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### Exercise-Induced Dyspnea in College-Aged Athletes

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#### ABSTRACT

**Purpose:** Shortness of breath or difficulty breathing during exercise is referred to as exercise-induced dyspnea (EID), and is a common complaint from athletes. The purpose of this study was to assess the prevalence of EID among college aged athletes and to explore the medical encounters, including diagnostic testing, arising from this complaint. **Method:** We surveyed intercollegiate (n=122) and club sport (n=103) athletes regarding their experience with EID, including medical diagnoses, diagnostic procedures, environmental factors, and treatment effectiveness. **Results:** Fifty-two percent of respondents (n=112) reported episodes of EID. Intercollegiate and club sport athletes did not differ in regard to the prevalence of EID, utilization of health provider services, or diagnoses. Sixty-six percent of respondents with EID reported a physician visit secondary to EID with resulting diagnoses of asthma, EIB, allergies, stress reaction, and vocal cord dysfunction, or a combination of two or more of these conditions. Less than 30% of those diagnosed with asthma and/or EIB reported a diagnosis based on a pulmonary function test. **Conclusions and Recommendations:** EID is a common, yet complex, condition that appears to be as prevalent in club sports as it is in intercollegiate athletics. Asthma and exercise-induced bronchospasm (EIB) are the most familiar diagnoses associated with EID, though many conditions present with similar symptoms. Objective diagnostic testing was not commonly reported among college-aged athletes with asthma or EIB in this study. This finding conflicts with recent evidence-based recommendations for objective testing for athletes with EID to ensure appropriate and effective treatment plans.

#### INTRODUCTION

Dyspnea is a subjective sensation of difficulty breathing that may be associated with a variety of disorders.<sup>1</sup> Athletes engaged in strenuous exercise may experience dyspnea in varying degrees and many seek the advice of health care professionals when dyspnea interferes with a desired level of athletic performance. These patients may report a feeling of being "short of breath" or "unable to catch my breath," or may perceive their cardio-respiratory fitness level to be inadequate when compared to peers. Exercise-induced dyspnea (EID) may be related to cardiac and non-cardiac conditions. Cardiac conditions are a rare source of dyspnea in otherwise healthy athletic individuals, but should be considered in the context of pulmonary hypertension, hypertrophic cardiomyopathy, and dysrhythmias.<sup>2</sup> Non-cardiac conditions with symptoms of dyspnea include asthma, exercise

induced bronchospasm (EIB), vocal cord dysfunction, hyperventilation syndrome, anemia, physiologic limitations, and de-conditioning.<sup>2-4</sup> In some cases of unexplained dyspnea, a non-specific diagnosis of reactive airway disease has been used.<sup>5</sup> These conditions have overlapping symptoms (e.g., wheezing, coughing, chest tightness, shortness of breath) making self-reported symptoms unreliable for diagnostic purposes.<sup>3-7</sup>

Investigations of exercise-related respiratory complaints often focus on asthma and EIB, and these are common diagnoses in cases of self-reported EID. Asthma has been diagnosed in 8% of Americans, and 50-90% of individuals with asthma report that exercise exacerbates respiratory symptoms (bronchospasm).<sup>4,7,8</sup> Exercise-induced asthma (EIA) is the term for individuals with asthma exacerbated by exercise.<sup>3</sup> However, some individuals demonstrate bronchospasm secondary to exercise in the absence of underlying asthma, and the recommended term for this is EIB. Reports of prevalence of EIB range from 5-20% of the general population, up to 39% of intercollegiate athletes, and 30-50% of elite athletes.<sup>3,4,7,8</sup> College and elite athletes experience EIB more frequently than the general population, yet the true prevalence of EIB remains poorly defined.<sup>4,10</sup> It has been suggested that EIB is simultaneously under-, and over- diagnosed.<sup>7,11-13</sup>

Vocal cord dysfunction (VCD) is increasingly suspected in individuals with EID and has been diagnosed in 3-8% of athletes and in 12% of military recruits complaining of dyspnea related to exertion.<sup>14-16</sup> Further, VCD has been identified as a concomitant condition in 30-50% of patients with EIB.<sup>17-19</sup> Other studies have attributed EID to physiologic exercise limitation (maximum capacity of cardiovascular system) and to poor fitness or de-conditioning.<sup>11,12</sup> Another condition to consider in EID is hyperventilation, which occurs when respiration exceeds metabolic demands and when a decrease in arterial partial pressure of carbon dioxide (pCO<sub>2</sub>) and an increase in pH of the body fluids are observed.<sup>20</sup> If hyperventilation is sustained, dyspnea, light-headedness, paraesthesia, anxiety, and sweating may occur. These symptoms are collectively referred to as Hyperventilation Syndrome (HVS).<sup>20</sup> HVS has been misdiagnosed as asthma despite a lack of other clinical features.<sup>21</sup>

