Incidence of exercise-induced bronchospasm in Olympic winter sport athletes

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ABSTRACT

WILBER, R. L., K. W. RUNDELL, L. SZMEDRA, D. M. JENKINSON, J. IM, and S. D. DRAKE. Incidence of exercise-induced bronchospasm in Olympic winter sport athletes. *Med. Sci. Sports Exerc.*, Vol. 32, No. 4, pp. 732–737, 2000. **Purpose:** The purpose of this project was to determine the incidence of exercise-induced bronchospasm (EIB) among U.S. Olympic winter sport athletes. **Methods:** Subjects included female and male members of the 1998 U.S. Winter Olympic Team from the following sports: biathlon, cross-country ski, figure skating, ice hockey, Nordic combined, long-track speedskating, and short-track speedskating. Assessment of EIB was conducted in conjunction with an "actual competition" (Olympic Trials, World Team Trials, World Cup Event, U.S. National Championships) or a "simulated competition" (time trial, game), which served as the exercise challenge. Standard spirometry tests were performed preexercise and at 5, 10, and 15 min postexercise. An athlete was considered EIB-positive based on a postexercise decrement in $FEV_1 \geq 10\%$. **Results:** For the seven sports evaluated on the 1998 U.S. Winter Olympic Team, the overall incidence of EIB across all sports and genders was 23%. The highest incidence of EIB was found in cross-country skiers, where 50% of the athletes (female = 57%; male = 43%) were diagnosed with EIB. Across the seven sports evaluated, the prevalence of EIB among the female and male athletes was 26% and 18%, respectively. Among those individuals found to be EIB-positive were athletes who won a team gold medal, one individual silver medal, and one individual bronze medal at the Nagano Winter Olympics. **Conclusions:** These data suggest that: 1) EIB is prevalent in several Olympic winter sports and affects nearly one of every four elite winter sport athletes; 2) the winter sport with the highest incidence of EIB is cross-country skiing; 3) in general, EIB is more prevalent in female versus male elite winter sport athletes; and 4) athletes may compete successfully at the international level despite having EIB. **Key Words:** ASTHMA, EXERCISE-INDUCED BRONCHOSPASM, ELITE ATHLETES, WINTER SPORT ATHLETES

It is well established that a cold and dry ambient environment is an important factor contributing to the severity of exercise-induced bronchospasm (EIB) (2). Increased bronchial responsiveness resulting from the performance of exercise in cold and dry environmental conditions has been associated with two potential pathophysiological mechanisms (13,15). The first of these mechanisms is referred to as the hyperosmolarity theory. This theory contends that the exercise-induced hyperventilation of cold dry air leads to a loss of heat and water from the epithelium of the bronchial mucosa, a physiological response that is necessary to warm and humidify the inhaled air. The loss of heat and water from the bronchial mucosa results in an increase in the tissue's osmolarity, which in turn triggers the release of histamine and other mediators to induce bronchoconstriction. The second proposed mechanism, the thermal expenditure theory, proposes that rapid rewarming of the airways after exercise causes bronchoconstriction. Specifically, it is believed that during intense exercise in a cold and dry environment, heat is lost to the exhaled air from the bronchiolar blood vessels of the pulmonary vascular bed. After exercise, these bronchiolar blood vessels are rewarmed, which results in vasodilation and hyperemia, thereby causing bronchoconstriction.

Despite the fact that a cold and dry ambient environment is a well known exacerbant of exercise-induced bronchospasm, there are minimal data on the incidence of EIB in winter sport athletes. Data are particularly scarce for winter sport athletes who are competitive at the World Championship and/or Olympic level. Larsson et al. (8) used a methacholine challenge protocol to assess the incidence of asthma in elite Swedish female and male cross-country skiers (N = 42) and age- and gender-matched control subjects (N = 29). Asthma was defined as "bronchial hyperresponsiveness" (quantified as a PC_{20} methacholine concentration below the 10th percentile of control values) plus two symptoms identified from a written survey (cough, abnormal shortness of breath, chest tightness, and wheezing induced by asthma trigger factors, such as exercise and/or cold air). Asthma, as defined by the study criteria, was significantly more prevalent in the cross-country skiers (33%) versus the control

