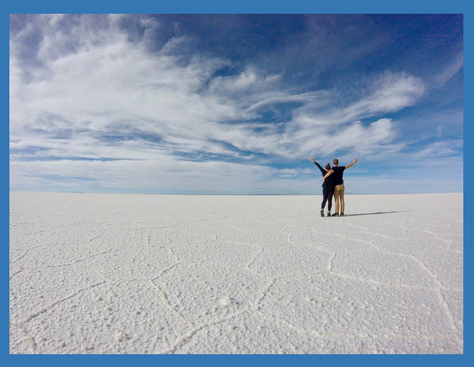

World Travel With Type-1 Diabetes

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Background

Living with type 1 diabetes and using insulin pump therapy (IPT), the authors travelled together for four months through 11 countries. Those with type-1 diabetes are less likely to travel and there is great variation in professional advice (sometimes dangerous and often overcomplicated) (1). For those who do manage to travel it is generally a positive experience and enhances one's understanding of their own diabetes and self-management. Travelling with type 1 diabetes presents various added challenges, which are reviewed here, so that they can be overcome.

Air Travel

When boarding for air travel it is important to consider the distribution of diabetes supplies in hand luggage and hold luggage. Insulin at least, must be carried in hand luggage, as exposure to extreme cold in the hold could affect its potency. We opted to carry all diabetes supplies and paraphernalia in our hand luggage in case of required access due to delays or emergencies, and to avoid loss or damage which may occur with hold luggage. Some airlines will permit extra hand luggage allowance for this purpose, so consider contacting in advance.

Crossing into a different time-zone with an insulin pump, one should simply change the time-setting of the insulin pump to the destination time on departure. This may result in over or under delivery of insulin in the short term, so frequent blood glucose testing is key. We made prudent use of flash glucose monitoring when entering new time-zones (2).

During air travel, one is usually sedate, with a reduced metabolic rate and increased insulin resistance, and should therefore consider applying an increased temporary basal rate.

During takeoff, reduced atmospheric pressure can cause bubbles to form in the insulin chamber and/or inadvertent insulin delivery (3). Thus, we recommend the pump is disconnected and stopped during takeoff. Once at cruising altitude, the chamber and tubing should be primed to remove visible bubbles before reconnecting. Priming should be repeated upon landing.

Dehydration frequently occurs during air travel, and this is more likely and more severe in the presence of diabetes, with associated increase in risk of developing diabetic ketoacidosis as well as venous thromboembolic disease.

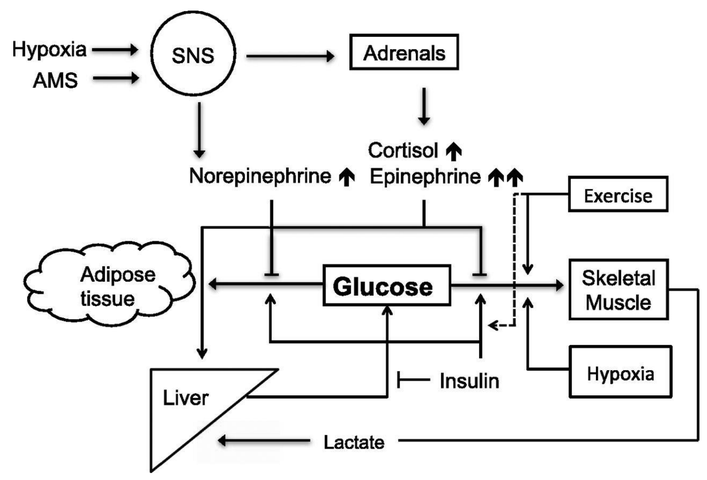

Figure 2. Physiologcal effects of altitude on glucose homeostasis (11). AMS = acute mountain sickness SNS = sympathetic nervous system

Airport Security

People with diabetes have reported feelings of insecurity, fear, prejudice, rejection and shame while transiting through airport security. A number of factors create this negative experience, including the hostility of the environment, language barriers, poor understanding among airport security staff, and a lack of clear or unified advice about insulin pumps and airport security technologies (4).

