletes regarding relevant side effects if they are continuing to exercise (eg, tendonitis with quinolones).

- Detect and consider factors that may be relevant in an athletic individual presenting with recurrent infection (eg, nutritional deficiency).

Pulmonary embolism

- Clinicians should be aware that high levels of physical conditioning may mask classical clinical features of pulmonary embolism (eg, tachycardia), and given several risk factors are often present (eg, long-haul travel), there should be a high index of suspicion for this diagnosis.
- Decision making regarding anticoagulation for athletes involved in contact sport is complex and should involve an expert multidisciplinary team and the athlete.

Pneumothorax

- Immediate management and follow-up should proceed in accordance with current BTS guidelines. A conservative approach enables early mobilisation with reduced risk of complications associated with intervention.
- In recurrent pneumothorax, surgical management is most effective in reducing future risk of recurrence. Surgery may be timed at a period of low training intensity and competition but should be discussed in the context of an expert thoracic surgical multidisciplinary team.

Less common conditions

- SIPE is a rare cause of acute haemoptysis and dyspnoea during sport. Acute treatment involves removing the athlete from the water, warming and removing constrictive clothing. Oxygen, diuretics and beta-2 agonists and vasodilator agents may be considered on a case-by-case basis.
- Exercise-induced anaphylaxis should be considered in individuals with relevant clinical features that develop with any form of physical activity. The diagnosis is often overlooked and requires a high index of suspicion and onward referral to an allergy specialist for further assessment.

Section 5: specific considerations in high-level athletes

- Athletic individuals will often ask when it is safe to return to training and competitive sport. In most respiratory conditions, in the absence of high-quality evidence, this decision should be made based on the presence of any ongoing symptoms and an assessment of risk, in conjunction with the athletes and their clinical team. Expectations of recovery time should be managed in accordance with the severity of the initial illness, and it is advisable to use a graded return to sport.
- Some athletes presenting with persistent unexplained respiratory symptoms±recurrent infections±fatigue may have the unexplained underperformance syndrome (UUPS) and benefit from expert input from a sports clinician.
- Highly competitive, elite or professional athletes will often need to consider antidoping regulations. While the onus is on the athlete to check regulations with respect to any specific medication, it is helpful for clinicians to check medications with up-to-date online resources and to be aware of the rules regarding the most commonly prescribed medications in respiratory disease.
- Never withhold medication for a severe or life-threatening respiratory disease for fear of an antidoping recommendation. Treat immediately, but document all clinical and investigational findings and flag this to the athlete so they can address if special documentation approval is later needed.

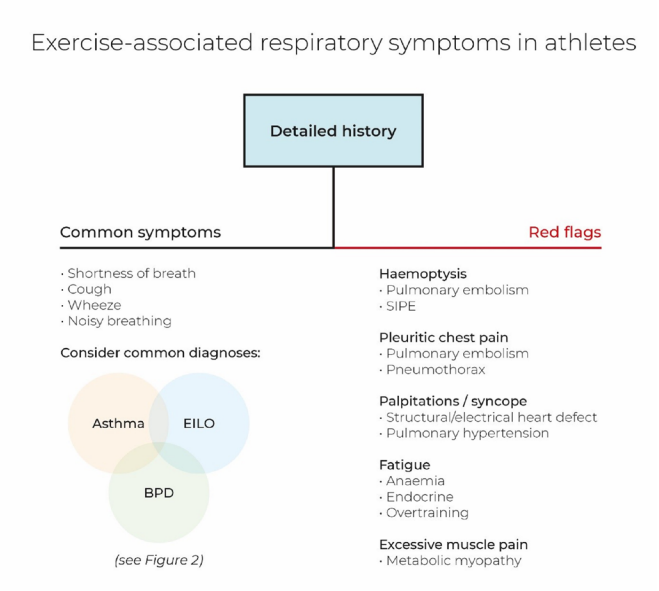

Figure 1 Initial approach to exercise-associated respiratory symptoms in the athlete. BPD, breathing pattern disorder; EILO, exercise-induced laryngeal obstruction; SIPE, swimming induced pulmonary oedema.

SECTION 1: GENERAL APPROACH TO ASSESSMENT

Initial assessment: history

The clinical assessment of any athletic individual presenting with respiratory symptoms should start with the standard clinical approach to history and examination. It is important that clinical conditions that would be considered in the general population (eg, anaemia) are not overlooked simply because of an individual's highly trained or athletic background. It is important that 'red flag' symptoms are identified and characterised further, if present (eg, pleuritic chest pain) (figure 1).

The most commonly encountered conditions cause symptoms during or immediately following exercise, and the differential diagnosis includes prevalent conditions such as EIB, EILO and BPD (figure 1). To evaluate the key differential diagnoses, history-taking should focus on exploring the nature, onset, time-course and recovery pattern of exercise-related symptoms (figure 2). Several clinical characteristics (eg, age of athlete) and risk factors (eg, presence of atopy) can be helpful in modifying the pretest probability of a given diagnosis (see relevant sections further). A collateral history from an observer, such as a family member or coach, can also provide useful additional information.

If feasible, it can be informative to assess an athlete at the time they develop symptoms, for example, track side or pool side. If this is not possible, then asking an athlete or their coach to record (with appropriate consent obtained) a selfie-type video of when they develop their symptoms can be helpful, especially in the context of a potential diagnosis of EILO (see section 3).

