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Case Report

Case Studies: Optimal Glucose Profiles in Air Traffic Control Officers

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Summary

Aviation personnel, including air traffic control officers (ATCOs) on insulin, are assessed as unfit in many countries, including most European, due to pending hypoglycemia-related incapacitation risk. However, over the last decades, insulin treatment has become progressively safer through steadily evolving technological advances. Consequently, the Federal Aviation Administration (FAA) in the USA and the European Union Aviation Safety Agency (EASA) in Europe have considered whether aeromedical examiners might assess pilots on insulin as fit for flight under specific protocols. Such a position might pave the way for fit assessment in all insulin-treated aviation officers and ATCOs, who, despite experiencing different environmental stress factors, show the same high commitment to their jobs as pilots. After showing the excellent continuous-glucose-monitoring-proved metabolic profile attained by two insulin-treated ATCOs (one working as apron, the other immediately after being diagnosed), we discuss the literature concerning potential stress-related glucose changes and suggest allowing them to go on working to let the system exploit at best the significant time and financial resources spent in challenging, highly specialized job training given growing reduction in staff for planned retirements in the next few years.

Keywords: Air traffic control officers; Type 1 diabetes; Insulin; Continuous glucose monitoring

Introduction

At present, air traffic control officers (ATCOs) must meet the same medical requirements as flying professionals to be certified and are, therefore, considered unfit whenever they require insulin treatment for Type 1 diabetes mellitus (T1DM).

Besides facing a stressful work environment predisposing to high glucose levels which, if persistent, would threaten health, ATCOs undergo such a limitation for the pending insulin-related risk for sudden incapacitation due to low blood glucose concentrations, currently defined as level 1 (3.0–3.8 mmol/L or 54-69 mg/dL) or level 2 (< 54 mmol/L or 54 mg/dl) hypoglycemia [1]. Indeed, this risk was real until only old syringe-based administration systems for so-called "*rapid*" regular insulin and the slow NPH (neutral protamine Hagedorn) product were available. Nowadays, those elements have been mostly substituted for by pens with fast-acting or basal insulin analogs closely reflecting spontaneous pancreatic secretion in the hand of well-trained and motivated patients and, even more, by semi- of fully-automated insulin pumps keeping users within the world-wide accepted glucose "*time in range*" (TIR) range of 70-180 mg/dl [3,8-10.0 mmol/L] for over 70% of the day [2].

To gain insight into glucose control of insulin-treated ATCOs highly committed to their jobs, we analyzed the results attained by one apron manager with T1DM and an ATCO recently diagnosed with LADA (Latent Autoimmune Diabetes of the Adult), a subtype of T1DM occurring later in life. Both gave us informed consent to analyze and publish samples of a great deal of their recorded readings.

Case Report 1

M.I., a 31-year-old French woman working as an apron manager at the largest airport in France, was assessed as unfit for ATCO activities because of insulin-requiring diabetes. She exercises regularly and is well-educated on carbohydrate (CHO) counting and insulin dose adaptation to changing CHO intake and perturbing factors, including physical activity. She wears a sensor-integrated insulin pump, which helps her adapt the insulin release rate semi-automatically.

Her laboratory results, including glycated hemoglobin (HbA1c), were all within the normal range and she proved to be free of any macro- or microvascular, eye, or renal diabetes complications.

To assess real-life evidence of her glucose control under leisure and working conditions, we asked her to provide us with wearable sensor-based continuous glucose monitoring (CGM) profiles recorded while managing aircraft on the ground, around the terminals, and in leisure time. She eagerly accepted to do so for the benefit of science only.

She sent us readings from the last five months, as shown below. Since it is practically impossible to publish all CGM reading sets, here we provide typical samples of a rest day and a working day to witness her stable glucose levels, especially the lack of any hypo- or hyperglycemic events in either condition.

As shown in (Figures 1, 2), glucose control was fully superimposable under working and non-working conditions. Working periods are represented within yellow rectangular areas, with purple inner rectangles pointing to close contact with pilots maneuvering on the ground. Her optimized metabolic control is reflected in her excellent HbA1c level of 6.2% and a Time in Range (TIR) of 90%.

