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**Reply**

We sincerely thank Dr. Mehta for his valuable comments on our paper (1). We believe his considerations add important evidence to our review, and hope this will further encourage the cardiology community to contemplate old concepts with the challenging attitude that obstructive coronary artery disease and ischemic heart disease are not synonyms!

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## Airway Remodeling and Cardiac Arrest in Long-Distance Ski Races

We read with great interest the article by Hällmarker et al. (1) regarding the incidence of cardiac arrest in Vasaloppet, the world's largest ski race, in which they report that coronary heart disease was the cause for cardiac arrest in 80% of victims. Despite the fact that long-distance skiers are generally well-trained individuals, exertional rhabdomyolysis and inflammation-induced prothrombotic changes during prolonged strenuous exercise may lead to rupture of previously silent coronary atherosclerotic plaque (2). Nevertheless, exercising in cold weather, not only increases the risk of acute cardiac events (3), but may also result in permanent airway diseases.

Endurance skiers inhale large volumes of cold air during exercise while performing at  $\geq 80\%$  of their maximal oxygen consumption and have minute ventilations in excess of 100 l/min (4). This results not only in loss of water and heat from the lower respiratory tract, but also in neutrophilic and lymphocytic bronchial inflammation, epithelial damage, airway remodeling, and increased airway hyper-responsiveness (5). Interestingly, Larsson et al. (6) reported that asthma, asthma-like symptoms, and bronchial hyper-responsiveness are much more common in cross-country skiers than in the general population and nonskiers. Repeated chronic hyperventilation can cause permanent bronchial disorders that may induce ventilatory limitations during intense ski races (7).

Occasionally, cardiac arrest in a person with asthma may be sudden and related to cardiac arrhythmias caused by hypoxia, asphyxia due to severe bronchospasm and mucous plugging, or dynamic hyperinflation that reduces venous return, blood pressure, and, eventually, coronary perfusion pressure, especially in dehydrated athletes with silent coronary artery disease (2,8). Of note, exercise-induced bronchoconstriction may also occur in healthy individuals without known asthma (9). Therefore, thorough pre-participation screening and preventive measures to diminish exposure of the airways to cold air should be instituted for all winter sports athletes.

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## Reply

We want to thank Drs. Chalkias and Xanthos from the University of Athens, Greece, for their interest in our study. Certainly, the mechanisms of cardiac arrest and a possible relationship with airway obstruction caused by exercise in cold weather are of interest in our northern part of the world, where many practice winter sports. There is a high prevalence of asthma among cross-country skiers.

We have statistics of temperatures from 10 long-distance (90 km) ski races with fatalities during the race and 114 races without fatalities. The mean morning temperature in races with fatal outcomes was  $-11.1^{\circ}\text{C}$ , and average day temperature was  $-5.4^{\circ}\text{C}$  (range  $+0.8$  to  $-11.9^{\circ}\text{C}$ ). In the nonfatal races, the mean morning temperature was  $-9.6^{\circ}\text{C}$ , and the average day temperature was  $-4.6^{\circ}\text{C}$  (range  $+5.3$  to  $-20.5^{\circ}\text{C}$ ). The variation between races

was great, and the lowest temperatures were recorded in races without fatal incidents.

From 1979 to 2012, 922 skiers were referred to a hospital emergency department. Of these, 20 skiers (2.2 %) had obstructive airway problems of asthma type. Thus, 1 of 43,000 cross-country skiers had to seek hospital care for airway obstruction.

In our original letter to the editor in the *Journal* (1), we described 20 cases of cardiac arrest. Interviews with the surviving patients and relatives of those who died did not reveal any history of obstructive airway symptoms.

In summary, our experience of cross-country skiing in Vasaloppet does not give any obvious support to airway obstruction as a major cause for morbidity during the race nor does it appear to be an important underlying mechanism for developing cardiac arrest during strenuous exercise in cold temperatures.

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