A thorough assessment should include evaluation of relevant comorbidities (eg, reflux and nasal disease) and social history (eg, schooling and home environment). In competitive athletes, it is important to discuss the level of competition and to explore and acknowledge concerns relating to sporting performance and the impact of symptoms on exercise capability. In young athletes, assessing and detecting psychological distress±features of overtraining is important (see section 5). It is also important to directly explore understanding of antidoping regulations and to address any fears or anxieties associated with the use of medications, in this context.

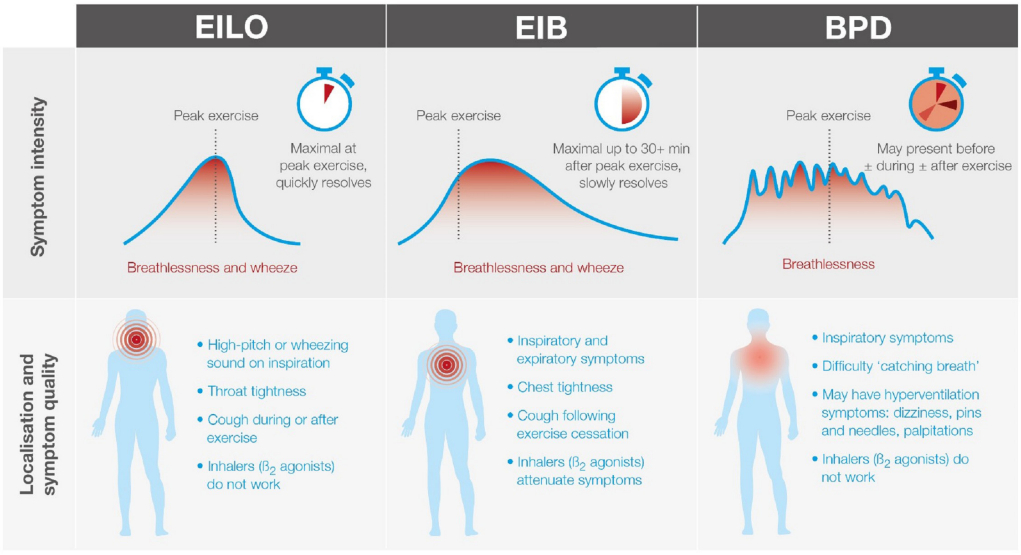

Figure 2 Clinical features of the key differential diagnoses for breathlessness±wheeze in athletic individuals. Adapted from Griffin *et al*.[41] BPD, breathing pattern disorder; EIB, exercise induced bronchoconstriction; EILO, exercise-induced laryngeal obstruction.

Initial assessment: examination

In most cases, clinical examination of an athlete at rest will be normal. This is to be expected, given symptoms will most commonly be present on exertion. It is still important, however, to perform a thorough cardiorespiratory examination to exclude alternative diagnoses (eg, auscultate for cardiac murmurs) and, where relevant, measure oxygen saturation level and blood pressure. It should be noted that heightened physiological conditioning may alter certain standard assessment parameters/observations (eg, resting heart rate), and this may thus mask the typical findings expected in some cardiorespiratory pathologies (eg, pulmonary emboli).

Investigations

Simple baseline investigations in an athlete with unexplained breathlessness should include a full blood count to check for anaemia and eosinophilia ($\geq 0.3 \times 10^9$/L) and an ECG to look for abnormal morphology or electrical pre-excitation patterns.[7]

A chest radiograph is typically not indicated in a young individual with sport-related respiratory issues (ie, in most cases will not provide a diagnosis) but should be performed in an athlete with persistent symptoms (eg, a chronic daily cough)±there are abnormal clinical findings±on the suspicion of an infiltrate or pleural problem, for example, clinical pneumothorax. The place of clinic-based physiological measurements (eg, spirometry) is covered in section 2, but undertaking this type of measurement when an athlete is at rest and asymptomatic (ie, in the clinic) may be falsely reassuring.

More detailed investigations, such as additional blood profiling, imaging or echocardiography, may be indicated, depending on the potential differential diagnoses arising from the initial clinical assessment, but in most cases, subsequent investigation will focus on further physiological tests (section 2).

SECTION 2: FURTHER INVESTIGATION

In the most common clinical presentations (eg, breathlessness and wheeze) some form of physiological testing will be required. Figure 3 provides an approach that can be used to complement clinical evaluation. This approach is based on a decision tree that considers the initial likelihood or pretest probability of a given diagnosis; that is, if an athletic individual reports or shows a video of exercise-associated stridor during high-intensity exercise, then it would be appropriate to consider a diagnosis of EILO (see section 3). This approach is also cognisant of the fact that bronchoprovocation tests have poor diagnostic value in individuals with a low pretest probability of airways disease.[8] Key considerations and caveats when performing and interpreting physiological tests in athletic individuals are covered in online supplemental table S1.

