

# Type 1 diabetes mellitus at very high altitude

The summit of Mount Damāvand (5670 m) safely reached by 18 patients with type 1 diabetes mellitus



**FIGURE 1** On the way to the summit

**To the Editor** Nowadays, a growing number of people, including patients with type 1 diabetes mellitus, travel to high-altitude locations. Such travel is not without risk, and diabetes can increase the potential dangers of travel at extreme altitudes. Travelers ascending above 2500 m are susceptible to 3 main forms of acute altitude illness: acute mountain sickness, high-altitude cerebral edema, and high-altitude pulmonary edema.<sup>1,2</sup> Physiological responses to high-altitude hypoxic environments include increased ventilation, heart rate, blood pressure, and hormonal responses; however, elevated counter-regulatory hormones and other hypoxia-related mechanisms can impair glycemic control in patients with diabetes.<sup>3,4</sup> In addition, the accurate

performance of medical devices typically used by type 1 diabetes patients, such as glucose meters and insulin pumps, has not been verified at high altitudes.<sup>1,3</sup> Other problems with metabolic control may be associated with altitude-related anorexia, increased energy expenditure, increased risk of dehydration, or diabetic ketoacidosis.<sup>3-6</sup> This makes mountain hiking at high altitudes a particular challenge for patients with type 1 diabetes.<sup>1-6</sup>

With these facts in mind, 3 years ago we created the “5000 meters above sugar level” initiative; the ultimate goal of the endeavor being patients with type 1 diabetes reaching a peak of more than 5000 m in altitude. We aimed to prove that patients with type 1 diabetes, who have detailed knowledge

**FIGURE 2** Damāvand captured! The group photo on the peak



and understanding of their disease, could safely hike to very high altitudes. We also aimed to develop high-altitude insulin management protocols. Step-by-step, we integrated our group, improving the “teamwork” approach, and developing the technical skills concerning mountain climbing.<sup>7,8</sup>

We defined the inclusion criteria as follows: type 1 diabetes (except patients in remission), acceptable metabolic control (hemoglobin A<sub>1c</sub> [HbA<sub>1c</sub>] <7.5%), good diabetes self-management skills, and good compliance prior to expedition. Importantly, a high level of physical activity/fitness prior to involvement in our trek was not an inclusion criterion. Our group consisted of individuals with a very high level of baseline physical activity (2 months prior to our trip, 4 participants successfully completed the “Butchers race”: a 84-km mountain marathon), as well as those with a baseline physical activity similar to that of an average member of the society. The latter group was encouraged to increase their activity prior to the expedition according to their individual capabilities. The exclusion criteria were defined as follows: presence of complications (retinopathy, neuropathy, nephropathy), uncontrolled hypertension (systolic blood pressure >150 mmHg or diastolic blood pressure >90 mmHg), unawareness of severe hypoglycemia, severe cardiac or peripheral arterial disease, and smoking.

Our team for the final expedition to Mount Damāvand (Iran) consisted of 19 patients (2 of whom were women) with type 1 diabetes. They were at a mean age of 32.5 years (range, 23–48 years), had a mean body mass index of 23.8 kg/m<sup>2</sup> (range, 19.7–30.2 kg/m<sup>2</sup>), a mean HbA<sub>1c</sub> level of 6.6% (range, 5.9–7.1%), and a mean diabetes duration of 12.6 years (range, 3–29 years). All patients were treated with personal insulin pumps. Two patients were medical doctors; there was also a diabetes educator

and a diabetes technician. Two medical doctors, who did not have diabetes, supported the group.

Our expedition started on July 15, 2016. We spent 1 night at the Polour Resort, Iran (altitude, 2270 m), after which we drove to Goosfand-Sara (altitude, 3200 m), where we began our ascent to the shelter (4200 m). The following day, after spending the night at the shelter, we climbed to 4700 m to acclimate to the altitude. Originally, similar acclimatization ascents were planned to follow; however, our delayed arrival to Iran (caused by political situation in a transit country) left us with the difficult decision of either stopping at that altitude or rescheduling the summit attack for the next day. Eventually, we decided to try to reach Mount Damāvand, and of the entire group, 18 patients decided to challenge the mountain (FIGURE 1). All of them reached the peak without major problems; however, almost all suffered acute mountain sickness to varying degrees (FIGURE 2). We met with the most difficult part of the climb about 300 m under the peak, at a location called “Smoke Mountain”, where steaming sulfuric gas makes breathing difficult (FIGURE 3). Holding one’s breath under conditions of severe hypoxia is quite a challenge! After reaching the peak, all participants descended safely, returning to the shelter (FIGURE 4).

The entire expedition avoided severe hypoglycemia and metabolic/glycemic decompensation. We have shown that patients with type 1 diabetes, with different levels of physical fitness, can safely climb to very high altitudes. All of the data concerning diabetes management collected during the expedition is currently undergoing analysis and will be published soon. We believe that trekking at high altitude can encourage type 1 diabetes patients to participate in regular physical activity, help develop positive interpersonal relationships, facilitate experience exchange among

**FIGURE 3** Steaming sulfuric gas at “Smoke Mountain”



**FIGURE 4** Celebration of safe capture of Damāvand in the shelter



patients and doctors, and lead to improvement in diabetes self-management skills and outcomes. Finally, we have shown that dreams come true and diabetes does not have to be an obstacle to combating the greatest challenges.

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