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subjects (3%). In addition, 55% of the athletes had asthma as defined by the study criteria *or* as previously diagnosed by a physician. There was no significant difference in bronchial responsiveness between the winter and summer seasons in either the skiers or controls (8). Provost-Craig et al. (10) reported that within a group of 100 competitive figure skaters (including some Olympic caliber athletes), 30% of the athletes were EIB-positive based on a postexercise decrement in $FEV_1 \geq 10\%$. Heir and Oseid (5) used a questionnaire to determine the prevalence of asthma and/or EIB among "high level" female and male Norwegian cross-country skiers ($N = 153$) and age-, gender-, and environmentally-matched controls ($N = 306$). The prevalence of asthma "as diagnosed by a physician" was significantly higher in the cross-country skiers (14%) versus the controls (5%). In addition, exercise-induced respiratory symptoms (chest tightness, shortness of breath, cough, wheezing, and sputum production) were much more frequent among the cross-country skiers; at least one exercise-induced respiratory symptom was reported by 86% of the athletes compared with 35% of the control subjects (5). Survey data reported recently by Weiler and Hunt (17) indicated that 17% of the athletes on the 1998 U.S. Winter Olympic Team had a history of EIB. Within that group, 12% had a known diagnosis of asthma and had taken medications, 3% had a diagnosis but were not taking medications, and 2% had never been diagnosed but took asthma medications (17).

Collectively, limited data on the incidence of exercise-induced bronchospasm among elite winter sport athletes suggests that asthma and/or EIB are more prevalent in elite athletes versus age-, gender-, and environmentally-matched controls. However, the few studies that have assessed the incidence of EIB in elite winter sport athletes have relied on survey data or have evaluated EIB in a limited number of winter sports (cross-country skiing, figure skating). Accordingly, the purpose of this project was to evaluate the prevalence of EIB among Olympic team athletes from several winter sports using pre- and post-exercise spirometry. A unique aspect of this study was the fact that EIB screening was conducted on Olympic athletes in the field in conjunction with an "actual competition" (Olympic Trials, World Team Trials, World Cup Event, U.S. National Championships) or a "simulated competition" (time trial, game). We believed that evaluation of EIB in the field using an actual or simulated competition as the exercise challenge would provide two distinct advantages over testing in the clinical environment: 1) athletes would produce a sustained competitive effort, as opposed to exercising for 6–8 min at 85–90% HR_{max} per a standard clinical protocol; and 2) athletes would be evaluated in the ambient cold environment in which they typically train and compete. Thus, by using a protocol that allowed for the evaluation of EIB during highly competitive, sport-specific situations in a cold ambient environment, we believed that a more valid quantification of the incidence of EIB among Olympic winter sport athletes would result.

METHODS

Subjects. Subjects included female and male U.S. elite winter sport athletes from the following sports: biathlon ($N = 34$), cross-country ski ($N = 14$), figure skating ($N = 60$), ice hockey ($N = 26$; female athletes only), Nordic combined ($N = 10$; male athletes only), long-track speedskating ($N = 15$), and short-track speedskating ($N = 11$). Procedures were outlined and written informed consent was obtained from the subjects before testing. All experimental procedures were approved by the Institutional Review Board of the Sport Science and Technology Division of the United States Olympic Committee (USOC).

Procedures. Assessment of EIB was conducted in conjunction with an "actual competition" (Olympic Trials, World Team Trials, World Cup Event, U.S. National Championships) or a "simulated competition" (time trial, game), which served as the exercise challenge. Standard spirometry tests were performed preexercise and at 5, 10, and 15 min postexercise using a calibrated computerized 10.2-L rolling dry-seal spirometer (Sensormedics, Yorba Linda, CA). Pulmonary function measures included forced vital capacity (FVC), forced expiratory volume in the first second of maximal expiration (FEV_1), FEV_1/FVC ratio, midmaximal expiratory flow rate ($FEF_{25–75}$), and peak expiratory flow rate (PEF). Details of the spirometry procedure are as follows.