An initial step in assessment in most athletes with respiratory symptoms will be spirometry. This test is widely available and should be performed to accepted standards and thus 'quality assured'.[9] In the case of airflow obstruction, it is important that spirometry is repeated following administration of a bronchodilator (online supplemental table S1). The decision of when to refer to secondary care will depend on local expertise and access to investigations. Some primary care facilities may have access to fractional exhaled nitric oxide (FeNO) testing to evaluate airway inflammation, although this may require discussion with or onward referral to a diagnostic hub or secondary care centre. Bronchoprovocation testing and CPET will nearly always require referral to a secondary care centre and even then, many non-specialist centres will only have limited access to direct bronchoprovocation (eg, methacholine challenge testing), as opposed to the 'gold-standard' indirect bronchoprovocation methodologies, recommended in the diagnosis of EIB in athletes (online supplemental table S1).[10]

More complex physiological exercise-based tests may be indicated following initial investigations. One such test, the CLE test, is now widely considered to be the gold-standard diagnostic test for EILO[11]; a flexible laryngoscope is passed transnasally and remains in situ to evaluate laryngeal movement while an individual then performs exercise to precipitate symptoms. See BTS website, for specialist exercise/CLE testing centres, including for paediatric assessment.

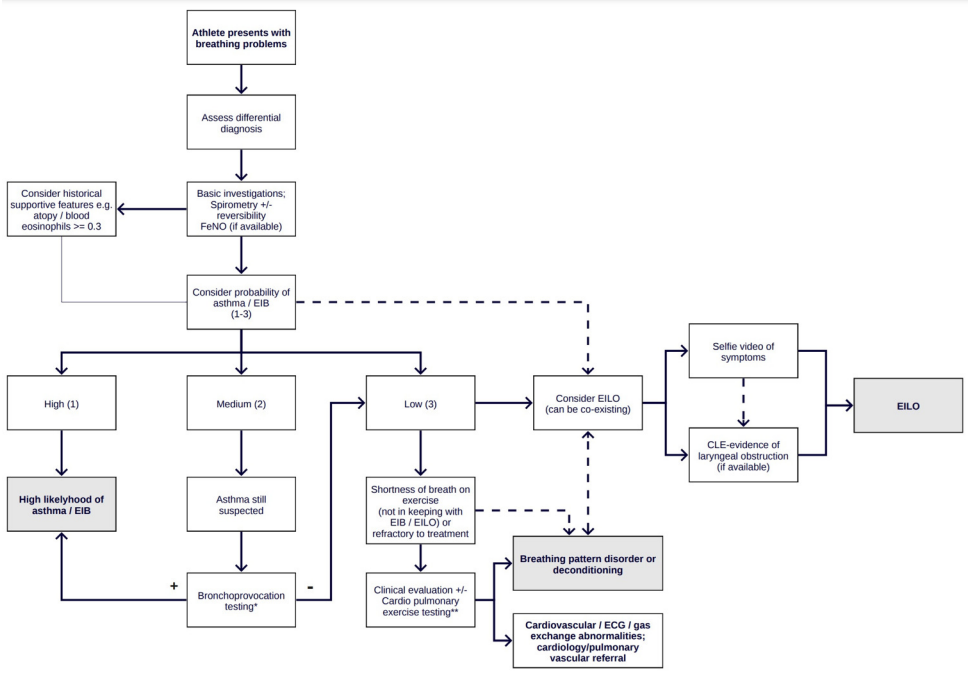

Figure 3 Investigational algorithm for the assessment of the key differential diagnoses of breathlessness and wheeze in athletes. (1) High probability of asthma/EIB; clinical history indicative and investigations positive (eg, positive bronchodilator reversibility); (2) medium probability of asthma/EIB; clinical history indicative but investigations negative; (3) low probability of asthma/EIB; clinical history unsupportive and investigations negative. Note: EIB/BPD and EILO can coexist in the same individual. *For bronchoprovocation testing options/explanation, see online supplemental table S1; **±Full lung function, ±other specialist lung function tests (eg, respiratory muscle strength testing). BPD, breathing pattern disorder; CLE, continuous laryngoscopy during exercise; EIB, exercise induced bronchoconstriction; EILO, exercise-induced laryngeal obstruction; FeNO, fractional exhaled nitric oxide.

SECTION 3: CLINICAL ASSESSMENT AND MANAGEMENT OF COMMONLY ENCOUNTERED CONDITIONS

Exercise-induced bronchoconstriction

Background

EIB describes the phenomenon when intense physical exercise triggers acute lower airway narrowing.[12] The term EIB is favoured over exercise-induced asthma, because exercise does not cause or induce the clinical disease 'asthma' and EIB can occur in the absence of other classical features of asthma.

In the general population, EIB is most commonly encountered in people, particularly children, with asthma who are not optimally controlled.[13] Exercise is among the most commonly reported stimuli to trigger bronchoconstriction in asthmatics, with the prevalence varying, depending on exercise type, intensity and environment.[14] EIB is also prevalent in elite athletes, specifically those participating in swimming or winter sports exercise.[15] In this context, it can occur in the absence of other features of asthma (eg, nocturnal awakening) and common markers of airway inflammation (ie, type 2 pattern), where it is sometimes termed 'sports asthma'. It has been proposed that this may arise from a process akin to lower airway 'injury', promoting airway hyper-responsiveness, arising from the ventilatory challenge of undertaking regular high-intensity endurance sports, particularly in potentially noxious environments, for example, cross-country skiing in very cold air.[16 17]

