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Cough in exercise and athletes

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ABSTRACT

Cough is the most common respiratory symptom reported by athletes and can significantly impact on health status, ability to train and athletic performance. The presence of cough in an athlete is typically taken to indicate exercise-induced bronchoconstriction (EIB), yet in many athletes with chronic cough there is no objective evidence of airway hyper-responsiveness (AHR) or heightened airway inflammation. Moreover, cough in athletes often fails to respond to a therapeutic asthma strategy, thus further work is urgently needed to progress our understanding of the pathophysiology of exercise-associated cough in this unique population.

This article provides an overview of the current state of knowledge of exercise-associated cough in athletes. The article summarises our understanding of pathophysiological basis of cough in this context and provides a pragmatic clinical approach to this problem.

Contents

1. Introduction

Exercise-associated cough is frequently reported by athletic individuals and can significantly impact their health status and ability to prepare for and perform sport [1]. Indeed, troublesome cough is so commonly encountered in certain sports that a number of colloquialisms have arisen to describe this condition, e.g. 'locker room' cough and 'swimmers hack'.

In athletic individuals, exercise-associated cough is often taken to indicate the presence of exercise-induced bronchoconstriction (EIB), prompting initiation of asthma treatment. However, studies in athletes often reveal a poor relationship between the presence of cough and EIB, when objective testing is employed [2–5]. Recent studies substantiate this position by revealing that cough is equally prevalent in athletes with or without EIB [2,6,7] and there is now improved recognition that cough is a key symptom in other prevalent exercise-associated respiratory disorders, such as exercise-induced laryngeal obstruction (EILO) ([8]).

Several studies have advanced our understanding of cough in athletes. Specifically, exercise-associated cough appears more prevalent in endurance athletes [4] and particularly those competing in winter sports [3]. Coughing also appears to become more prominent and problematic over the course of an athlete's

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competitive season [6]. Regardless, our knowledge in this area still remains at a relatively embryonic stage and there are very few well-conducted treatment trials for cough in athletic populations [9].

This review aims to provide an overview of cough in athletic individuals, with a focus on the impact, possible pathophysiological mechanisms and current treatment options. The article is based on a presentation given at the 9th International Symposium on Cough.

2. Exercise and cough

Exercise is recognized to place a unique set of physiological demands on the respiratory system. Indeed, even low levels of physical activity mandate an immediate increase in minute ventilation (V_E), whilst strenuous exercise can exert significant physical and chemical stress on the airway tract.

Moreover, it is now well established that high-intensity exercise, particularly when performed in noxious environments (e.g. cold air or some swimming pool environments) can precipitate airway changes; with features in keeping with an inflammatory 'injury' profile [10] and a 'dysfunctional' physiological response, i.e. promoting airways hyper-responsiveness (AHR) [11]. Having said this, whilst it might be assumed that exercise would always act as a protussive stimulus, studies reveal that exercise may in fact attenuate this symptom and down-regulate cough hyper-sensitivity [12].

It is now over thirty years since Banner and Green [13] found that healthy individuals reported cough after exercising in cold weather and investigated the effects of hyperpnoea on cough [14]. Individuals with normal spirometry and no evidence of AHR performed hyperpnoea in ambient (25 °c), subfreezing (−16 °c), warm dry (39 °c) and warm fully-saturated (39 °c) conditions for four minutes at ventilatory rates similar to those that occur during strenuous exercise. The study revealed that coughing occurred predominantly *following* rather than *during* hyperpnoea and that cough frequency only exceeded baseline values when the environmental conditions promoted airway heat and water loss i.e. in the ambient, subfreezing and warm dry conditions. This aligns with the clinical observation that, for the majority of individuals, troublesome cough is a *post-exercise* phenomenon [6,15].