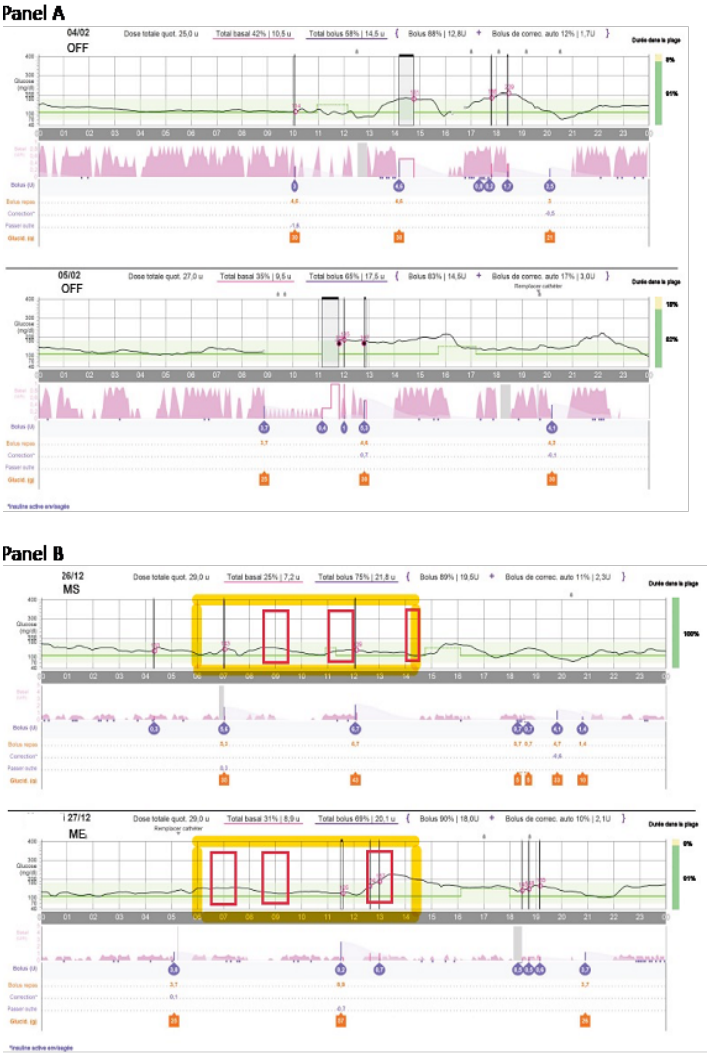

Figure 1: Continuous subcutaneous glucose readings under non-working **(Panel A)** and working **(Panel B)** conditions in the first subject. Working periods are represented within yellow rectangular areas, with red inner rectangles showing close radio contact with pilots maneuvering on the ground.

