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REVIEW ARTICLE Open Access

Management of Diabetes on Long Trips and High Temperatures

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Abstract

Although safe and fast, air travel can cause problems in diabetic passengers and pilots. In fact, most diabetes -related emergencies can be prevented during the flight. Diabetic passengers and pilots can fly safely with proper control and planning. During air travel, diabetes sufferers are faced with unhealthy diet choices, limited access to medicines and health services, disrupted drug dosing intervals, and exposure to hypobaric aircraft cabin environments. Disruptions to routine dosing intervals are most severe when travelers cross multiple time zones. Traveling east or west will shorten or lengthen the interval between scheduled doses. This increases the possibility of inadvertent, premature, or delayed administration of antihyperglycemic therapy. In this review, we have discussed in detail about flights in diabetic passengers and some issues to be considered during and after the flight especially in high temperature.

Keywords: air travel; diabetes mellitus; high temperature

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Introduction

Every individual in the current era often travels for various purposes, whether for hobbies, business needs, or work, including individuals with chronic illnesses. Individuals with chronic illnesses, such as diabetes, may be particularly vulnerable to the emotional and physical stress associated with travel. According to the United States Travel and Tourism Overview report, domestic travel in the United States increased to more than 2.25 billion individual trips in 2017. Data from the United States Centers for Disease Control and Prevention and the United States Travel Association indicate that, given this travel frequency and the known prevalence of diabetes, approximately 17 million individuals with diabetes travel for leisure each year, while another 5.6 million travel for business purposes. This number is expected to continue rising (Mullin et al., 2018).

Diabetes is largely a self-managed disease, however when food, climate, time zones and conditions change during travel, diabetes patients may face unique challenges in treating their diabetes. A study showed that 15% of travelers with diabetes who require insulin stated that insulin use influenced their choice of travel destination, both in terms of health risks in the country or destination. However, type 1 or 2 diabetes patients can travel safely if they employ appropriate self-management skills and adequate preparation (Oberg & Ostenson, 2021).

During air travel, diabetes sufferers are faced with unhealthy diet choices, limited access to medicines and health services, disrupted drug dosing intervals, and exposure to hypobaric aircraft cabin environments. Disruptions to routine dosing intervals are most severe when travelers cross multiple time zones. Traveling east or west will shorten or lengthen the interval between scheduled doses. This increases the possibility of inadvertent, premature, or delayed administration of antihyperglycemic therapy (Zubac et al., 2020).

In this discussion, we will explain the management of type 2 diabetes mellitus (T2DM) patients who will be going on a long trip and this is related to an increase in temperature during the trip.

Discussion

The term flight length or long flight in the world of aviation refers to the flight distance used by commercial airlines as a guideline in classifying

flights. Based on the length of the flight traveled, flights are grouped into three categories, namely, short-haul, medium-haul and long-haul flight categories. Long-haul flights are defined as flights with a flight length longer than 2,200–2,600 nm (4,100–4,800 km). Long-haul flights are defined as flights that have a flying duration of more than 12 hours. Long flights bring their own challenges for passengers so they require special attention to ensure their health, especially for passengers who have a history of certain diseases, one of which is diabetes (McCarthy & Buchard, 2013).

Flight with Diabetes

Most diabetes patients treated with insulin or oral antidiabetic drugs can travel safely under acceptable glycemic control, by following several important rules during the flight. Passengers must carry all their medications with them during the flight. This medicinal liquid, such as insulin, is allowed in quantities above the 100 mL limit, provided that it must undergo identity verification. However, passengers must inform the relevant airline about this before travelling. In addition, passengers must keep documents from specialist doctors reporting their health conditions.[2,5] Patients who use insulin pumps and/or continuous glucose monitoring devices (CGM: Continuous Glucose Monitoring) must also contact the airline they will fly with regarding the rules for using these devices while flight. Insulin pumps can interact electromagnetically with some safety systems used at airports. Since metal detectors at airports will not damage the device, the insulin pump and CGM system may remain with the person when passing through the security system. However, this device should not be passed through an X-ray machine. When passing through a body scanner at an airport, the pump or CGM system must be removed or a different passing security assessment must be requested.