Clinical presentation and evaluation

The symptoms of EIB include shortness of breath±increased effort of breathing, chest tightness, wheeze and/or cough. Symptoms and physiological evidence of bronchoconstriction typically worsen immediately *after cessation* of intense exercise,[12] but individuals with EIB will often report difficulty 'catching their breath', in the early phases of an exercise bout. The intensity and duration of hyperpnoea and the humidity and temperature of the inspired air can influence the airway response, and thus very strenuous exercise (eg, running hard for 5–10 min) performed in cold dry air or potentially noxious environments (eg, high ozone/airborne particulates) is most likely to precipitate airway narrowing. A diagnosis of EIB is more likely in those with a history of atopy (eg, particularly animal allergy) and in those taking part in high-intensity endurance sports.[18 19]

The symptoms of EIB are the same as those precipitated by exposure to common asthma triggers. Studies have established that a symptom-based diagnosis is poorly predictive of EIB, when compared with the results from objective testing, for example, bronchoprovocation testing.[4 5] Accordingly, it is highly recommended that a diagnosis of EIB is supported by objective testing.[12] This may include serial (reproducible) spirometric measurements, made after a specific exercise test or with an indirect bronchoprovocation challenge (see section 2, online supplemental table S1). The CSG does not recommend a 'diagnostic trial' of beta-2 agonist inhaler in this context, given the difficulties in subsequent interpretation from (1) potential suboptimal inhaler technique and adherence; (2) impact of a placebo response;(3) lack of appropriate treatment for any underlying airway inflammation; (4) confounding from an overlap between EILO, EIB and BPD; and (5) impact of beta-2 agonist tachyphylaxis.

Exercise-associated cough is a prevalent problem with 15% of athletes reporting this problem in one study.[1] It is often taken to indicate the presence of EIB, prompting initiation±escalation of asthma treatment.[20] However, studies in athletes reveal

Table 1 Management of EIB in athletes

Non-pharamacological	Pharmacological
Specific warm-up strategies	Ensure high-quality standard care
► Perform interval high-intensity or a combination of high-intensity and low-intensity warm-up activity 10–15 min before exercise, for example, 30 s bouts close to heart rate max.[22] This is aiming to induce a refractory period that should last up to 2 hours. ► Discuss that some breathing control exercises may help.	► Explain rationale for treatment and address any concerns regarding anti-doping, for example, athlete not wishing to use any form of 'steroid'. ► Check and ensure good inhaler technique. ► Provide a self-management plan and discuss anacute care plan, where relevant. ► Provide annual influenza vaccination. ► Do not withhold acute emergency treatment in exacerbation for fear of antidoping.
Airway protection/trigger avoidance	Specific therapy for EIB
► Ensure optimal treatment of allergen sensitivities/ management of pollen exposure in relevant season. ► In cold air, a heat and moisture exchanger (HME) mask or face covering (eg, snood) can warm and humidify the inspired air. ► Avoid smoke or noxious (eg, highly polluted) environments	For patients with frequent EIB who need $ß_2$-agonist frequently (more than two times a week[27 29]) to treat symptoms, use either budesonide/formoterol on demand for EIB or 10–15 min pre-exercise.[29] On demand, use of budesonide/formoterol has been shown to be as effective as regular low-dose inhaled corticosteroid dose[29] or Regular two times per day inhaled corticosteroid±bronchodilator pre-exercise[29] or Oral montelukast regularly once per day±bronchodilator pre-exercise.[30 99] If EIB symptoms remain troublesome, consider a mast cell stabilising drug (cromoglicate or nedocromil)[34] or an inhaled anticholinergic[32] 10–15 min before exercise Review international guidance to ensure one is up to date with management recommendations for asthma.
Dietary modification	Detect and treat comorbid conditions
► Some athletes may wish to trial omega-3, low salt diet, vitamin C and increased caffeine intake for EIB.[12]	► In patients with EIB and allergies, treat with topical corticosteroid±an antihistamine.[100] ► Detect and treat reflux and nasal disease.

EIB, exercise-induced bronchoconstriction.

a poor relationship between the presence of cough and markers of asthma, when objective testing is employed, and this symptom appears to be equally prevalent in athletes with or without EIB.[21] There is also now improved recognition that cough is a key symptom in other conditions, such as EILO and BPD, but also may be arising from a general cough hypersensitivity process. Clinical assessment should thus focus on identifying treatable factors (eg, from non-acid reflux or rhinitis) and employ objective investigations (eg, FeNO) before administration/increasing asthma treatment. In the paediatric population, cough as a sole symptom is not a feature of asthma, and airway treatment is not recommended for this symptom.

Management

A comprehensive approach to the management of EIB in athletes should include consideration for both pharmacological and nonpharmacological strategies. Important non-pharmacological recommendations include the use of specific warm-up exercise regimes[22] and airway protection during cold weather (ie, wearing a snood) (table 1).[12]

The pharmacological treatment of airway disease is constantly evolving, and therefore it is recommended that readers refer to BTS/Scottish Intercollegiate Guidelines Network (SIGN) asthma guidelines[23] and international guidance statements, for example, Global Initiative for Asthma.[24] A detailed review of the evidence base for treatment of EIB is also provided in a guideline produced by the American Thoracic Society.[12]

As stated previously, EIB is often a feature of poorly controlled asthma and thus ancillary features of this syndrome±raised markers of airway inflammation±eosinophilia should prompt timely escalation in standard asthma therapy.[23] As with any patient with airway disease, athletes with confirmed asthma should be afforded standard high-quality asthma care, including annual influenza vaccination and a regular assessment of inhaler technique (table 1).

