Diabetes Mellitus Type 1 and Skydiving

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Charles "Chuck" Yeager in the Bell X-1 cockpit
Is this man completely healthy?

Charles "Chuck" Yeager in the Bell X-1 cockpit
New concepts in aerospace medicine?

**Classical Medicine:**
Abnormal Physiology in Normal Environment

**Aerospace Medicine:**
Normal Physiology in Abnormal Environment
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Advances in medicine during the last decades open the possibility of...

Abnormal Physiology in Abnormal Environment
Individuals with type 1 diabetes mellitus (T1DM) have raised concerns about being prohibited from participation in air sports such as skydiving in a number of countries, one of which is Sweden.

The critique is that this prohibition has been instituted without an open discussion or well-founded argumentation, and without any clear medical evidence. The regulatory coherence is also questioned.

It can be reasonably assumed that T1DM would constitute a risk factor for injury or fatality in skydiving; a catastrophic scenario being mid-air loss of consciousness due to acute, unanticipated hypoglycemia.
Type 1 diabetes mellitus

- A policy survey distributed to the national parachuting organizations that are active in the International Parachuting Commission indicated international regulatory heterogeneity regarding the policies of T1DM and skydiving.¹

- Further investigations seem warranted, to create a basis for evidence based recommendations regarding T1DM and these kind of activities.

¹ Manuscript to be submitted.
Environmental physiology

- Is there anything in the skydiving environment per se that could be problematic for individuals with T1DM?

- Repetitive rapid-onset hypobaric hypoxia exposures?

- Glucose levels and working memory in individuals with T1DM during such environmental stress have not been assessed.
Methods

Methods

Prof. Johan Jendle wearing continuous glucose monitor (CGM) sensors during a bench study in a barochamber at Karolinska University Hospital, Stockholm, Sweden.
Methods

- Six subjects with T1DM and six controls were included.
- Using a hypobaric chamber, the ambient air pressure was changed to simulate a standard skydive from 4,000 m (13,000 feet) above mean sea level. Repeated six times to mimic a day of skydiving.
- All subjects carried a continuous glucose monitor (CGM). Capillary glucose tests were taken in order to calibrate the CGM.
- Working memory was evaluated through digit span by a licensed psychologist before, at the end of a maximum altitude stand-by, and after each cycle.
- Hemoglobin oxygen saturation and heart rate were monitored.
- Subjects with T1DM dosed insulin themselves. Lunch break was between the third and the fourth cycle.
Results

• No subject experienced symptomatic hypoglycemia with impaired working memory during the simulations.

• One asymptomatic hypoglycemia episode with a plasma glucose level of < 3.9 mmol/L was recorded in a subject with T1DM, with a corresponding CGM trend indicating declining glucose levels.

• Interstitial glucose levels of < 3.9 mmol/L were recorded by CGM in three of the controls during the simulations.

• There were no significant differences in working memory, hemoglobin oxygen saturation, or heart rate, between the T1DM subjects and the controls.
**Hemoglobin oxygen saturation**

**FIG. 3.** Mean hemoglobin oxygen saturation (SpO2%) in the group with type 1 diabetes mellitus (T1DM) (black lines; $n=6$) and the controls (gray lines; $n=6$) during the study investigating glucose excursions when changing ambient air pressure simulating skydiving. The striped lines show the 95% confidence interval. The dashed black line shows the median ambient air pressure in the chamber.
Heart rate

FIG. 4. Mean heart rate index in the group with type 1 diabetes mellitus (T1DM) (black line; n = 6) and the controls (gray line; n = 6) during the study investigating glucose excursions when changing ambient air pressure simulating skydiving. A heart rate index of 100 indicated no difference in heart rate compared with baseline values. The striped lines show the 95% confidence interval. The dashed black line shows the median ambient air pressure in the chamber.
FIG. 2. Mean interstitial glucose levels measured by continuous glucose monitoring in the group with type 1 diabetes mellitus (T1DM) (black line; n = 6) and the controls (gray line; n = 6) during the study investigating glucose excursions when changing ambient air pressure simulating skydiving. The striped lines show the 95% confidence interval. Gray bands indicate "ground" (G). White bands indicate "jump cycle" (J). A lunch break was taken between the third and the fourth jump cycles.
Working memory

Results of the digit span forward test relative to baseline (span - baseline) before, at the end of the stand-by at the simulated 4,000m altitude, and after the simulations in the hypobaric chamber during the study investigating glucose excursions when changing ambient air pressure simulating skydiving in the group with type 1 diabetes mellitus (T1DM) and the controls (n = 6 in both groups). The boxplots show the median and the 25% and 75% interquartile range. The “whiskers” show the 5th and 95th percentiles. The dots show the most extreme observations outside this range.
Conclusions

- No significant differences in working memory between the group with T1DM and the controls were found.

- The hemoglobin oxygen saturation dropped, and the heart rate rose, showing a reverse and synchronous relationship to the drop in ambient pressure.

- These findings will not bring our group a Nobel Prize.

- But they form a baseline prior to future real-world studies.
Future real-world studies

• Real repetitive skydives may induce greater stress than repetitive hypobaric chamber confinements, leading to more unpredictable glucose responses.

• Poor caloric intake, thermal stress, and unforeseen delays during a day of real skydiving may have an impact on glucose levels and need to be studied.

• Since a skydiver receives multiple, simultaneous stimuli (vision, balance, awareness of the surrounding airspace) during a real-world skydive, working memory might be more affected compared with being maintained in a hypobaric chamber.

• Both CGM and digit span measurements seem doable in the field.
By comparison: T1DM and SCUBA diving

- Swedish recommendations on T1DM and SCUBA diving were recently changed from absolute prohibition to evidence based recommendations. These include:
- HbA1c 5–8.8% (52–73 mmol/mol) without any long-term diabetic complications. No episode of severe hypoglycaemia during the last year. No report of hypoglycaemic unawareness.
- Good knowledge of how to adjust insulin doses and the amount of carbohydrates prior to physical activity. Blood glucose monitoring 4-6 times daily during SCUBA diving.
- Diving depth should allow direct ascent.
- Diver with T1DM should dive with a buddy without T1DM.
- Divemaster/instructor/buddy informed about limitations and special conditions that apply to SCUBA diving with T1DM.

By comparison: T1DM and SCUBA diving

- Would it not seem a good idea to try to create similar evidence based recommendations for skydiving and T1DM?
Thank You.
Questions?

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