In other words, patients using this system must alert security at the airport. Relevant airlines should be required to provide suitable diabetic meals during flights. Passengers with diabetes should keep related equipment (glucometer, lancets, batteries, insulin pump reservoir, insulin pump infusion set, ketone strips, and medical ID card) and medications (oral antidiabetics and insulin) in their carry-on baggage. They should keep simple carbohydrates, such as glucose tablets or sugar, and foods containing long-acting carbohydrates in their carry-on bag to avoid possible meal delays. Passengers should also store insulin, which they will not use during the flight, in their carry-on baggage to avoid possible exposure to temperatures that can cause damage and loss of insulin (usually freezers). Glucagon preparations should be carried in their original containers, again in carry-on baggage (Lin et al., 2019)

Preparation for Flight in Patients with Diabetes

A person with diabetes will face a number of important challenges when traveling on a long flight. Before leaving, it is important for diabetes sufferers to carry out a health evaluation, ensure that their medication and insulin prescriptions are up to date, and provide sufficient supplies such as a glucometer, glucose tablets and snacks. Additionally, international travel also brings additional factors such as time zone differences, changes in diet, medication dosage adjustments, and health risks such as deep vein thrombosis. During the trip, special attention is also required to changes in sleep patterns and the accuracy of glucose measurements, especially at altitude. Being prepared to face emergency situations is also very important. While on the plane, patients and families also need to pay attention to the risk of jetlag, hypoglycemia or hyperglycemia, running out of medication supplies, the risk of comorbidities, infections, leg injuries, and lack of knowledge about how to navigate medical emergencies abroad. Additionally, an important dilemma for people taking insulin concerns transportation and administration of insulin during travel, especially when traveling across multiple time zones. The dilemma also extends to glucose monitoring devices, such as continuous glucose monitors and insulin injection devices including insulin pens and subcutaneous insulin infusions (Uğurlu, 2021).

Special Considerations for Diabetic Patients Using Insulin and Willing to Fly

Managing insulin while traveling across different time zones can be challenging for individuals with diabetes. Time zone changes can disrupt medication schedules, potentially affecting blood glucose control. Proper planning and dose adjustments are essential to maintain stable blood gluocose levels and prevent complications. Below are some key guidelines for insulin adjustments during travel:

Patients taking insulin twice daily: During their trip East, patients should get their usual morning injection, however, reduce the evening dose by 10%. It may be more appropriate to use insulin in frequent, small doses (such as making half the dose of rapid-acting insulin you receive before meals) on flights lasting more than 24 hours. During their travels to the West, as patients may remain awake for a long time (6-7 hours) after a dose and eat normal evening insulin, they may then take a small dose 6 hours after this dose and then eat (Uğurlu, 2021; Oberg & Ostenson, 2021).

Patients taking a single daily dose of long-acting insulin: During travel to the East, these patients should continue their medication schedule and receive regular meals according to the time zone at their destination. Traveling to the West does not present any serious problems, except for

mild hyperglycemia that may occur the next day of arrival. This situation can be corrected by increasing the insulin dose on the day in question (Uğurlu, 2021; Oberg & Ostenson, 2021).

Use of Insulin Pumps and Continuous Blood Glucose Monitoring in Airplane Passengers

Flight-related hypoglycemia has been reported in diabetics treated with insulin pumps (continuous subcutaneous insulin infusion. This may be related to air compression inside the infusion set or a direct effect on the insulin release system in the pump. It has been shown that insulin pumps release more insulin than the set speed during decompression. Although the ambient pressure at sea level is 760 mm Hg (1 atmosphere), the cabin pressure decreases by 200–560 mm Hg as the aircraft climbs to 40,000 ft undesired release of insulin from the pump. Air dissolves in water in direct proportion to the ambient pressure. As the plane rises, the ambient pressure decreases, and air bubbles form in the solution (Oberg & Ostenson, 2021; Zubac et al., 2020; McCarthy & Buchard, 2013).