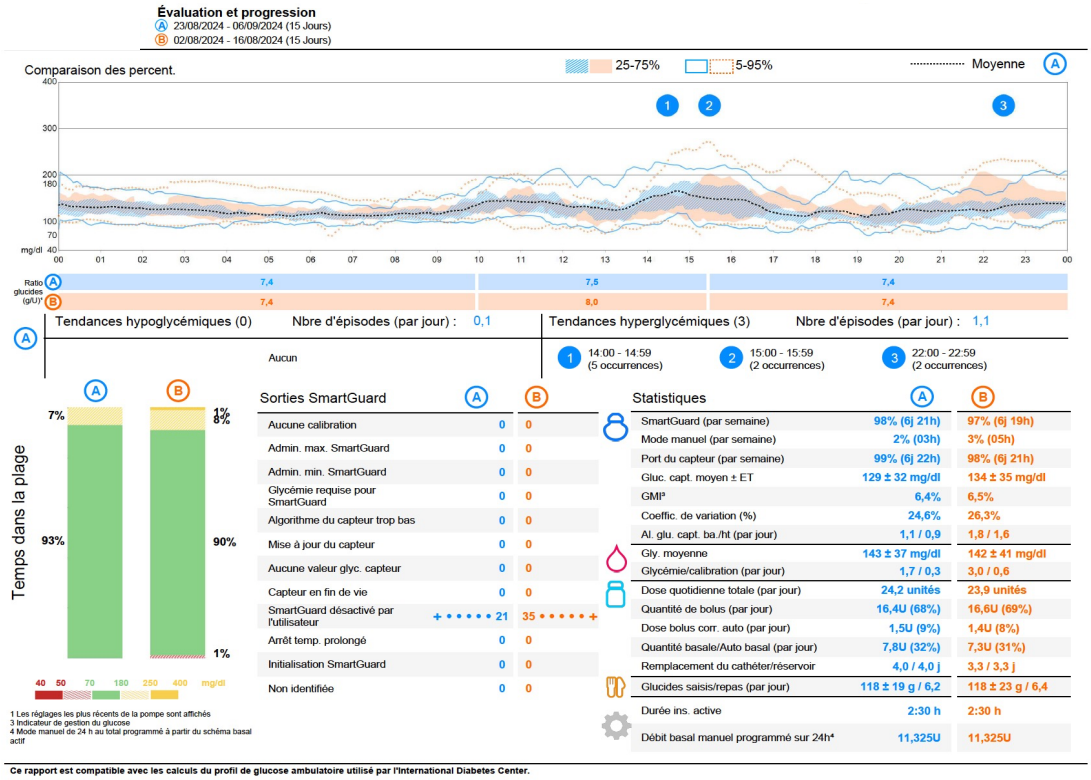

Figure 2: A 28-day (14 + 14 day) CGM report from the first subject.

Case Report 2

C.B., a 49-year-old male ATCO working in the tower of a major airport in Portugal, is also physically active and is well-educated on CHO counting and insulin dose adaptation to changing CHO intake and perturbing factors, among which exercise.

His laboratory results, including HbA1c, were all within the normal range, and he was free of any macro- or microvascular, eye, or renal diabetes complications.

He had just been diagnosed as insulin-requiring but had kept the CGM files of recordings made during his previous three-month daily work, which he eagerly accepted to send us free for the benefit of science only. He is on a long-acting insulin analog and insulin-sensitizing agents during the day.

A from (Figures 3, 4), the subject's CGM readings show no significant differences in glucose trends between working and non-working days. His HbA1c is 5.7% with a TIR of 97%, reflecting excellent metabolic control.

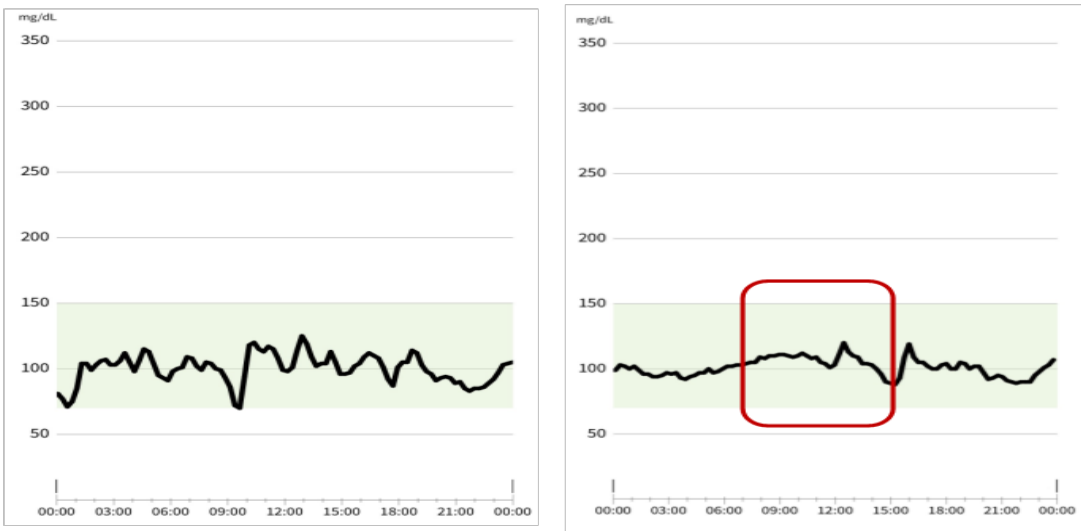

Figure 3: Continuous subcutaneous glucose readings under non-working (Panel A) and working (Panel B) conditions in the second subject. The working period is represented within the red rectangular area.

