Effects of moderate-severe exercise on blood glucose in Type 1 diabetic adolescents treated with insulin pump or glargine insulin

M. Delvecchio1, C. Zecchino1, G. Salzano2, M.F. Faienza1, L. Cavallo1, F. De Luca2, and F. Lombardo2

1Department of Biomedicine of Developmental Age, University of Bari, Bari; 2Department of Pediatric Sciences, University of Messina, Messina, Italy

ABSTRACT. Background: Few papers focus on exercise-related blood glucose (BG) in patients on continuous sc insulin infusion (CSII) or multiple daily injections (MDI) with glargine. Aim: The main objective was to evaluate the degree of glycemic control in Type 1 diabetes mellitus adolescents on CSII doing physical activity with pump switched on or off. These findings were also compared with a small group of patients on MDI with glargine. Subjects and methods: Eight patients on CSII (basal rate continued or turned off in alternating sessions) and 5 on MDI joined 4 sessions of moderate-severe exercise. Results: Post-exercise BG significantly increased with the pump off and was unchanged/decreased with the pump on and MDI groups vs baseline. The hypoglycemia rate was not different among the 3 groups at any time. Pump on: hypoglycemias more frequent both at bedtime (p=0.031) and at awakening (p<0.001) than before dinner and at awakening than at bedtime (p=0.044). Pump off: hypoglycemias more frequent both at bedtime (p=0.010) and at awakening (p=0.031) than before dinner. MDI: no differences. Conclusions: Glargine is safe and reducing the pre-lunch insulin is unnecessary. Subjects on insulin pump should not stop the basal rate. If they stop the pump, some actions are advisable: pre-exercise insulin bolus, pre-sleeping snack rich in carbohydrates, slight reduction of the overnight basal rate. On the other hand, if the basal rate is unmodified, the ingestion of sugary drinks during the exercise, the reduction of the overnight basal rate, a reduction of the pre-dinner insulin bolus and/or a pre-sleeping snack should be considered. (J. Endocrinol. Invest. 32: 519-524, 2009)

INTRODUCTION

Since exercise has widely been recognized as a cornerstone in the management of Type 1 diabetes mellitus (T1DM), patients have been encouraged to engage in physical activity on a regular basis (1, 2). Although the real long-term benefits on blood glucose (BG) control are yet to be ascertained (3-5), exercise is acknowledged to improve physical and cardiovascular fitness, lipid profile, well-being, self-confidence, and helps to control weight gain (6-14).

Physical activity requires considerable compliance from patients and, despite the advantages, is often considered a challenge because of the potential adverse effects related to glycemic instability (15). Hypoglycemia, due to an increased insulin sensitivity of the muscles (16), is the most common and dangerous risk and may occur during exercise and recovery phase (10, 17-19). Hyperglycemia, with or without ketosis, may occur mainly in patients with poor glycemic control (18, 20, 21) and after anaerobic exercise (8, 20).

In recent years, regimens with multiple daily injections (MDI) with long-acting analogue as background insulin (22-24) and continuous sc insulin infusion (CSII) (25-27) have been significantly improved, becoming safer and more effective in achieving a tight glucose control. Despite some suggestions to engage physical activity safely (2, 28), few articles have focused on exercise-related BG in patients on CSII or MDI with glargine (17, 29-33) and some questions have not been completely answered, especially for the anaerobic exercises. The patients on insulin pump may switch off or reduce the basal rate infusion to avoid the risk of hypoglycemia during the exercise (33), but they do not know how much the basal rate should be reduced or if switching off the pump is better. On the other hand, the patients on glargine cannot modify their basal insulin in case of unplanned exercise, and so can eat only small amounts of carbohydrates to avoid the risk of hypoglycemia. In both situations, however, there is little data about the BG control during the recovery phase.

Lastly, previous studies assessed the effects of standardized exercise on BG in subjects on CSII or MDI, but what happens in real life when adolescents do not do standardized physical activity has never been evaluated.

The primary aim of our study is to compare the degree of glycemic control achieved in adolescents with T1DM who are managed using an insulin infusion pump when it is switched on vs when it is off, during moderate-severe exercise as closely similar as possible to their real life. In addition, as a secondary objective, we compared these findings with those obtained in a small group of age-matched patients on MDI with long-acting insulin analogue performing the same exercises.

MATERIAL AND METHODS

Subjects

The inclusion criteria were: 1) pubertal patients (breast development ≥2nd Tanner stage for females, testicular volume ≥4 ml

Key-words: Continuous subcutaneous insulin infusion, long-acting insulin analogue, school camp, sport, Type 1 diabetes mellitus.

Correspondence: L. Cavallo, MD, University of Bari, Department of Biomedicine of Developmental Age - Piazza Giulio Cesare, 11 - 70124 Bari, Italy.

E-mail: lucicaval@tin.it

Accepted December 29, 2008.

