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Safe and Successful Completion of a Half Marathon by an Adult With Type 1 Diabetes Using a Personalized Open Source Artificial Pancreas System

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Introduction

Automated insulin delivery systems, both commercial and open source, have shown to be safe and effective in reducing hypoglycemia during physical activity in the previous studies.[1–3] However, publications on people with diabetes (PwD) running half and/or full marathons are scarce and no reports exist on closed-loop control under extreme sports conditions.[4]

In this case report, we describe the safe and successful completion of a half marathon in Burg-Lübbenau, Germany by an adult with type 1 diabetes (T1D) using a Do-it-Yourself Artificial Pancreas System (DIYAPS).

Methods

The total route was 21.1 km with 1.8 m difference in altitude. The runner was a 49-year-old male living with T1D for 32 years, previously using a DIYAPS for 23 months, and a monthly average training volume of 60 km.

A Dexcom G6 CGM sensor, an Accu-Chek Spirit Combo insulin pump, and an OpenAPS-based open-source algorithm (AndroidAPS) were used.[5] Sensor glucose levels, insulin delivery, and carbohydrate intake were uploaded to the PwD's personal Nightscout server, an open-source remote monitoring platform (Figure 1).[6]

Results

During training, the runner created an exercise profile with an increased insulin sensitivity factor (ISF) of 90 mg/dL per unit instead of 50 mg/dL. Basal rates were reduced from 0.75 to 0.4 U/h. Carb ratio was increased from 10 to 38 g/U. A temporary target of 150 mg/dL was set during exercise.

The exercise profile was activated 30 minutes prior to the race, with the intention to have active insulin on board from the previous regular profile in order to cover the expected glucose peak due to adrenaline release at the start of the race. An initial temporary target of 180 mg/dL was set to avoid overdosing by the algorithm due to the short adrenaline peak. A total of 36 g of carbohydrates (bread) were consumed before and 24 g (sports gel with glucose syrup and maltodextrin) during the race.

The race was successfully completed after 01:52, 41 hours with an average pace of 5:12 min/km. Time in range was 100% during the race and 95.8% on race day and the following day, with an average glucose level of 119 mg/dL (+− 27.2 mg/dL). No time below range (<70 mg/dL) was detected during the race, and 1.2% within race day and the following day, with 63 mg/dL being the lowest sensor glucose reading detected.

After race completion, a correction bolus of 2 U was administered and the regular profile with a target glucose level of 100 mg/dL and the regular basal rate were reactivated. One hour after the race, another manual correction bolus of 1.4 U was administered. Three hours after the race, a temporary override profile with 80% overall insulin needs, affecting basal rate, ISF, and carb ratio, was used in order to avoid hypoglycemia due to postexercise glycogen replenishment. Insulin needs were again increased to 90% the following day, 32 hours after race completion, when the replenishment effect slowly faded.

Conclusion

This case report demonstrates that prolonged and intense physical activity, such as half marathons, can be safely completed by PwD using closed loop systems and DIYAPS in particular. Hypoglycemia and hyperglycemia could be successfully avoided by setting temporary closed-loop targets.

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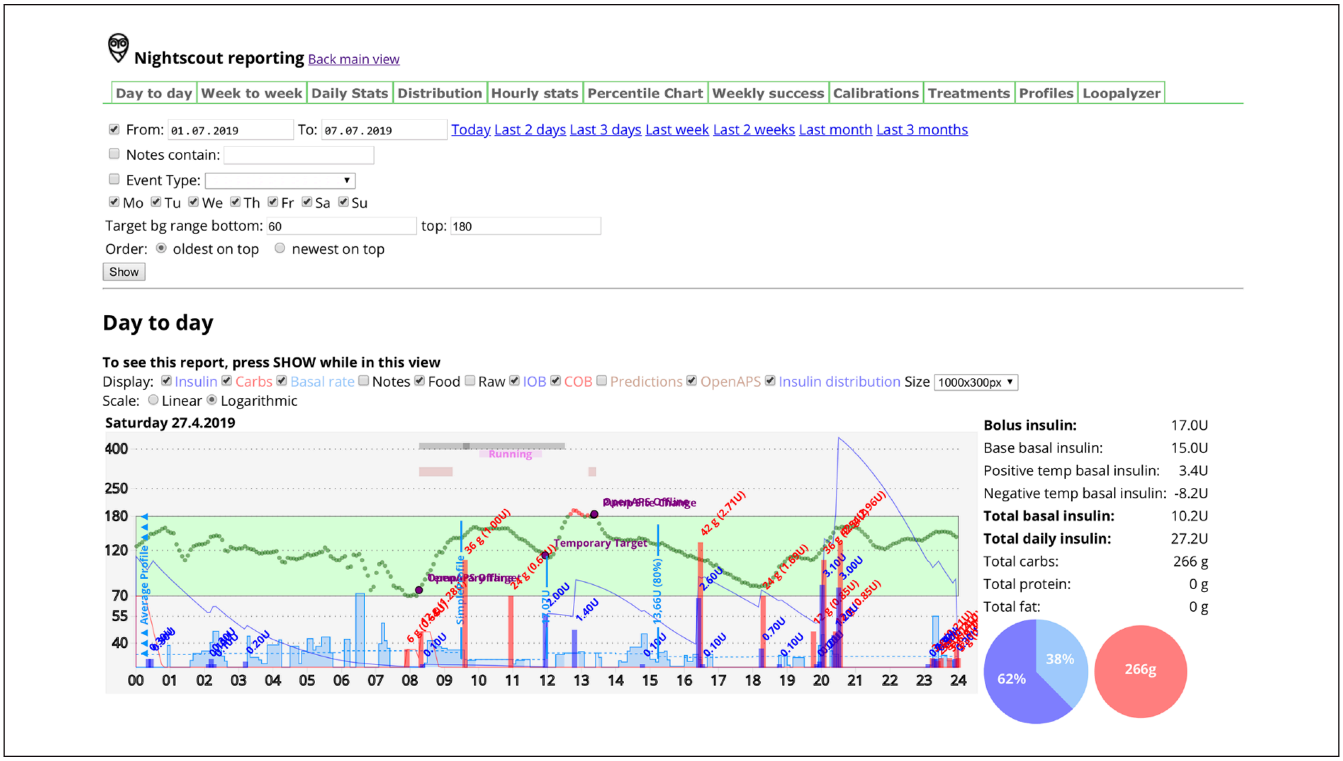

Figure 1. Nightscout documentation of AndroidAPS on race day.
Green: glucose target range from 70 to 180 mg/dL. Upper graph: sensor glucose profile. Red: carbohydrate intake. Light blue: basal rate. Dark blue: bolus insulin. Purple: temporary targets. The race started at 10:00 AM and was successfully finished at 12:00 PM.

Declaration of Conflicting Interests

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