It is generally accepted that EIB is responsive to the correct inhaler therapy strategy, most often used prophylactically before exercise. Historically, most athletes have been prescribed an inhaled short-acting beta agonist (SABA), to be taken 10–15 min before exertion. Studies have shown, however, that excessive use of short-acting beta-2 agonist (eg, as may be used by a competitive athlete exercising two times every day per week) may lead to tachyphylaxis and loss of a bronchoprotective effect during exercise.[25–28] The use of pre-exercise and on-demand inhaled corticosteroid /fast-acting long-acting beta-2 agonist, for example, budesonide/formoterol, has been shown to be superior to on-demand SABA use in reducing EIB in mild asthmatics and, in addition, reduced EIB over 6 weeks as effectively as an inhaled corticosteroid.[29]

Leucotriene receptor antagonists (LTRAs) such as montelukast may also protect some athletes against EIB with no development of tolerance when taken daily.[30] LTRAs may be useful in athletes who want to avoid using inhalers. LTRAs should be taken at least 2 hours before exercise for maximum protective effect with the effect lasting up to 24 hours.[31]

Some clinicians may opt to use anticholinergic inhaler therapy,[32] and mast cell stabilising agents such as cromoglicate or nedocromil[33 34] have also been used in the treatment of EIB.[12] In patients with EIB and allergies, an antihistamine may also be helpful in improving overall asthma control but does not appear to have an effect on EIB.[12 35] A regime that allows for moderate exercise during summer will not necessarily be effective or appropriate in an elite athlete competing in winter sports, and this should be considered when discussing treatment.

Treatment of an acute asthma attack in an athlete should follow conventional guidelines (see BTS /SIGN asthma guidelines).[23] It is important that systemic anti-inflammatory treatment (eg, prednisolone or hydrocortisone) is not withheld on the basis of concern regarding antidoping considerations (see section 5); the priority should always be to deliver prompt and appropriate

delivery of treatment.[36] Clinicians treating a competitive or elite athlete in an emergency should diligently document all clinical features and examination findings and relevant results (eg, peak flow) so that an athlete can apply for a therapeutic use exemption if needed. Athletes should refrain from intense training or competition for a period after an attack (see section 5).

Exercise-induced laryngeal obstruction

Background

The term EILO describes a transient, reversible narrowing of the larynx that occurs during high-intensity exercise.[37] This impairs airflow in the upper airway and increases the work of breathing.[38] In most cases, EILO is caused by a narrowing at the level of the supraglottic laryngeal structures (ie, arytenoid cartilages/aryepiglottic folds) and thus above the vocal cords. As such, in most cases of EILO, the term exercise-induced vocal cord dysfunction is a misnomer.

The prevalence of EILO appears to be similar to EIB and is highest in adolescents and young adults, in the range of 5%–10% and with a female preponderance.[39] EILO can coexist with asthma and in one study was present in a third of competitive athletes with unexplained cough and wheeze.[40]

Clinical presentation and evaluation

Symptoms of EILO usually develop during intense exercise and tend to settle rapidly (ie, within minutes) on exercise cessation. Athletes with EILO often report a difficulty 'breathing in' or 'filling the lungs', and upper chest±throat discomfort.[41] On closer questioning, there is typically a history of noisy breathing, often audible to others in close proximity.[42] In contrast, it is unusual for individuals with EIB to present with a very loud wheeze on exercise. Although intuitive, asking about 'wheeze or stridor' is not necessarily helpful; many individuals have difficulty discerning whether the noise arises on inspiration or expiration.[43] It can thus be more useful to mimic the sound of stridor or to show athletes a video of EILO (see linked file; to be linked BTS website, if permitted) to determine if they recognise the features. It may also be helpful to request for an athlete to record a selfie-type mobile phone video when symptomatic to help interrogate the nature of the exertional 'wheeze'. The gold-standard means of diagnosis for EILO is, however, CLE testing (see section 2).

A comprehensive history should explore the duration of symptoms and response to any therapies trialled; typically, EILO fails to respond to short-acting beta-2 agonist inhalers, but EIB and EILO can coexist, confounding the precision of a clinical-based diagnosis. It is helpful to enquire about untreated reflux, use of caffeinated supplements (ie, gels) and troublesome nasal symptoms, all of which can directly or indirectly heighten laryngeal irritation.[37]

Management

Several management approaches exist for EILO, but to date, there are no randomised controlled trials to direct management, and thus, the overall evidence base to guide treatment is very weak. First-line treatment typically involves conservative (therapy-based) management, tailored to individual need, and is associated with an improvement in 60% or more of individuals.[44] Initial patient engagement and understanding are key to success, and several freely accessible patient educational resources are available to support clinicians.[41 45] It is essential that any factors causing upper airway irritation and comorbidities (eg, overlapping asthma and nasal or reflux disease) are assessed and managed.