Preexercise. Athletes reported to the competition venue for preexercise evaluation, which was completed before the athletes began to warm up or do any other major physical activity. Athletes refrained from taking any medications that might have confounded the pulmonary function results. After proper instruction and orientation, the athlete completed the following uninterrupted breathing sequence (20): 1) three normal tidal volume breaths, 2) maximal inhalation, 3) forced maximal exhalation, and 4) maximal inhalation. Successful completion of this breathing sequence was considered as trial 1. After adequate recovery (1–2 min), the breathing sequence was repeated twice for a total of three preexercise trials. Using specific criteria (16), the best (i.e., highest values) of the three preexercise trials was selected for analysis. Any athlete whose preexercise FVC and/or FEV_1 was less than 70% of age-, height-, and gender-predicted values (7) was excluded from the study.

Exercise challenge. Upon completion of their normal precompetition warm-up, the athletes completed an "actual competition" (Olympic Trials, World Team Trials, World Cup Event, U.S. National Championships) or a "simulated competition" such as a time trial or an uninterrupted game/ scrimmage. Table 1 provides the details of each of the sport-specific exercise challenges, including the ambient conditions in which they were performed.

Postexercise. Athletes completed spirometry tests at 5, 10, and 15 min postexercise after the identical procedures used in the preexercise spirometry test with the following exception: only one trial was performed at each of the postexercise time points so as not to exhaust the athletes and compromise their breathing technique. The entire EIB

TABLE 1. Details of the sport-specific exercise challenges used to evaluate exercise-induced bronchospasm (EIB) in U.S. Olympic winter sport athletes.

Sport	Competition	Location	Ambient Conditions		
			Temp (°C)	P_B (mm Hg)	RH (%)
Biathlon	1997 U.S. World Team Trials[a]	Mt. Van Hoevenberg, Lake Placid, NY	−12 to −11	700–713	50–100
Cross-country ski	1998 U.S. Olympic Team Trials[b]	Mt. Van Hoevenberg, Lake Placid, NY	−18 to −0	700–707	30–50
Figure skating	Simulated "long program"[c]	World Arena, Colorado Springs, CO	8 – 10	610–615	30–35
Hockey	Simulated game[d]	Olympic Ice Center, Lake Placid, NY	10 – 13	713–722	40–45
Nordic combined	1997 World Cup Event[e]	Mt. Van Hoevenberg, Lake Placid, NY	−7 to −5	700	45–50
Speedskating—LT	1500-m time trial	Pettit Ice Center, Milwaukee, WI	10 – 12	745	50–55
Speedskating—ST	1000-m time trial	World Arena, Colorado Springs, CO	8 – 10	612	30–35

[a] Cross-country ski distances included 7.5, 10, 15, and 21 km.
[b] Cross-country ski distances included 5 km (classical), 10 km (classical and skating), 15 km (skating), and 30 km (skating).
[c] Long program ~ 4 min.
[d] Athletes were evaluated after completion of several line shifts (line shift ~ 2 min).
[e] Cross-country ski distance was 15 km.
P_B, barometric pressure; RH, relative humidity; LT, long track; ST, short track.

evaluation required the athlete to successfully complete six trials (three preexercise trials; one trial at 5, 10, and 15 min postexercise).

Diagnosis of exercise-induced bronchospasm. The best of the preexercise trials, along with the individual trials measured at 5, 10, and 15 min postexercise were used to determine the presence of EIB. An athlete was considered EIB-positive based on a postexercise decrement in $FEV_1 \geq$ 10% (14).

Calculation of the EIB incidence rate for U.S. Olympic Team athletes. The prevalence of EIB was determined for seven sports represented on the 1998 U.S. Winter Olympic Team. After the U.S. Olympic Team roster was finalized, a subgroup of "Olympic athletes" was analyzed retrospectively from our original data pool (which included non-Olympians and Olympians). Using the subgroup of "Olympic athletes," the EIB incidence rate was determined by calculating a ratio of the number EIB-positive athletes to the total number of athletes and multiplying that value by 100. This calculation was made using the EIB-positive athletes and total number of athletes from each of the seven Olympic winter sports that we evaluated. A minimal number of athletes (3%) who made the 1998 U.S. Winter Olympic Team in the sports that we evaluated were not in our original data pool for reasons beyond our control (international travel, injury, etc.).