Airport technologies can cause damage to insulin pumps through x-ray radiation and magnetic fields. Individual insulin pump manufacturers should be contacted for advice, but there is consensus that pump exposure to walk-through metal-detectors is safe (5). Unless specified otherwise by the manufacturer, we recommend avoiding pump exposure to x-ray machines and whole-body scanners (Figure 1).

There have been reports of significant harm occurring when security staff have insisted on insulin pump removal or insisted that the insulin pump must pass through the x-ray machine (4). This should always be avoided.

For the purpose of smooth transit through airport security a letter from one's diabetes healthcare team outlining the diagnosis, required equipment/medication, the hazards of airport security technologies and the pump/equipment serial numbers.

Figure 1. Airport security technologies and insulin pumps. ✓ = safe ✗ = unsafe

Altitude

People with type-1 diabetes have similar success rates to disease-free individuals when tackling high-altitude expeditions, although it is important to be healthy, physically fit, well-prepared and capable of self-management. These expeditions are an effective form of physical activity – encouraged to all with diabetes – and can boost self-management skills (6, 7).

Though the person with diabetes is no more likely to develop acute mountain sickness, it is more hazardous when it occurs: its symptoms can mask hypoglycaemia, there is an increased risk of ketonuria and ketoacidosis, and it contributes to hyperglycaemia. Ketoacidosis risk is compounded by poor performance of glucose meters, which tend to underestimate high blood glucose (8, 9), and the use of acetazolamide (used to treat AMS), which causes excretion of bicarbonate and therefore diminished adaptive buffering of acidosis (10). Gradual ascent with time for acclimatisation protects from these effects.

Increased insulin resistance occurs in correlation with increasing altitude. The physiological processes behind this are summarised in figure 2 (11). Interestingly there is also an exaggerated stress response to exercise, such that insulin requirements tend to increase, despite the insulin-sensitising effects of exercise (12). The other physiological affects which must be considered with diabetes are summarised in figure 3 (13).

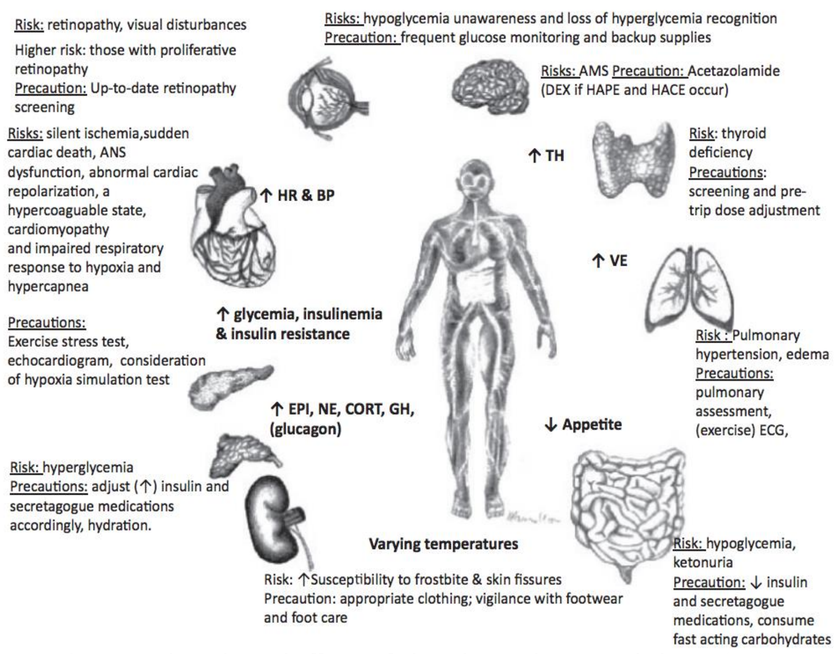

Figure 3. Physiological effects of altitude in relation to diabetes (13).

Climate

Various climates may be encountered when travelling abroad. Temperature can have significant impacts for the person with diabetes. Hot climates cause more rapid insulin absorption, and may increase insulin sensitivity. This can cause hypoglycaemia without appropriate adjustments to insulin delivery. Using prolonged boluses can counteract the rapidity of absorption, and temporary basal reductions may help reduce incidence of hypoglycaemia. Those with diabetes are also at higher risk of developing febrile illnesses in tropical climates (14).