Specific rescue breathing techniques facilitate adjustment of the oropharyngeal–laryngeal aperture and often ease symptom burden successfully. In particular, the teaching of EILO-biphasic inspiratory breathing techniques can be very beneficial.[44 46] Inspiratory muscle retraining has been used in the treatment of some forms of EILO,[47] but care should be taken not to compromise an optimal breathing pattern (see section 3, on breathing pattern disorder). For therapy-resistant individuals, surgical management (ie, laser supraglottoplasty) may be a viable treatment option when there is severe supraglottic collapse with pronounced symptoms.[48]

Breathing pattern disorder

Background

The term BPD is often used interchangeably and variably with dysfunctional breathing and hyperventilation. It can be defined as an alteration in the normal biomechanical pattern of breathing, leading to intrusive symptoms[49] that can impact athletic performance and quality of life.[50] BPD can occur in the presence or absence of other comorbidities, including EIB, EILO and/or anxiety, and in this context can act to overlap or amplify symptoms and make them appear 'treatment resistant'.[51] It is vital that any other condition or comorbidity is detected, considered and optimised prior to assuming an athlete's symptoms are fully explained by BPD.

Clinical presentation and evaluation

Excessive breathlessness that is disproportionate to the level of activity is a key feature of BPD. Other respiratory symptoms include difficulty taking deep or 'satisfying' breaths, frequent upper body / chest discomfort and tightness. Less common symptoms include dry cough, throat clearance, throat tightness, dizziness and palpitations.[52] Athletic individuals often also report a perceived difficulty recovering between hard physical efforts.[53]

Symptoms predominantly occur at peak exercise intensity but may be variably present at other times, including during simple activities of daily living (eg, starting to climb a flight of stairs). They can be exacerbated with performance pressure, low self-esteem, anxiety or stress[50] and may resolve as a more normal breathing pattern resumes.

Assessment at rest and during a provoked attack can help to identify the key indicators of BPD compared with normal breathing patterns (online supplemental table S2).[54 55] Typical features include a raised breathing frequency, predominantly apical/upper chest movement during respiration, asynchrony between upper and lower chest and excessive mouth breathing. There may also be frequent sighing, yawning or excessive accessory muscle use.[49 53]

Sports-specific exercise testing is also helpful for diagnosis and, if possible, a field-based assessment can be conducted to evaluate breathing pattern during repeated physical efforts, with spirometry, video analysis or visual feedback and correlation of symptoms with breathlessness and exertion scales. Assessing an athlete's core stability and posture is important as particular positions (slumped with rounded shoulders) can impede diaphragmatic recruitment.

Management

At the current time, there are very few high-quality studies using randomised controlled methodology in sport-associated BPD. This acknowledged, specialist physiotherapy-led breathing

pattern retraining is most commonly used as the main treatment for BPD, progressing from rest to sport-specific tasks.[56] However, high-quality breathing retraining physiotherapy is not yet widely accessible, and thus online sources of information can be helpful[57] (see, eg, https://www.physiotherapyforbpd.org.uk/). Furthermore, visual or video feedback during therapy sessions can facilitate breathing retraining. Athlete and coach education and understanding is paramount to effective management, and as BPD is often multidimensional, a holistic approach is required to address the biomechanical, psychophysiological and musculoskeletal factors (ie, ensuring good posture and core stability).[58] Management of coexisting conditions (EIB, nasal or reflux disease, anxiety or mood state disorders) should also be optimised, as these can contribute to BPD.

SECTION 4: ATHLETE-SPECIFIC CONSIDERATIONS IN COMMON RESPIRATORY PROBLEMS

Respiratory tract infection

Background and evaluation

RTI is the most common reason an athlete will seek acute medical review[59 60] and can significantly impact training availability and competition performance. As in the general population, most RTIs in athletic individuals are viral in origin[61] and require a conservative/supportive approach to management. It is important not to lower the threshold of using antibiotics in athletes due to a number of side effects, for example, tendinitis, QTc prolongation and gastrointestinal upset.

In the case of suspected or confirmed bacterial infection±pneumonia (ie, based on a constellation of symptoms, signs, ±chest X-ray (CXR) change±culture results), treatment should proceed as per standard guidance.[62] Frequently used risk assessment tools in the assessment of pneumonia may underestimate risk in the young,[63] and the enhanced physiological reserve of elite athletes may lead to further underestimation and so should be interpreted with caution.

Specific causes of bacterial infection that require consideration in athletic individuals include *Legionella* pneumonia and necrotising pneumonia caused by the Panton-Valentine leuocidin-producing strain of *Staphylococcus aureus*. Although both are rare, athlete-specific environmental factors (eg, showering environments and soft tissue/skin infection, respectively) increase risk,[62] and these conditions can have an atypical presentation with neurological and gastrointestinal symptoms.[62] Thus, a high index of suspicion is required, with full systemic examination, to prompt treatment for these potentially life-threatening conditions.[64]

Management

Suspected or confirmed pneumonia should be managed in line with local and national guidelines, with best supportive care and typically with a 5–7 day course of antibiotics. Recent travel history should be considered when choosing antibiotics[65] and athletes should be pre-counselled regarding potential side effects (eg, quinolones and tendonitis).

Recovery from pneumonia is varied with studies reporting anywhere between 97% of symptoms having resolved at 10 days but up to >50% of patients still reporting fatigue at 90 days,[66] with current national guidance recommending clinical evaluation at 6 weeks.[62] It is thus important to precounsel athletes regarding the duration of recovery time in order to manage expectations. Moreover, a degree of deconditioning should be expected and is probably the most common cause of postpneumonia fatigue. Delayed recovery should prompt consideration of further investigation (eg, checking inflammatory markers and thyroid function and repeating a CXR).