RESULTS

For the seven sports evaluated on the 1998 U.S. Winter Olympic Team, the overall incidence of EIB across all sports and genders was 23% (Table 2). Among those found to be EIB-positive were athletes who won a team gold medal, one individual silver medal, and one individual bronze medal at the 1998 Nagano Winter Olympics. Spirometry results for one of these medalists are shown in Figure 1. Among the seven sports evaluated on the 1998 U.S. Winter Olympic Team, the highest incidence of EIB was found in cross-country skiers (female = 57%; male = 43%), whereas the lowest was measured in biathlon where no female or male biathlete was diagnosed with EIB (Table 2). The second highest incidence of EIB was observed in the short-track speedskaters (female = 50%; male = 33%). Across all seven Olympic winter sports evaluated, the prevalence of EIB among the female athletes was 26%, whereas EIB was diagnosed in 18% of the male athletes (Table 2). Similarly, EIB was more common among the women in each sport where female and male data were collected except in the sport of biathlon.

DISCUSSION

The purpose of this project was to evaluate the prevalence of EIB among Olympic caliber athletes from several winter sports. A unique aspect of this study was the fact that EIB screening was conducted on Olympic athletes in the field in conjunction with actual or simulated competition. Previous authors (9,13) have suggested that elite athletes should be evaluated for EIB using sport- and environmentally-specific protocols to ensure a more accurate diagnosis. In addition, it seems important to evaluate elite winter sport athletes during the competitive season when EIB may be more prevalent than during the off-season (4). To our knowledge, this study represents the first attempt at determining the incidence of EIB in Olympic athletes from several winter sports during the competitive season using a protocol that required the athletes to produce a sustained near-maximal effort in a cold environment. By using this sport- and environmentally-specific protocol, we believe that a more valid quantification of the incidence of EIB among elite winter sport athletes was documented.

TABLE 2. Incidence of exercise-induced bronchospasm (EIB) among athletes on the 1998 U.S. Winter Olympic Team.

Sport	Incidence of EIB (%)		
	Female	Male	Team
Biathlon	0	0	0
Cross-country ski	57	43	50
Figure skating	29	14	21
Hockey	15	*a*	15
Nordic combined	*b*	17	17
Speedskating—LT	25	0	9
Speedskating—ST	50	33	43
Total	26	18	23

[a] Men's hockey team was not evaluated.
[b] Nordic combined is a male-specific sport.
LT, long track; ST, short track.