The bubbles in the pump are replaced with insulin and cause increased insulin release. This increased insulin release can cause hypoglycemia 1 -2 hours after departure. As the plane begins to land, the air pressure rises again, and the bubbles again dissolve in the solution and stop the release of insulin for a while. Decreased insulin release can cause hyperglycemia. If air bubbles are removed before landing, the pump will discharge normally. Changes in insulin release during flight may result in different clinical effects depending on several factors such as insulin sensitivity, glycemic control, food intake, and pump settings. A study showed that changes in environmental pressure during commercial flights did not affect the mechanical function of insulin pumps. However, to avoid the problems described above, individuals using insulin pumps should be informed of the issues to consider during the flight. The increasing use of advanced CGM systems highlights the importance of evaluating sensor systems as well as pump function under different pressure conditions. In CGM systems, as in most glucometers, the glucose oxygenase method is used. However, the accuracy and performance of the CGM system is slightly affected by hypobaric weather conditions such as 0.5 and 0.75 atm. However, literature data are insufficient to evaluate the accuracy and performance of insulin pumps and CGM systems during flight conditions in diabetic patients (McCarthy & Buchard, 2013; Lin et al., 2019; Pavela et al., 2018).

Effects of Climatic Conditions on Diabetic Patients

Climatic conditions significantly impact diabetes management, influencing blood glucose levels, insulin absorption, and overall health risks. In warm climates, individuals with diabetes, especially those taking diuretics or sodium-glucose cotransporter-2 (SGLT2) inhibitors, are more prone to dehydration, which raises blood glucose and creates a cycle of worsening hyperglycemia and osmotic diuresis. Heat-related illnesses, acute kidney injury, and metabolic imbalances are also concerns. To mitigate these risks, staying well-hydrated, minimizing caffeine and alcohol intake, wearing loose, breathable clothing, and protecting diabetes medications and monitoring devices from excessive heat are essential. Insulin absorption is faster in hot weather, increasing the risk of hypoglycemia, requiring careful dosage adjustments.[12]

Cold climates present different challenges, such as increased HbA1C levels, reduced physical activity, and greater insulin resistance. Vasoconstriction in cold weather slows insulin absorption, leading to potential fluctuations in blood glucose levels. Diabetes devices, including glucose meters, insulin pumps, and test strips, may malfunction in freezing temperatures, and insulin can become ineffective if exposed to extreme cold. Individuals with diabetes, particularly those with neuropathy or peripheral vascular disease, are more vulnerable to frostbite and should ensure proper insulation and warmth for both their bodies and medical supplies. [12]

High altitudes pose additional risks, including lower oxygen levels, low humidity, and increased insulin resistance due to heightened catecholamine release. Hypoglycemia symptoms can be mistaken for altitude sickness, and medications like glucocorticoids and acetazolamide, used to treat altitude sickness, may further disrupt glucose control. The effect of altitude on insulin needs varies—slow climbs can increase glucose levels and insulin requirements, while rapid ascents can lead to greater energy expenditure and lower insulin needs. Diabetes devices may also be affected by cold temperatures at high altitudes, requiring careful handling. Regardless of the climate, effective diabetes management in extreme conditions requires proactive planning, frequent blood glucose monitoring, appropriate medication adjustments, and protection of medical supplies to ensure stability and safety (Rajkumar, 2022)

Relationship Between Exposure To High Temperatures In Diabetes Mellitus

Diabetes mellitus patients are susceptible to complications, both acute and chronic.[14] Exposure to high temperatures can cause a T2DM sufferer who travels to fall into dangerous conditions such as diabetic ketoacidosis, severe hypoglycemia, and cardiovascular disorders. They are more susceptible to the negative effects of high temperatures compared to those without diabetes.