Conversely, cold climates cause slower insulin absorption, so it is important to allow sufficient time for insulin boluses to take effect before administering further doses of insulin and 'over-correcting'. One must also be wary of suddenly increased insulin absorption on entering a heated building and erratic/unpredictable insulin absorption when undertaking exercise in the cold. Hypoglycaemia is particularly dangerous in cold climates, as the sweating predisposes to hypothermia. Frostbite, skin fissures and secondary infections are also dangers for those with diabetes.

In unfamiliar climates, dysregulation is likely to occur, so it is important to increase the frequency of blood glucose testing – something which is poorly done by the diabetic traveler (14).

Extreme temperatures also create challenges for insulin storage. Access to a refrigerator is available in most hot-climate parts f the world, but otherwise, Frio medical storage devices are effective. It is also important to remember to avoid overheating of the insulin in the pump and tubing by avoideing exposure to direct sunlight and hot surfaces (including your own body surface). In comparison, in cold climates, one can keep their insulin and tubing against their skin and well insulated to avoid exposure to extreme cold.

Apart from insulin, glucose monitoring equipment can perform poorly at extremes of temperature and at high humidity. Function is generally normal at 15-35°C, but may be inaccurate or cease to function completely at extremes. As well as protecting equipment from temperature extremes, test strips should be kept from direct sunlight (ultraviolet light) and high humidity, control solution should be used frequently and a low threshold for ketone testing adopted.

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References

1.Gill, G. V., and S. Redmond. "Insulin treatment, time-zones and air travel: a survey of current advice from British Diabetic Clinics." *Diabetic medicine* 10.8 (1993): 764-767.
2.Chandran, Manju, and Steven V. Edelman. "Have insulin, will Fly: diabetes management during Air travel and time zone adjustment strategies." *Clinical Diabetes* 21.2 (2003): 82-85.
3.King, Bruce R., et al. "Changes in altitude cause unintended insulin delivery from insulin pumps." *Diabetes care* 34.9 (2011): 1932-1933.
4.McGhee, Katie. "Diabetes and air travel: Ensuring security, promoting dignity." *International Airport Review* (2017).
5.Nassar, Adrienne A., Curtiss B. Cook, and Steve Edelman. "Diabetes management during travel." *Diabetes Management* 2.3 (2012): 205-212.
6.Moore, K., et al. "Extreme altitude mountaineering and type 1 diabetes; the Diabetes Federation of Ireland Kilimanjaro Expedition." *Diabetic medicine* 18.9 (2001): 749-755.
7.Brubaker, Patricia L. "Adventure travel and type 1 diabetes." *Diabetes Care* 28.10 (2005): 2563-2572.
8.Fink, Kenneth S., Dale B. Christensen, and Allan Ellsworth. "Effect of high altitude on blood glucose meter performance." *Diabetes technology & therapeutics* 4.5 (2002): 627-635
9.Giordano, Beverlyp, et al. "Performance of seven blood glucose testing systems at high altitude." *The Diabetes Educator* 15.5 (1989): 444-448.
10.Moore, K., C. Thompson, and R. Hayes. "Diabetes and extreme altitude mountaineering." *British journal of sports medicine* 35.2 (2001): 83-83.
11.de Mol, Pieter, et al. "Physical Activity at Altitude: Challenges for People With Diabetes." *Diabetes Care* 37.8 (2014): 2404-2413.
12.de Mol, Pieter, et al. "Increased insulin requirements during exercise at very high altitude in type 1 diabetes." *Diabetes Care*34.3 (2011): 591-595.
13.Mohajeri, S., et al. "Diabetes, trekking and high altitude: recognizing and preparing for the risks." *Diabetic Medicine* 32.11 (2015): 1425-1437.
14.Driessen, Sebastiaan O., Frank GJ Cobelens, and Robert J. Ligthelm. "Travel-related morbidity in travelers with insulin-dependent diabetes mellitus." *Journal of travel medicine* 6.1 (1999): 12-15.