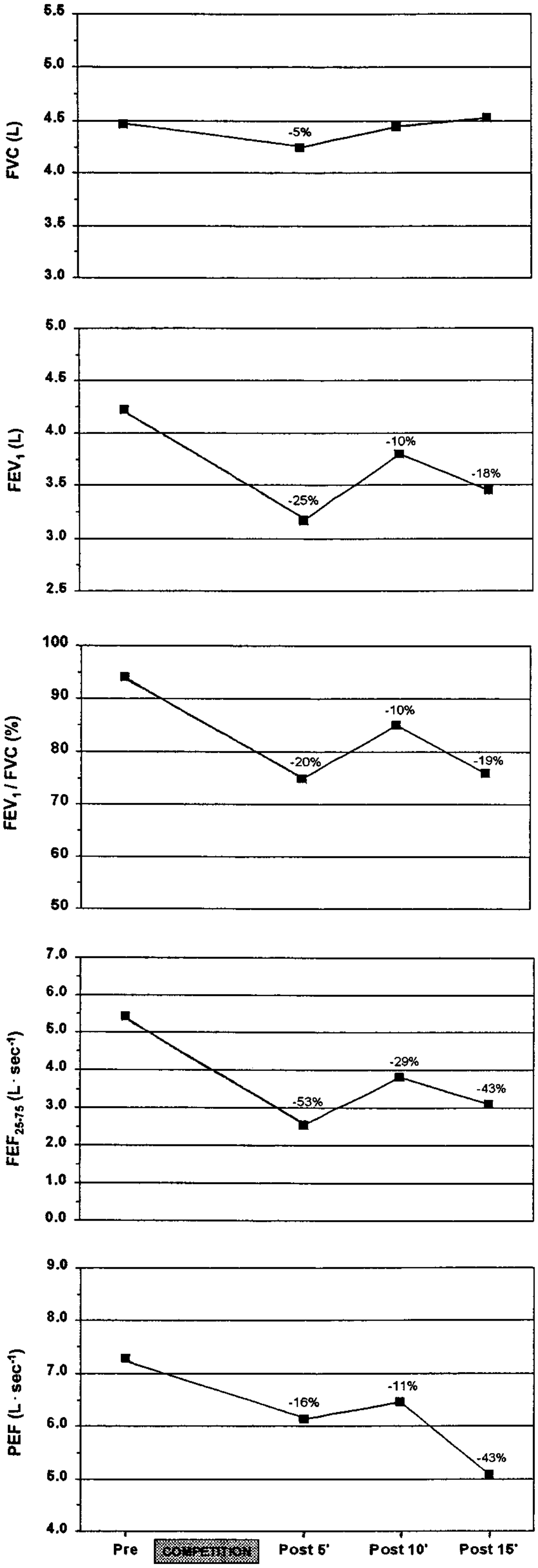

Figure 1—Spirometry results for a member of the 1998 U.S. Winter Olympic Team. The results shown here were obtained approximately 4 months before the Nagano Winter Olympics. A standard asthma medication regimen was prescribed by the team physician based on these results. The athlete was a medalist at the Nagano Winter Olympics. The values shown are decrements in pulmonary function parameters at 5, 10, and 15 min postexercise relative to preexercise. FVC, forced vital capacity; FEV$_1$, forced expiratory volume in the 1st second of maximal expiration; FEF$_{25-75}$, midmaximal expiratory flow rate; PEF, peak expiratory flow rate.

Among the seven sports on the 1998 U.S. Winter Olympic Team that we evaluated, the overall incidence of EIB across all sports and genders was 23% (Table 2) which is higher relative to the incidence rate for "physically active people" (3–15%) (12). It should be noted that some of the Olympic winter sports (alpine skiing, bobsled, curling, luge, ski jumping) were not included in this study due to logistical and time constraints. However, in those sports where the exercise intensity and/or duration is relatively low (e.g., curling, ski jumping), it seems logical to assume that the incidence of EIB is minimal. On the other hand, in the physically demanding sport of alpine skiing the prevalence of EIB may be fairly high. Despite these limitations, we believe that the 23% incidence rate derived from seven of the Olympic winter sports provides a relatively accurate quantification of the prevalence of EIB for the 1998 U.S. Winter Olympic Team.

Weiler and Hunt (17) recently indicated that 17% of the athletes on the 1998 U.S. Winter Olympic Team had a history of EIB. Within that group, 12% had a known diagnosis of asthma or EIB and had taken medications, 3% had a diagnosis but were not taking medications, and 2% had never been diagnosed but took asthma medications. The 17% incidence rate reported by Weiler and Hunt (17) was lower than the 23% rate that we observed. This discrepancy may be explained by the fact that the findings of Weiler and Hunt (17) are based on survey data, whereas our results are based on pulmonary function tests performed in conjunction with an actual or simulated competition. Collectively, the data of these two investigations suggested that EIB was prevalent in approximately one of every five athletes on the 1998 U.S. Winter Olympic Team.

Among the seven sports that we evaluated on the 1998 U.S. Winter Olympic Team, the highest prevalence of EIB was found in cross-country skiers (Table 2). Exercise-induced bronchospasm was diagnosed in 50% of the cross-country skiers, with the incidence of EIB found to be higher in the female athletes (57%) versus the male athletes (43%). Similar findings were reported by Larsson et al. (8), who used a methacholine challenge protocol to determine the incidence of asthma in elite Swedish female and male cross-country skiers. Larsson et al. (8) defined asthma as "bronchial hyperresponsiveness" (quantified as a PC_{20} methacholine concentration below the 10th percentile of control values) plus two symptoms identified from a written survey (cough, abnormal shortness of breath, chest tightness, and wheezing induced by asthma trigger factors such as exercise and/or cold air). Asthma, as defined by the study criteria, was significantly more prevalent in the cross-country skiers (33%) versus control subjects (3%). In addition, Larsson et al. (8) reported that 55% of the athletes had asthma as defined by the study criteria *or* as previously diagnosed by a physician. Thus, based on our data and the findings of others (8) it appears that the highest rates of EIB among elite winter sport athletes are found in cross-country skiers, and that EIB may be manifest in approximately half of all elite cross-country skiers. This is not surprising given the intensity and duration of cross-country skiing, as well as the extraordinary exposure to cold and dry environmental conditions that cross-country skiers encounter during training and competition. Indeed, the ambient temperatures that the cross-country skiers competed in at the 1998 U.S. Olympic Trials (−18 to 0° C) were the coldest of all the environmental conditions in this study (Table 1).