Diabetics with autonomic neuropathy may

have difficulty regulating body temperature, resulting in difficulty cooling down in hot weather, which can result in hyperthermia, where the body temperature rises above 38°C. Hyperthermia can cause various serious complications including dehydration, kidney failure, and even death. High blood glucose levels in diabetes can draw water from the body through osmotic diuresis, increasing the risk of dehydration. They are also more susceptible to skin and foot infections (Bevier et al., 2022)

Climate change may affect the physical environment for diabetes patients. Dehydration caused by high temperatures can make blood glucose readings higher and excessive sweating can interfere with the accuracy of glucose monitoring. The sensitivity of a glucose meter can be affected by environmental temperature. Apart from age and type of diabetes, exposure to high temperatures also increases the risk of hospitalization for patients. Extreme temperatures can affect thermoregulation, which can lead to disease or injury such as neuropathy (Tarlton et al., 2024)

Temperature also affects air quality and can increase the growth of microorganisms. Diabetic patients have a high risk of being infected with microorganisms due to decreased immunity, especially diseases such as tuberculosis (TB), due to disturbances in the function of the immune system. Inappropriate temperatures can increase conditions that support bacterial growth and TB transmission. Exposure to high temperatures also affects glucose and fat metabolism, disrupting the activity of the glucokinase enzyme which plays a role in carbohydrate metabolism and increasing free fatty acid oxidation and reducing lipid synthesis, causing metabolic disorders in diabetes patients (Bevier et al., 2022; Tarlton et al., 2024)

In one study conducted, it was stated that hot temperatures for type 1 diabetes sufferers had an influence on the body's response. At a comfortable temperature (23-25°C), type 1 diabetes patients have higher skin and extremity blood flow compared to healthy people, due to vasodilation which is influenced by high levels of insulin in the blood. However, the skin's maximal ability to vasodilate may be reduced in type 1 diabetes patients. Factors such as a lack of C-peptide, which reduces skin blood flow and higher basal oxidative stress, are associated with impaired heat loss in type 1 diabetes. in sweat, such as anhidrosis of the lower body and hyperhidrosis of the upper body, also indicates the presence of early neuropathy. Research suggests that individuals with type 1 diabetes who are physically active may experience a decrease in sweat production, which may increase the risk of hyperthermia. This highlights the importance of understanding how type 1 diabetes affects the peripheral and nervous systems in regulating body temperature (McCarthy & Buchard, 2013; Rajkumar, 2022; Bevier et al., 2022).

People with T2DM often have difficulty regulating their body temperature, especially due to disorders such as neuropathy and other diabetes complications. Epidemiological data during heat waves show that individuals with T2DM have a much higher risk of heat illness or even death. Individuals with T2DM generally have impaired skin blood flow responses to pharmacological stimuli, local skin heating, and overall body heating. These effects appear to be influenced by fitness level, with people with T2DM who exercise tending to have less severe impairment in skin blood vessel dilation, although maximal skin blood flow tends to be lower in them compared with healthy ones. Studies of local sweating in T2DM also show impairment compared with healthy people, although there are studies that report different results. Changes in regional sweating in T2DM are similar to those in type 1 diabetes, with relative anhidrosis in the lower half of the body and euhidrosis or hyperhidrosis in the upper half (Tarlton et al., 2024; Centers for Disease Control and Prevention [CDC], 2024).

Considerations for Diabetes Patients Traveling by Air

The following are things that can be taken into consideration for individuals with diabetes who wish to undertake long air travel (Tarlton et al., 2024; Centers for Disease Control and Prevention [CDC], 2024) :

Pilots are advised to carry an adequate glucometer and glucose-containing snack. Blood glucose checks are important, especially for pilots who are concerned about the safety of their passengers. Blood glucose checking should be done three times, as follows :

Thirty minutes after eating food containing glucose (if the first measurement is <90 mg/dL). If the result is <90 mg/dL again, it is recommended to consume another snack containing 15 grams of glucose, then measure again after 30 minutes. If the result is >270 mg/dL, it is not recommended to fly.