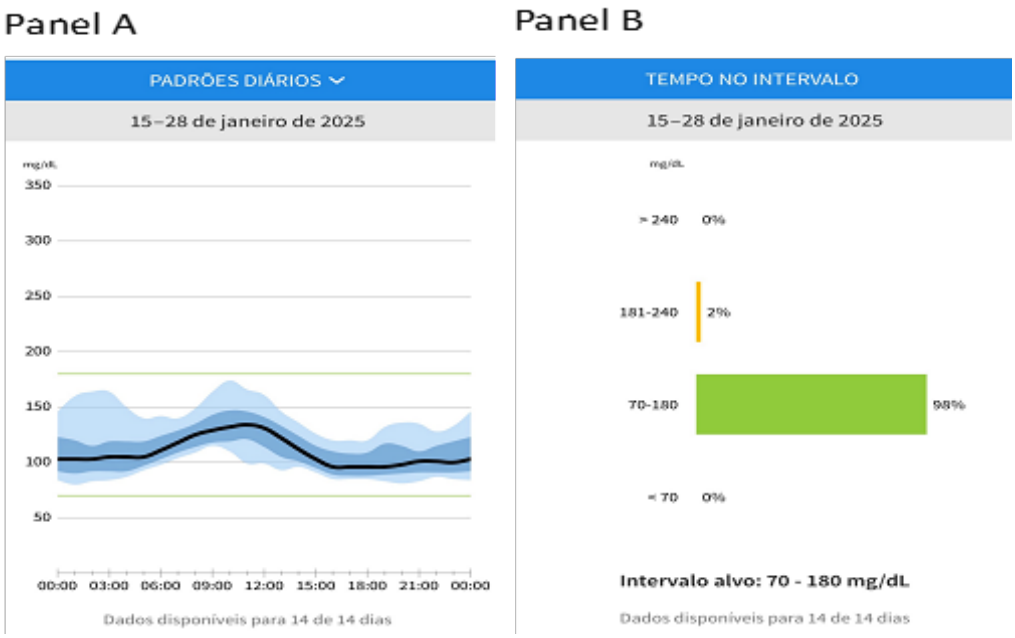

Figure 4: A glucose profile from the second subject showing the 14-day mean glucose profile clearly showing a fully satisfying glucose control within the frame of the 70-180 mg/dl range on the left and his optimal TIR on the right.

Discussion

While these individual cases do not constitute formal scientific evidence, they illustrate the enviable metabolic control achieved and maintained over time by well-educated professionals in both the presence and absence of working-related stress.

Given the recently published reassuring results of the ARA MED 330 protocol from the European Union Aviation Safety Agency (EASA) involving pilots on insulin for years 3, the continuous progress in diabetes technology and the strong commitment to the best lifestyle and glucose control management practice to keep fit-for-job and the current, extremely safe insulin treatment strategies, hypoglycemia could be seen as a negligible incapacitation risk factor for ATCOs in general. Indeed, we could not find any hypoglycemic events in our cases.

On the other hand, the two subjects also proved to never go beyond the upper level of the "*green range*" accepted for pilots included in the ARA MED 330 protocol (15.0 mmol/L or 270 mg/dL), which was acceptable in terms of work efficiency [3].

Stress can be defined as a human reaction to emotional, cognitive, and physical challenges, especially, yet not necessarily, when subjects are vigilant against imminent dangers. Indeed, ATCOs are working in situations characterized by high stressful communication/management needs and environmental constraints as integral part of their job, which is classified by the U.S. Department of Labor at the upper fourth level [4]. As a consequence of that, the vast majority of controllers retire before the expected age with stress-related work disabilities [5].

Explaining ATCO stress only by the level of air traffic activity and potential conflicts may not be far-sighted. However, to be accepted in the starting ATCO course, all candidates have to pass specific psycho-technical tests and group dynamics exercises to provide the system with sufficient guarantees of their ability to cope with highly stressing conditions despite a well-tested overload mitigation system of the work environment they are expected to live in.