Given the fact that the highest incidence of EIB among the Olympic athletes that we evaluated was found in cross-country skiers, it was somewhat surprising that biathlon, a winter sport that combines cross-country skiing and rifle marksmanship, had a relatively low incidence of EIB. In fact, no female or male biathlete on the 1998 U.S. Winter Olympic Team was diagnosed with EIB (Table 2). On most of the days that we screened the biathletes for EIB, the ambient conditions were relatively cold and dry. However, one of the competition days at the U.S. Biathlon World Team Trials was characterized by unseasonably warm (11°C) and humid conditions. It is quite possible that some of the biathletes who were found to be asymptomatic for EIB on that day may have been diagnosed as EIB-positive if they were evaluated in colder, more seasonable conditions. This appears to have been true for three of the Olympic team biathletes who tested negative for EIB on the unseasonably warm day at the U.S. Biathlon World Team Trials (present study) but were EIB-positive when tested by our group during the post-Olympic year in very cold and dry conditions (11). Perhaps a more representative estimate of the prevalence of EIB among elite biathletes is the 12% incidence rate that we observed for the U.S. National Team, a larger group that was comprised of both Olympians and non-Olympians.

The second highest incidence of EIB among the Olympic athletes that we evaluated was found in short-track speedskating, where 43% of the athletes (female = 50%, male = 33%) were diagnosed with EIB. The exercise challenge for the short-track speedskaters was a 1000-m time trial, which was performed on a regulation-size ice hockey rink. Total duration of the 1000-m time trial ranged from approximately 1:40 (min:s) to 1:42 for the women, and 1:30 to 1:33 for the men. Among the exercise challenges used for all seven Olympic winter sports evaluated in this study, the 1000-m time trial performed by the short-track speedskaters was the shortest in terms of duration and distance. Despite the fact that the short-track speedskaters exercised for less than 2 min, over 40% of the athletes were diagnosed with EIB. This suggests that near-maximal exercise intensity and accompanying high ventilatory rate may be more critical factors than exercise duration in triggering EIB among elite winter sport athletes. Another possible factor explaining the relatively high incidence of EIB among the short-track speedskaters may be related to the fact that they were evaluated at moderate altitude (1860 m/6100 ft), whereas most of the other sports were not. Thus, decrements in P_IO_2 and/or relative humidity (i.e., dry subalpine air) may have contributed to the relatively high occurrence of EIB in short-track speedskating. A final factor that must be considered is the effect of air pollutants such as carbon monoxide (CO) and nitrogen dioxide (NO_2), which are emitted by fuel-powered ice resurfacing machines and have been shown to increase bronchial resistance (1). The short-track speedskaters were evaluated for EIB in an ice rink that used an electrically powered ice resurfacing vehicle and had trained for approximately 3 months before the EIB test in the same facility. However, before that time the speedskaters had trained for several months in an ice rink that used a fuel-powered ice resurfacing machine. Therefore, it is possible that previous chronic exposure to CO and NO_2 may have been a factor contributing to the relatively high incidence of EIB in the short-track speedskaters.