A variety of conditions can be associated with EID, yet our understanding of the prevalence of EID and differential diagnoses is limited. Studies evaluating dyspneic symptoms in athletes tend to focus on asthma and EIB, though some include atopy/allergies. Reports on the prevalence of "asthma mimics" such as VCD or HVS commonly describe patients previously diagnosed with asthma or EIB. There is limited information on the prevalence of EID and its effect on athletic participation.

Further, existing reports focus on intercollegiate or elite athletes with little attention to what might be termed sub-elite athletes. Club sport participants fill a gap between intercollegiate and recreational athletes, yet are often overlooked in published studies. We feel this group may provide an age- and gender-matched population that has similar exercise requirements without the tight structure associated with intercollegiate athletics. The purpose of this study was to explore the prevalence of EID in athletes who participate in club and intercollegiate athletics and to compare the resulting medical encounters, including diagnostic testing, for these two groups.

## **METHODS**

A questionnaire was distributed electronically to intercollegiate athletes (n = 294) and club sport participants (n = 475) at a university in the Midwest of the United States. A link to the questionnaire was included in an invitation to participate in the study that was sent to all rostered athletes. One e-mail reminder was sent two weeks after the initial contact. This study was approved by the Institutional Review Board.

Intercollegiate athletes (ICA) were defined as those listed on the official roster of a college athletic team sanctioned by the National Collegiate Athletic Association (NCAA), and club sport participants (CSP) were defined as those college students who participated in organized, competitive athletics not sponsored by the NCAA. Club sports typically receive less institutional funding and fewer support services than NCAA sponsored sports.

Participants were asked to identify the type and level of their athletic participation as well as provide information regarding EID and the results of subsequent health care encounters related to this condition. Data collected included characterization of dyspneic episodes, diagnostic procedures, physician diagnoses, treatment and effectiveness of treatment, and any alteration of participation secondary to EID. Data analysis techniques included descriptive (frequencies, cross-tabulations) and comparative (ANOVA, Chi Square) measures. Data analysis was conducted utilizing a statistical software program (PASW 18.0, SPSS, Inc., Chicago, IL).

## Results

The questionnaire was distributed electronically to 769 athletes. Two hundred twenty-four questionnaires were returned (29%); 214 had complete data. The response rate for CSPs was 21% (102/475) and 41.5% for ICAs (122/294). Females provided 58.4% of all usable data (n=125) and represented 66% of ICA respondents. (Table 1)

**Table 1. Respondents with Usable Data by Gender**

	Male n (%)	Female n (%)	Population
Respondents‡	89 (41.6)	125 (58.4)	47% male; 53% female
Intercollegiate †	41 (33.6)	81 (66.4)	46.5% male; 53.5% female
Club Sports	48 (42.2)	44 (47.8)	Not available

‡Male:female ratio overall not different from University enrollment census;  $p > .05$   
† Male:female ratio for ICA indicates greater female representation compared to athletic department census ;  $p = .0002$ ; 95% CI 0.5942, 0.7201

Overall, 52% of respondents (n=112) reported previous episodes of EID, with 58% of all females (n=73) and 44% of all males (n=39) reporting EID (Table 2). Forty-six percent of participants reporting EID attributed this, in part, to their level of fitness.

**Table 2. Athletes with Self-Reported EID**

	Endurance Classification			Total ‡
	Low to moderate	High	Very high	
	n (%)	n (%)	n (%)	
<b>ICA</b>	12 (48%)	13 (34%)	37 (63%)	62/122 (50.8%)
<b>Female</b>	9 (56%)	10 (38.4%)	27 (69.2%)	46
<b>Male</b>	3 (33%)	3 (25%)	10 (50%)	16
<b>CSP</b>	7 (37%)	30 (60%)	10 (43%)	50/92 (54.3%)
<b>Female</b>	4 (50%)	16 (64%)	7 (63%)	27
<b>Male</b>	3 (27.7%)	14 (56%)	6 (50%)	23

n = number of respondents with EID;  
% = percentage of respondents participating in particular sport classification who self-report EID;  
‡ No significant difference in self-reported EID between ICA and CSP  $\chi^2 = 0.262$ ,  $p = 0.61$   
‡ Females more likely to report EID [F (1, 212) = 4.481,  $p = .035$ ]

Sixty-six percent of respondents with EID (n=74) sought direction from a health care professional. No difference was found in the rate at which ICAs and CSPs sought medical assistance or in the rates at which they reported being treated for EID (Table 3). Participants reported a variety of medical diagnosis resulting from their physician encounters (Table 4). With regard to asthma and EIB, 27 respondents reported a diagnosis of asthma (12.6%) and 35 reported a diagnosis of EIB (16.3%), yet less than 30% of respondents reported a diagnosis through a pulmonary function test (PFT) (29%, and 28.6%, respectively).