In the first 30 minutes of the flight, every hour of the flight, and 30 minutes before landing. If the result is <90 mg/dL, it is recommended to eat a light meal containing 30 grams of glucose. In this condition, blood glucose must be maintained at 90-270 mg/dL. If blood glucose is found to exceed 270 mg/dL, the pilot must land at the nearest airport. Flights can only be carried out when the blood glucose is in a safe range.

Passengers are advised to carry adequate glucometers, oral diabetes medication, insulin. Monitoring the patient's blood glucose should be performed frequently. If the plasma glucose is >250 mg/dL, then urine ketones must be done, if the results are positive, then insulin must be added.

Medication time in time difference. The time of use of insulin or antidiabetic drugs does not need to be changed if the patient is flying north or south and if the flight to the West or East is less than 5

hours. Changes to insulin administration times are only made if the flight is to the west or east which involves 6-12 time zones. If the patient flies west, the time will be longer, so more insulin may be needed, while flying east means the time will be shorter and therefore require less insulin. This of course requires consideration from the relevant specialist doctor.

Restrictions on insulin pumps and continuous glucose monitoring (CGM) devices. The insulin pump can interact electromagnetically with security devices at airports, namely X-ray scanners. Therefore, it is recommended to report to the relevant officer and include a medical letter from the relevant specialist doctor so that the insulin pump and CGM device can be permitted to be carried in the aircraft cabin.

Rules regarding insulin pumps during flights. The insulin cartridge can only hold 1.5 mL of insulin, and the plunger or pump must be removed before takeoff. When using insulin at high altitudes, the cartridge should be taken out, and any air bubbles must be eliminated before use. In case of an emergency, such as cabin decompression, the pump or plunger must also be removed to ensure proper functioning and safety.

Management of Diabetes Mellitus Patients During Activities at High Temperatures

In diabetes management, the main goal is to improve the patient's quality of life. To achieve this, there are several goals that must be achieved (Centers for Disease Control and Prevention [CDC], 2024) :

The short-term goal is to eliminate diabetes symptoms, improve quality of life, and reduce the risk of acute complications.

The long-term goal is to prevent and inhibit the development of microangiopathy and macroangiopathy.

The ultimate goal is to reduce diabetes morbidity and mortality.

To achieve this goal, it is necessary to control blood glucose, blood pressure, body weight and lipid profile through comprehensive patient management. This is related to carrying out physical activity, several conditions must be considered to ensure safety and effectiveness (Centers for Disease Control and Prevention [CDC], 2024).

The first thing to pay attention to is that blood glucose monitoring must be done before, during and after physical activity, with checks every 30 minutes. Second, increased ketones in the blood (>1.5 mmol/L or urine 2+) can be a contraindication to physical activity. Third, a history of hypoglycemia should be considered and communication with a doctor should be made. Fourth, carbohydrate availability must be available if hypoglycemia occurs, by consuming carbohydrates every 20-30 minutes. In addition, fluid intake should be increased before, after and during exercise, with fluid consumption of 250 mL every 20-30 minutes. Thus, diabetes patients can carry out physical activity safely and effectively (Centers for Disease Control and Prevention [CDC], 2024; Kenny et al., 2016).

Conclusion

Long distance travel or long flights are air travel that ranges from 7-15 hours or more. Long flights bring their own challenges for passengers so they require special attention to ensure their health, especially for passengers who have a history of certain diseases, one of which is diabetes. Diabetes mellitus patients who are continuously exposed to high temperatures and are also on long-distance flights can experience dangerous conditions such as diabetic ketoacidosis (blood that is too acidic), severe hypoglycemia, and cardiovascular disorders. High temperatures can cause increased water and energy needs. In the management of T2DM sufferers, especially in special conditions such as when traveling long distances and at high temperatures, it is hoped that diabetics always consult a doctor and report it to local health officials.

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