There is little published evidence to provide robust guidance on 'return-to-play (RTP)' advice following RTI. Historically, the so called 'neck check' rule has been used by sports physicians, with a graduated return to exercise recommended if symptoms are confined only to the upper respiratory tract.[67] It is generally considered safe to commence a graded RTP once an athlete has had no fever for 24 hours off antipyretics and has no ongoing active features of pneumonia (eg, chest pain and dyspnoea).

Often athletes with recurrent infection (i.e. >3 per year) will enquire regarding strategies to reduce infection risk. Standard screening tests to rule out heightened infection risk are important, as well as considering potential underlying medical conditions,[2] but other more general factors are also relevant, that is, sleep deprivation, relative nutritional deficiency, high levels of psychological stress and good advice regarding general hygiene.[68]

COVID-19 considerations

Recommendations regarding the management of respiratory issues arising from SARS-CoV-2 infection is rapidly evolving and it is thus recommended that the medical team and athlete follow the most up-to-date regulations specific to their sport, country and region.

Due to the risk of cardiovascular and respiratory sequelae, the main sport-specific issues for SARS-CoV-2 relate to safe RTP after illness. Current recommendations are conflicting and based predominantly on expert opinion.[69] A stratified approach is generally recommended, depending on severity of initial illness.[70 71] Readers are referred to the International Olympic Committee athlete hub for a regularly updated source of information.[72] Moreover, some athletic individuals may report protracted respiratory symptoms following SARS-CoV-2 infection.[73] Evaluation of these symptoms should proceed in line with BTS/National Institute for Health and Care Excellence (NICE) recommendations,[74] but further sport-specific investigations may be required.[69]

Pulmonary embolism

Background and evaluation

The risk of venous thromboembolism (VTE) should not be overlooked in an athlete and should be assessed on its own merits, with relevant risk factors including[75]

- Travel for competition and training.
- Trauma.
- Immobilisation, for example, following injury.
- Haemoconcentration: dehydration in training or competition, heat stress.
- Polycythaemia.
- Vascular wall injury: microtrauma from repetitive training activities.

Preventative strategies such as antiembolism stockings for long flights and adequate hydration should be encouraged.

Management

The diagnostic pathways, acute management and decisions regarding long-term anticoagulation for athletes should not deviate from national/international guidelines.[75 76] For many athletes, the initiation of anticoagulation has immediate consequences for sporting capability. Participation in high-level contact sport such as rugby is not recommended while anticoagulated, whereas low-contact sports such as swimming may

be undertaken with minimal increased risk.[77] In this context, it is therefore important that management decision making is undertaken in specialist multidisciplinary VTE follow-up services typically run by a respiratory physician and thrombosis expert. Seeking early advice is key to allowing an athlete back to safe activities at the soonest possible opportunity to maintain strength, fitness and mental health.

Stepwise strategies have been proposed for graduated return to non-contact activity and involve resumption of activity of daily living in weeks 1–3 then return to aerobic exercise over the following 3 weeks when clot lysis and recanalisation have occurred.[78] In the absence of high-quality studies, these recommendations are based on expert opinion and may be too conservative, resulting in deconditioning. There is no evidence that early resumption of physical activity causes harm, and post-VTE physical activity has been shown to reduce the incidence of post-thrombotic syndrome in deep vein thrombosis[79] and improve long-term outcomes.[80] Symptoms should resolve within a few weeks, but full resolution should be expected by 3 months. If persistent symptoms exist at this point, despite therapeutic anticoagulation, then further investigation should be undertaken. The most common explanation for incomplete recovery at 3 months is deconditioning[81 82] due to loss of training time and volume; however, chronic thromboembolic disease (with or without pulmonary hypertension) should be investigated, including echocardiography, natriuretic peptides, ventilation–perfusion scintigraphy and CPET.[75] Lastly, with chronic thromboembolic disease excluded, dysfunctional breathing should also be considered following pulmonary embolism.

Pneumothorax

Background and evaluation

Most young athletic individuals who develop a pneumothorax will not have significant underlying lung disease, and therefore, secondary spontaneous pneumothorax will not be discussed. Primary spontaneous pneumothorax (PSP) has an incidence of 7.4–18.0 cases per 100 000 population each year in men and 1.2–6.0 per 100 000 population each year in women. Risk factors for PSP may be present in athletes, including being tall and male with low body mass index.[83] There is no evidence that PSP occurs due to high levels of physical activity.[84] Risk of recurrence of PSP following a first episode is around 30% at 1 year, with an increased risk in women particularly aged 31–50 years.[85]

Pneumothorax in specific circumstances

Traumatic pneumothorax is recognised in the context of contact sport and may be associated with additional injuries; assessment and management therefore should be in line with NICE trauma guidelines.[86]

Diving increases the risk of pneumothorax due to pulmonary barotrauma during ascent. Diving is not recommended following a spontaneous pneumothorax, unless treated by bilateral surgical pleurectomy, with normal postoperative lung function and thoracic CT scan.[87] Previous traumatic pneumothorax is not an absolute contraindication to diving, provided there is full radiographic resolution and normal lung function.[87]