**Table 3. Respondents Encounters with Health Care Professionals**

	ICA n (%)	CSP n (%)	Total n (%)
<b>Self-Reported Exercise Induced Dyspnea</b>	62	50	112
<b>Physician Visit ‡</b>	43 (69%)	31 (65%)	74 (66%)
<b>PFT</b>	12 (28%)*	6 (19%)*	18 (24%)*
<b>Receive Treatment §</b>	28 (65%)*	30 (96%)*	58 (70%)*
<b>Treatment is Effective †</b>	21 (75%)	28 (93%)	49 (84%)

\*Percentage of respondents reporting physician visit secondary to exercise induced dyspnea  
‡ No difference between groups  $\chi^2 = 0.402$ ,  $p = .526$   
§ No difference between groups  $\chi^2 = 0.902$ ,  $p = .342$   
† ICAs more likely to perceive treatment as ineffective  $\chi^2 = 5.48$ ,  $p = .019$

**Table 4. Reported Physician Diagnoses for Participants with EID**

Diagnosis	ICA (n=62)	CSP (n=50)	Total (n=112)	Comments
Asthma †	15 (24%)	12 (24%)	27 (24%)	26% ICA report PFT 33% CSP report PFT
EIB	19 (35%)	16 (32%)	35 (31%)	42% ICA report PFT ‡ 12% CSP report PFT
Allergies	28 (45%)	21 (42%)	49 (43.8%)	
Post-nasal drip	4 (6.4%)	1 (2%)	5 (4.5%)	
VCD	3 (4.8%)	2 (4%)	5 (4.5%)	
Stress Reaction	4 (6.5%)	2 (4%)	6 (5.3%)	
Other	0	3	3	Exercise induced angioedema (1); Thoracic facet syndrome (1); Repeated concussion (1)

ICA = Intercollegiate Athlete; CSP= Club Sport Participant; PFT = Pulmonary Function Test  
† includes 11 participants with asthma + EIB  
‡ ICA with EIB more likely to report PFT  $\chi^2 = 4.493$ ,  $p=0.034$

Environmental conditions were perceived as having an impact on EID, with 56% (n=51) of respondents with EID reporting more symptoms in cold weather and 75% (n=84) reporting more symptoms during practice or training sessions (Table 5). Respondents' characterization of EID symptoms is reported in Table 6. Dyspneic symptoms forced 17% of respondents with EID (n=19) to alter their participation in some way to manage symptoms of EID, with 2 respondents indicating that they retired from intercollegiate athletics as they were not able to attain a desired level of performance secondary to EID. Overall, ICAs were less likely to perceive interventions as being effective in treating EID ( $\chi^2 = 5.48$ ,  $p=0.019$ ).

**Table 5. Respondents' Recall of Environment of Exercise Induced Dyspnea**

Exercised related dyspnea n= 112					
Are symptoms more likely to occur in warm or cold weather?		Where are symptoms most likely to occur?		When are symptoms most likely to occur?*	
Warm	20 (18%)	Indoors	30 (27%)	Practice	84 (75%)
Cold	56 (51%)	Outdoors	39 (35%)	Competition	46 (41.5%)
No difference	34 (31%)	No difference	42 (39%)	When stressed	14 (12.5%)

\*Total exceeds 100% as twenty-four respondents indicated dyspneic episodes to be most likely in more than one setting (i.e., practice and competition, or practice and stressful situations)

**Table 6. The Most Common Complaints Associated with Exercise Induced Dyspnea**

When I have trouble breathing I experience:	n (%)
Trouble inhaling	44 (39%)
Tightness in chest	21 (19%)
Wheezing	20 (17%)
Tightness in throat	8 (7%)
Choking/Suffocating	5 (4.5%)
Numbness	4 (3.5%)
Trouble exhaling	3 (3%)
All of the above	4 (3.5%)

Participants were stratified into groups according to the endurance requirement of their particular sport. Utilizing the categories described by Thomas et al respondents were identified as having a low to moderate endurance requirement (LM), high endurance requirement (HE), and very high endurance requirement (VH) (Table 7).<sup>10</sup> Twenty percent of participants were categorized as low to moderate endurance (e.g. baseball, tennis), 41% as high endurance (e.g., basketball, soccer), and 38% as very high endurance (e.g. track and field, cycling, swimming). There was a tendency among ICA respondents to report EID more frequently in VH classification sports and for CSPs to report EID more frequently in HE classification of sport; these differences were not significant ( $F(2, 211) = 2.86$ ,  $p=0.058$ ) (Table 3).