Across the seven Olympic winter sports that were evaluated in this study, the incidence of EIB among female athletes was 26%, whereas EIB was diagnosed in 18% of the male athletes (Table 2). Similarly, EIB was more prevalent among the women in each sport where female and male data were collected except in the sport of biathlon: biathlon (female = 0%; male = 0%), cross-country ski (female = 57%; male = 43%), figure skating (female = 29%; male = 14%), long-track speedskating (female = 25%; male = 0%), and short-track speedskating (female = 50%, male = 33%). This finding is consistent with Weiler et al. (18) who reported on the incidence of asthma (defined as a past diagnosis of asthma or EIB, use of an asthma medication, or both) based on questionnaires filled out by members of the 1996 U.S. Summer Olympic Team. Of the 699 athletes who completed the questionnaire, 20% of the female athletes met the criteria for asthma, whereas 14% of the male athletes were identified as asthmatic. The incidence rate of EIB for female and male athletes on the 1996 U.S. Summer Olympic Team was not reported (18). Reasons for the higher rate of asthma and/or EIB in female elite athletes are not clear. Future investigations should attempt to evaluate the gender difference that we observed among athletes on the 1998 U.S. Winter Olympic Team.

Among those individuals found to be EIB-positive were athletes who won a team gold medal, one individual silver medal, and one individual bronze medal at the 1998 Nagano Winter Olympics. As shown in Figure 1, one of those medalists recorded decrements in FEV_1 of 25, 10, and 18% at 5, 10, and 15 min, respectively, after a sport- and environmentally-specific exercise challenge. On the basis of those results, the team physician prescribed a standard asthma medication regimen that allowed the athlete to successfully train and compete. Thus, the account of this athlete and other Olympic medalists (Jackie Joyner-Kersee, Tom Dolan, Amy Van Dyken) provides strong support for the argument that individuals with asthma and/or EIB can be physically active and can perform optimally even at the elite level. Indeed, Voy (16) reported that 11% of the athletes on the 1984 U.S. Summer Olympic Team had asthma and/or EIB; within that group, athletes from a variety of sports won 41 medals including 15 gold medals. An analysis of questionnaire data by Weiler et al. (18) indicated that 10% of the athletes on the 1996 U.S. Summer Olympic Team had "active asthma" (defined as the need for asthma medications at the time of completion of the questionnaire, or the need for medication on a permanent or semipermanent basis);

33% of those athletes won individual or team medals in a variety of sports.

The use of a sport- and environmentally-specific protocol in evaluating EIB in elite winter sport athletes was a unique characteristic of this study. We believe that the incidence of EIB may be underestimated when elite athletes are evaluated using a standard clinical protocol, e.g., exercising for 6–8 min at 85–90% HR_{max}. The rationale for using a protocol of this duration and intensity is based on the assumption that catecholamine release at higher exercise intensities (>95% HR_{max}) may have a bronchodilatory effect (6). However, this rationale is based on studies conducted on asthmatic children (3) and therefore may not be applicable to international caliber athletes. Indeed, our group recently demonstrated that among the athletes in this study who were identified as EIB-positive using a sport- and environmentally-specific protocol, 78% ($P < 0.05$) recorded *normal* pulmonary function results when they were evaluated for EIB using a clinical exercise challenge (11). This finding suggests that a clinical exercise protocol may not be sensitive enough to diagnose EIB in elite athletes and thus may produce "false negative" results if utilized (11). Therefore, we recommend the use of a sport- and environmentally-specific protocol when evaluating international caliber athletes for EIB.

In summary, the incidence of exercise-induced bronchospasm was evaluated among Olympic winter sport athletes. A unique screening procedure was used in which EIB testing was done in conjunction with an actual or simulated competition using a sport- and environmentally specific protocol. Among the seven sports on the 1998 U.S. Winter Olympic Team that we evaluated, the overall incidence of EIB across all sports and genders was 23%. The highest incidence of EIB was found in cross-country skiers where 50% of the athletes (female = 57%; male = 43%) were diagnosed with EIB. Across all sports evaluated, the prevalence of EIB among female athletes was 26%, whereas EIB was diagnosed in 18% of the male athletes. Additionally, exercise-induced bronchospasm was found to be more prevalent in female versus male athletes in nearly all of the winter sports that were assessed. Among those individuals found to be EIB-positive were athletes who won medals at the 1998 Nagano Winter Olympics. These data suggest that: 1) EIB is prevalent in several winter sports and affects nearly one of every four elite winter sport athletes; 2) the winter sport with the highest incidence of EIB is cross-country skiing; 3) in general, EIB is more prevalent in female versus male elite winter sport athletes; and 4) athletes may compete successfully at the international level despite having EIB.

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