First published online March 26, 2009.
for males) aged 11 to 17 yr, 2) diagnosis of T1DM >6 months before recruitment, 3) glycated hemoglobin (HbA₁c <10% at recruitment, 4) on CSII with short-acting insulin analogue or MDI with regular insulin and long-acting analogue at least for 3 months, 5) not in clinical remission phase. The patients joined a 4-day school camp focused on physical activity which took place in a holiday village equipped with gym, soccer field, and volleyball court. The study was conducted during the school camp because we thought it was the best to check food intake, sleeping, and all the daily activities.

Subjects were excluded if there was any diabetic complication or condition (hypoglycemia unawareness, no self-confidence with the insulin injections) considered dangerous for patients’ health if the camp was joined. A letter explaining design and aims of the camp was mailed to all eligible patients’ families and parents and a consent form to participate was obtained. Five males and 4 females on CSII and 1 male and 4 females on MDI participated. A male on CSII was excluded from the statistical analysis because of poor adherence to the protocol during the camp. In the patients on CSII, a short-acting insulin analogue (lispro, Eli Lilly, Indianapolis, IN) was delivered by an insulin pump (D-TRONplus, Roche Diagnostics, Basel, CH) into the abdominal fat pad. Patients on CSII self-administered insulin bolus 4 times a day, before breakfast, the 10:30 h snack, lunch, and dinner. Patients on MDI injected regular insulin (regular insulin, Eli Lilly, Indianapolis, IN) 30 min before each meal in the abdomen, and the long-acting insulin analogue (glargine, Sanofi-Aventis, Frankfurt am Main, D) at bed-time into buttocks or legs. All patients underwent a clinical visit. Patients’ height, weight, and HbA₁c were collected within 3 months before the camp start. The MDI and CSII groups were statistically similar (Table 1).

**Exercise procedure**

Every day the patients engaged in moderate-severe exercise from 16:00 h to 18:00 h. On the first and the second day, played volleyball for 55 min, rested for 10 min, and then played soccer for other 55 min. On the 3rd and the 4th day, they did exercise in a gym for 55 min, rested for 10 min, and then the males played soccer and the females played volleyball for other 55 min. When playing soccer, each patient played as goalkeeper for 5 min, so that the energy expenditure was similar for everyone. The gym session was with 15 min of brisk walking on a treadmill, 5-min rest, 15 min of cycling, 5-min rest, and 15 min of gymnastic exercises. During the gym session a heart rate monitor was worn, and patients were asked to perform exercises with a heart rate between 55 and 85% of maximum effort calculated as 220 – chronological age.

The basal rate was continued during the exercise from 16:00 h to 18:00 h the 1st and the 3rd day and switched off every other day. The basal rate was not reduced when the pump was on because in our experience diabetic patients often engage in physical activity without reducing the insulin infusion. When the pump was off, we did not administer an insulin bolus before or after the exercise. The pre-lunch insulin bolus was not reduced to mimic the effects of unplanned exercise. Except for exercise procedure, the insulin management was similar over the days with pump on and pump off and the patients were treated in the same way over the 4 days.

**Other procedures**

The daily caloric intake was standardized in the study design (carbohydrates 55-65%, lipids 20-30%, proteins 10-15%) and divided into 3 main meals (15-20% at breakfast, 08:00 h; 35-40% at lunch, 13:30 h; 25-30% at dinner, 20:00 h) and 2 snacks with 15-20 g of complex carbohydrates (at 10:30 h and 15:30 h). The patients went to sleep at midnight and were awakened at 7:30 h. As for the self-monitoring of BG, a 6 point-daily profile BG (fingerstick 30 min before and 120 after both breakfast and lunch, 30 min before dinner, and at 11:30 h) was recorded. BG was determined on capillary blood with the Accu-Chek Compact glucometer (Roche diagnostics, Basel, CH). The BG was checked 30 min before the exercise session. In patients with pre-exercise BG above 250 mg/dl (5 subjects, 253-279 mg/dl) ketosis was checked and proved negative every time. On the other hand, when it was below 100 mg/dl, it was checked again at the beginning of exercise and was above 100 mg/dl in all patients (28). In addition, BG was checked whenever the patients presented symptoms of hypoglycemia and at 03:00 h if the bedtime BG was below 150 mg/dl. Hypoglycemia (BG <70 mg/dl) was considered severe if the subject was confused and required assistance from another person, with or without glucagon injection, otherwise considered mild and corrected orally with 150 cc of fruit juice containing 10-15% of carbohydrates. Even if this choice may have some impact on the further course of BG and hypoglycemia rate, this is what the patients do in real life. If symptoms of hypoglycemia occurred during the exercise session, the patient was stopped until it felt well enough to start again and the BG exceeded 100 mg/dl.

**Statistical analysis**

We analyzed the exercise-related BG values on the basis of the therapeutic approach (pump on, pump off, and MDI). The 15:30 h BG was considered the baseline and compared to the BG at 19:30 h, at 23:30 h, and at 7:30 h the day after. The statistical analysis was performed with SPSS 11.5® computer software for Windows. As its normal distribution was checked by the Kolmogorov-Smirnov test, BG was reported as mean±SD and analyzed with parametric tests. The BG variance was considered as in-