**Table 7. Endurance Classification of Sport**

Low to Moderate Endurance	High Endurance	Very High Endurance
Baseball	Basketball	Cycling
Softball	Field Hockey	Crew
Tennis	Fencing	Running
Badminton	Ice Hockey	Swimming
Golf	Lacrosse Soccer	Track & Field
Racquetball	Volleyball	Water Polo

Adapted from Thomas et al, 2010

## Discussion

Dyspnea is a common complaint among ICAs and CSPs. Previous reports have suggested that shortness of breath is the most common respiratory complaint among athletes, and our findings support this as 52% of all respondents and virtually all (95%) of those with EID complained of difficulty inhaling or exhaling, tightness in the chest or throat, wheezing, or a sensation of suffocating. These symptoms are often associated with asthma or EIB, though self-reported symptoms have been found to be unreliable for the diagnosis of asthma or EIB.<sup>2,4,6-9,20,23-26</sup>

The prevalence of self-report of physician-diagnosed asthma in the current study (12.6%) is consistent with previous surveys of collegiate and elite (international level) athletes. Other questionnaire-based studies of intercollegiate and elite athletes have reported asthma prevalence rates of 10-17%.<sup>10,26-33</sup> Sixteen percent of our respondents reported a diagnosis of EIB, a figure certainly within the range reported among cohorts of ICAs (2.5-39%).<sup>6,25</sup> Almost one-quarter of respondents (23%) reported a diagnosis of allergies. This compares to 25% of German Olympic level athletes with a diagnosis of allergic rhinitis and 23.8% of Canadian athletes with nasal allergies.<sup>10,27</sup> Overall, 44% of our respondents with EID reported physician diagnosed allergies, and approximately 75% of these were reported as concomitant conditions with asthma and/or EIB. A relationship between allergic rhinitis and EID has been identified in the literature.<sup>3,4,10</sup>

Our respondents reported a remarkably low utilization of PFT in the evaluation of EID. It is possible that some respondents simply did not recall the testing or failed to understand the terminology. However, with only 28% percent of ICAs and 19% of CSPs with respiratory symptoms recalling a PFT, we cannot refute portrayals of diagnoses based on patient reported symptoms. In addition, fewer than 30% of respondents with physician-diagnosed asthma and/or EIB indicated a PFT was performed. Interestingly, ICAs with EIB were more likely to report a PFT, yet less likely to receive therapeutic intervention for EID. We did not ask when the respondents sought medical attention for their dyspnea and respondents may have been diagnosed prior to university enrollment. We do not know if regulations regarding beta-2 agonists and drug testing programs that impact intercollegiate, but not club sport programs, affect the prescribing practices of physicians treating these athletic patients.

The limited reporting of objective diagnostic testing is a concern as EIB is both under-recognized and over-diagnosed in the athletic population.<sup>6,7,13,25</sup> Rundell et al reported a similarity in the prevalence of EIB based on self-report and sport-environment specific exercise testing.<sup>7</sup> The authors cautioned, however, that the individuals in the two groups (those identified through self-report versus objective testing) were different, and suggested that self-reported symptoms in high level athletes are of little diagnostic value. The poor reliability of self-reported symptoms was also illustrated in a study of ICAs with a reported history of respiratory distress after exercise; only 2.8% of participants were identified as EIB positive (FEV<sub>1</sub> decrease  $\geq$  10%) after an exercise test.<sup>25</sup> A subsequent study that utilized eucapnic voluntary hyperpnea (EVH) testing to identify EIB in ICAs with physician-diagnosed EIB or self-described symptoms of EID reported 21.6% of participants tested positive for EIB.<sup>13</sup> Interestingly, 80% of the athletes in that study (16 of 20) who had been previously prescribed bronchodilators for control of EIB did not have a positive response on an objective diagnostic test. Parsons et al performed EVH on a group of ICAs with and without a history of EID and identified a positive test in 39% of participants.<sup>6</sup> A majority (86%) of the positive tests occurred in individuals who had reported no previous EIB or asthma, and only 35% of those with previous respiratory symptoms had a positive response to the challenge test. A bronchial challenge test, utilizing exercise, inhaled mannitol or EVH, with spirometry should be utilized to demonstrate evidence of bronchospasm.<sup>3,6,13</sup>