At the beginning of this century, Costa et al. analyzed the psychological pattern of ATCOs, trying to sort out the most relevant components of work stress (WS) [6]. They found that WS was related primarily to mental load, time pressure, and the burden of responsibility. Stressed individuals mainly reported digestive, neuropsychic, and cardiovascular psycho-somatic symptoms, although less frequently than observed in the general population. Regional center ATCOs reported such symptoms more frequently than Airport tower ATCOs; the same applied to those operating in radar than non-radar positions, respectively. However, family history, lifestyle, sleep pattern, chronotype (morningness being better for early shifts), and neurotic personality traits seemingly influence results [6].

At the same time, shiftwork has become less problematic due to the current excellent shift schedules. A common source of stress is 24-hour sleep deprivation (SD), potentially occurring as a function of sudden job requirements and inappropriate shift schedules as part of specific occupational environments. Indeed, SD makes people more susceptible to making errors by impairing attention and working memory through increased serum concentrations of stress hormones, including cortisol, epinephrine, and norepinephrine, without causing any changes in glucose and inflammatory markers compared to baseline [7].

Due to that, according to Iavicoli et al., occupational medicine specialists should allow complication-free, eumetabolic persons with diabetes (PwD) to fully implement their skills in any jobs by considering the least invasive organizational interventions in terms of acceptable shiftwork and night-time rosters and assuring easy access to fluid/electrolyte sources and tight blood glucose monitoring [8].

Indeed, considering the relatively null effect of real-life working-related stress on glucose levels in our two cases, we might speculate that stress experienced during duties has no substantial impact on their carbohydrate and insulin intake and, therefore, on their glucose profiles, thus causing neither relevant hyperglycemic spikes nor significant hypoglycemic troughs.

Such a conclusion is also in line with what was found by Wiesli et al. in T1DM patients undergoing acute psychosocial stress through the Trier Social Stress Test (TSST) under basal and postprandial conditions. They found no glucose changes in the fasting state, and there was only a significantly delayed glucose decrease in the postprandial period [9].

Another group investigating people with T1DM waking up in response to an alarm clock at 4 a.m. found CGM-based glucose concentrations to significantly increase by 18±6 mg/dl (1.0±0.3 mmo/L) only in the absence of nurse assistance [10]. According to Walker et al., adults with diabetes under higher work stress levels experience slightly higher HbA1c levels, witnessing the well-known hyperglycemic effect of stress and, therefore, the hypoglycemia-related incapacitation is a highly unexpected event unless PwD happen to reduce their CHO intake [11]. Such an observation had already been reported nine years before by Gonder-Frederick et al. in pump-wearing T1DM patients recording carbohydrate intake, insulin doses, and psychological stress ratings: the authors suggested the need for specific education in stress management and accurate insulin dose adaptation to changed carbohydrate intake [12].

Conclusion

Being an insulin-treated subject can take many resources. Also, some days can be more challenging than others. However, professionals with diabetes are commonly aware of the high risk they incur in terms of both life-threatening attitudes and failure to maintain their jobs and related income.

Therefore, once they have attained metabolic control, all flight personnel will do their best to stay safe and avoid extreme glucose

excursions as much as possible. Especially when using advanced hybrid pumps that enable semi-automatic glucose management throughout the day and consistently commit to the best glucose management, ATCOs on insulin will be very good at keeping in the tightest optimal range.

Provided their glucose control is acceptable for a sufficiently long period during and around working hours, forbidding professionals with T1DM to be or become ATCOs would seem unfair nowadays. Permitting them to obtain a fitness certificate appears logical and safe worldwide, not only in countries like the USA, where the Federal Aviation Administration (FAA) already paved the way to a CGM-based flight safety risk mitigation protocol for exercising airline transport or commercial pilot privileges [13]. Aeromedical examiners should employ a rigorous and structured evaluation process when assessing insulin-treated ATCOs for continued certification. A case-by-case assessment of individuals with diabetes seeking to become or continue as ATCOs is now warranted. This approach will promote positive outcomes such as increased motivation and job satisfaction. Allowing ATCOs diagnosed with T1DM after their qualification to continue with their current role will entitle society to make the best use of the significant time and financial resources spent on challenging, highly specialized job training given the growing reduction in staff for planned retirements in the next few years.

Acknowledgments

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