In an elegant study, Lavorini and colleagues [16] compared a cough threshold (an index of cough sensitivity) in healthy, physically active individuals, by increasing nebulizer outputs of ultrasonically nebulized distilled water (fog) in three different conditions; a control condition, cycling at 80% anaerobic threshold and during voluntary isocapnic hyperpnoea (performed at a similar V_E to the cycling condition). They found that cough (assessed audio visually by a trained observer), in the context of this experimental protocol was attenuated during exercise and to a similar extent during hyperpnoea. The authors concluded that exercise or voluntary hyperpnoea exerted inhibitory influences on coughing.

3. Mechanism(s) underlying exercise associated cough

Widdicombe and colleagues [17] previously highlighted several putative pathophysiological mechanisms that are likely to be relevant in exercise associated cough (Table 1). Undoubtedly, strenuous physical activity mandates a specific physiological response that can impact, in numerous ways, on cough regulatory mechanisms. These include direct effects from hyperpnoea and distension stress, acting on both the airway and chest wall; impact from local mediator release (e.g. substance P, adenosine triphosphate [ATP]) and changes in airway surface properties (e.g. osmolarity); direct activation of neural pathways via either chemical or mechanical factors and the impact of systemic alterations (e.g. sympathetic activity and catecholamine release) with increased cardiac output and pulmonary blood flow (Fig. 1).

Widdicombe and colleagues [17] reported that during exercise or voluntary hyperpnoea, it is likely that slowly adapting stretch receptors (SARs) in the airway play a role in modulating the cough response when breathing depth is increased. This notion is supported in a study by Nishino et al. [18] indicating lung inflation with continuous positive airway pressure (CPAP) increased the cough reflex in anaesthetised humans. Lung distortion/stretch can cause the release of prostaglandins, which have been shown to provoke cough through their effects on airway c-fibres [19].

In contrast, an increase in pulmonary blood flow, arising during exercise, may lead to cough inhibition. Paintal [20] found that, in a feline animal model, increased pulmonary blood flow stimulated pulmonary c-fibre receptors. In animal studies, pulmonary [21] and bronchial [22] c- fibres have been shown to inhibit cough via their activation from an increase in pulmonary blood flow.

A key factor in the development of cough in response to cold dry air exposure, relates to changes in the airway surface liquid properties and local irritation of airway mediated receptors. Typically, inspired air is conditioned (i.e. warmed and humidified) through heat exchange in the nasal cavity, before entering the more distal airway. This mechanism is compromised however during exercise. Specifically, when V_E exceeds a certain level (approximately 30 L/min) there is a switch from a nasal to oral predominant breathing pattern. This alteration has impact for the conditioning of air and in cold weather, the air temperature travelling through the trachea and bronchi can be as low as 20 °c [23]. The respiratory water loss and resultant airway surface mucosal drying may lead to both physical and chemical activation of cough receptors [14]. It also proposed that cough receptors may respond directly to thermal stimuli or to mediators that are produced or released as a consequence of this airway drying and cooling [6]. Ternesten-Hasseus et al. [24] found that following an exercise challenge in cold air (4 °C), in which participants cycled for 4 min at 50% of their maximal voluntary ventilation (MVV), cough sensitivity to capsaicin was increased in a group of patients with exercise-induced dyspnoea but without EIB. No such changes were observed in a control group.

Sue-Chu et al. [25] found that cough reflex sensitivity to capsaicin was not related to either AHR or EIB, suggesting that exercise was the key factor inducing cough, with no change in the cough reflex. They also observed that some athletes who experience an increase in cough 2–8 h following the exercise. Sue-Chu et al. [25] proposed that cold air inhalation during exercise could induce neurogenic inflammation with the release of tachykinins and kinins accompanied by the release of long acting mediators

Table 1
Potential mechanisms in the regulation of cough during exercise. Reproduced from (Widdicombe et al. [17]). Definition of abbreviations: SAR, slowly adapting airway mechanoreceptor.

Down regulation of cough	Up regulation of cough
SARs activation	SARs activation
C-fibre activation	Heat loss
Chest wall sensor activation	Hyperosmolality
Increase in plasma catecholamine levels	Increased central deposition of tussives

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