Management

First episode of PSP

Recent evidence supports a less invasive approach to PSP in young, healthy individuals, with data showing conservative management of PSP[88] and pleural vent[89] can be effective, with an acceptable time to resolution. In athletes, a more conservative approach may facilitate early mobilisation and reduced incidence of procedural complications that may interfere with recovery, training and competition. No dedicated studies exist regarding management of PSP in athletes, and therefore management and follow-up should be in accordance with current BTS guidelines

Athletes recovering from a pneumothorax will wish to know the immediate implications for sporting capability and travel. The BTS guidance recommends that normal physical activity can recommence with resolution of symptoms, but sports that involve extreme exertion and physical contact should be deferred until complete radiographic resolution. There are no data to support an alternative management strategy for athletes other than case series and expert opinion; therefore, it can be recommended that low-intensity aerobic exercise be undertaken if allowed by symptoms. Intensive training or contact sports should not be undertaken until radiographic resolution; this would also apply to weightlifting. Air travel can be undertaken 7 days from radiographic resolution.

Recurrent PSP

Athletes with recurrent PSP should be referred to a specialist thoracic MDT, with surgical input, to discuss risks and benefits of surgical management and different surgical approaches. Conservative management is associated with faster initial recovery time but a high rate of recurrence (≥30%)[90] and resultant interruption of training and competition. Definitive management reduces the risk of future recurrence (≤6%)[91] but can be associated with postoperative risks such as pain, infection, bleeding and a longer initial recovery time. If the episode of pneumothorax has resolved, consideration can be made to definitive management occurring during competition off-season.

Swimming-induced pulmonary oedema

Swimming provides a unique combination of circumstances which lead to a centralisation of circulating blood volume (cold, immersion, compression by wetsuits and supine exercise), which appears to be the main driver in susceptible individuals who develop SIPE.[92] It is uncommon, with reported estimates of 1.4% in triathletes but has a relatively high risk of recurrence when rechallenged, up to 75%.[92 93]

SIPE typically presents with breathlessness, cough, haemoptysis and/or chest tightness, and examination is consistent with pulmonary oedema with low oxygen saturations. Chest radiography, if performed acutely, will demonstrate pulmonary oedema. This will typically resolve in 24–48 hours.[92]

Acute treatment involves removing the athlete from the water, warming and removing constrictive clothing. Oxygen, diuretics and beta-2 agonists may be considered on a case-by-case basis. Athletes should subsequently undergo cardiac work-up to exclude structural heart disease. Since recurrence is common, athletes should be counselled on risks of undertaking a similar activity but also modifiable risk factors such as water temperature, use of constrictive wetsuits and avoiding excessive volume expansion prerace with water/salt. Other factors to consider include optimising antihypertensive medication in the older hypertensive athlete. Sildenafil has been suggested to reduce the risk, but this should only be undertaken under expert guidance.[94]

Exercise-induced anaphylaxis

Exercise-induced anaphylaxis is a rare and unpredictable syndrome encountered in athletes but also in those only undertaking small amounts of recreational or submaximal physical activity.[95] It most often occurs in association with the ingestion

of a food allergen around the time of exercise (but can be up to a few hours later), when it is referred to as food-dependent exercise-induced anaphylaxis. Individuals with this type of anaphylaxis can present with a broad range of different clinical features but with a prodromal phase followed most commonly by pruritus, urticaria, angioedema and dyspnoea. Severe cases can lead to collapse with hypotension. Often this condition is overlooked, and the differential diagnosis is broad and includes idiopathic anaphylaxis and cholinergic urticaria. Regardless, consideration should prompt clinicians to closely question and record a detailed history of food ingestion around the time of exercise and include this detail on referral to an allergy specialist.

SECTION 5: SPECIFIC CONSIDERATIONS IN COMPETITIVE/ELITE ATHLETES

Return-to-play

The term RTP is used to describe considerations and criteria for any athlete to be guided in engagement in sporting activity when unwell or recovering from an illness. In its most simple form, it may relate to providing advice on when it is safe or appropriate to return to high-intensity training following an acute infection. Generally, there is very little evidence base to provide robust prescriptive recommendations for this process, and as such, RTP is usually the outcome of a risk versus benefit balance. It should be a joint decision process and should involve athletes and relevant members of their support team. Specific disease-related RTP advice is given in relevant aforementioned sections, and for elite or professional athletes, this advice will typically be led by the team sports physician.

Overtraining/unexplained underperformance syndrome

To be successful, athletic training must involve overload and thus frequent short periods (1–2 weeks) of what might be termed 'functional over-reaching' or increasing training load significantly to obtain improved conditioning. When there is a prolonged imbalance between training/competition and recovery, 'non-functional over-reaching' may occur, resulting in maladaptation and the UUPS, if not addressed quickly.[96]

A range of symptoms have been reported with UUPS and often include fatigue and an unexpected sense of effort. Some athletes will, however, present with breathlessness, frequent minor infections and unexplained muscular soreness.[97 98] Athletes with this syndrome can take many months to return to full health and fitness, and if this is suspected, it is recommended that the affected athlete is signposted/referred to specialist sports physician.

Antidoping considerations

If you are consulting with a competitive athlete, consider if any antidoping considerations apply and raise this with the athlete; some competitive athletes will be part of a recognised antidoping testing pool (eg, those competing at national or international level). While the onus ultimately falls on athletes to ensure they do not breach the antidoping regulations (https://www.ukad.org.uk/about/anti-doping-rules), knowledge in this area is important for all clinicians (online supplemental table S3).

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