Exercise testing capable of mimicking sport activity is useful, but is not as sensitive as the EVH test and may not be appropriate for all athletes.<sup>24,25</sup> Several reports stress the importance of mimicking the environmental and exercise stress that triggers dyspnea and note that achieving appropriate exercise stress is difficult with highly trained athletes.<sup>24,31,32</sup> Exercise testing employed as part of a pre-participation physical exam identified EIB in 12% of high school athletes (FEV<sub>1</sub> decrease  $\geq$  15%).<sup>33</sup> This free-running test with spirometry better identified EIB than peak expiratory flow rate (PEFR) or symptom questionnaires. We

believe that the variance in prevalence rates reported in the literature underscores the influence the type of testing (or lack of testing) may have on these data.

With so much attention to asthma and EIB, it is important to recognize the other diagnoses reported in this study. None of the respondents reported a history of cardiac conditions or HVS, and none related their EID to these conditions. Slightly more than 2% of all respondents (2.3%) reported a diagnosis of VCD, 2.8% reported a diagnosis of stress reaction, and 2.8% reported post-nasal drip. The prevalence of VCD is slightly lower than that reported in previous studies, though the relationship between diagnoses of stress reaction and VCD described in previous reports leaves the possibility that VCD is under-diagnosed in this cohort.<sup>15,17</sup>

Our findings were consistent with previously published accounts of self-reported findings in regard to females reporting asthma, EIB, and VCD more frequently, and to cold weather as an exacerbating factor for EID.<sup>6,7,10,17,18,26,27,30</sup> Our findings did not identify a greater prevalence of EID in athletes from very high endurance sports, and this is consistent with prior self-reports of college-aged athletes.<sup>26</sup> Our respondents indicated EID occurs most often in practice settings, though this could be expected as athletes spend more time in practice than in competition. The relative high rate of EID during practice and competition indicates that athletes and athletic health care providers should be prepared for dyspneic episodes in either setting.

Forty-one percent of those with EID indicated a lack of fitness contributed to their EID. This perception was consistent among ICAs and CSPs with physician diagnosed asthma (40% and 41% respectively). In contrast, 27% of ICAs with EIB perceived poor fitness to be a factor in EID compared to 50% of CSPs. Low fitness levels may be underappreciated as a cause of EID in athletes; however, studies of young athletes (12-21 years old) reporting symptoms or a diagnosis of EIB identified poor fitness to be the source of EID in 23% of individuals.<sup>11,12</sup> Similarly, physiologic limitations have been identified as a source of EID in as many as ½ of adolescents referred for evaluation of asthma or asthma symptoms.<sup>11</sup> Healthcare providers must consider that some episodes of EID are a result of increased respiratory demands that exceed an individual's exercise capacity. The relative difficulty of performing objective testing to document physiological limitations may explain why this diagnosis is not high on the list of differential diagnoses for EID.

Finally, we suspected that ICAs, with access to the athletic health care team, would report a greater frequency of physician visits secondary to EID. Yet, we found no difference between groups relative to seeking advice of a health care provider with approximately 66% of those with EID reporting a physician visit secondary to EID. We observed similar rates of specific diagnoses for ICAs and CSPs with EID.

### Limitations

The response rate observed in CSPs was low (29%), and we do not have data on those who elected to not participate in this study. Further, the design of this study did not allow us to explore the accuracy of the reported diagnoses, as we relied on patient recollections, a limitation identified in other questionnaire-based studies. However, the degree to which our findings are consistent with previous questionnaire-based studies increases our confidence in the findings.

### Clinical Implications

EID is a common complaint among athletes, and athletes at various levels of competition are equally likely to seek medical advice when dyspnea interferes with athletic participation. Further, the self-reported prevalence of specific conditions associated with EID appear to be similar among ICAs and CSPs. Health care professionals should be aware of the signs and symptoms of various conditions that contribute to EID. With much attention directed toward asthma and EIB, concomitant conditions such as allergies, stress/anxiety, HVS, and VCD need to be considered. Given the discrepancy between self-reported symptoms and objective testing results, health care professionals must advocate for objective diagnostic testing for athletes complaining of EID to ensure appropriate and effective treatment plans.

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