Carbohydrate requirements during intermittent high intensity exercise compared to continuous moderate intensity exercise in individuals with type 1 diabetes

Tania Buehler[1], Lia Bally[2], Ayse Sila Dokumaci[1], Christoph Stettler[2], and Chris Boesch[1]

[1]Depts. Radiology and Clinical Research, University Bern, Bern, Switzerland, [2]Division of Endocrinology, Diabetes and Clinical Nutrition, Inselspital Bern, Bern, Switzerland

TARGET AUDIENCE: Those interested in glycogen metabolism and/or diabetes type 1.

PURPOSE: Continuous exercise of moderate intensity (CONT) increases the risk of exercise-associated hypoglycemia in individuals with type 1 diabetes (T1DM) if insulin doses are not adapted as it is frequently the case in clinical practice. In contrast high intensity exercise may raise blood glucose levels due to the activation of counter-regulatory hormones. The combination of low to moderate exercise with interspersed high-intensity activity (i.e. **intermittent high intensity exercise (IHE)**) may be a strategy to attenuate exercise-related decline in blood glucose and therefore prevent hypoglycemia without pre-exercise insulin treatment [1, 2]. However, the detailed metabolic regulation of IHE in T1DM has not been studied comprehensively. The purpose of the present study was to evaluate glucose requirements and hepatic and myocellular glycogen consumption during IHE compared to CONT in T1DM subjects.

METHODS: For this prospective, randomized cross-over study assessing glycogen consumption following two different exercise protocols (CONT, IHE) 10 male complication-free individuals with T1DM (27±4 y, BMI: 25.2±2.9 kg/m^2, mean HbA1c 7.2±0.7%, diabetes duration>5years) were enrolled. Study participants attended the clinical research facilities for preliminary study visits. A screening visit (assessment of anthropometrics, basic metabolic rate, and body composition) was performed in both trials, whereas for the exercise study (IHE vs. CONT) an incremental cardiopulmonary exercise test and a familiarization to the planned exercise interventions were carried out in addition. All subjects followed a 2-day standardization protocol prior to the ^{13}C MRS glycogen examinations in liver and the right quadriceps muscle. Standardization involved a diet with a predefined daily carbohydrate intake (50% of daily energy requirements according to a metabolic assessment using indirect calorimetry, withdrawal from exercise, and avoidance of alcohol and caffeine). Patients injected their usual insulin dose and had a standardized breakfast before 7 am on the three separated test days involving a baseline glycogen measurement, an exercise intervention (following either the CONT or IHE protocol) with a glycogen measurement afterwards. The isoenergetic exercise interventions consisted of a 90 min cycling session at 40-50% VO_2 peak with (IHE) and without (CONT) interspersed 10 s maximal sprints every 10 min. Stable glycemia was maintained within the euglycemic range using a 10% oral glucose solution following a pre-specified algorithm. MR localizer images and ^{1}H decoupled natural abundance ^{13}C spectra (see Fig. 1) were recorded on a standard clinical 3.0 Tesla MR scanner (TRIO, Siemens Erlangen, Germany) using a transmit-receive ^{1}H/^{13}C flexible surface coil (RAPID Biomedical GmbH, Rimpar, Germany).

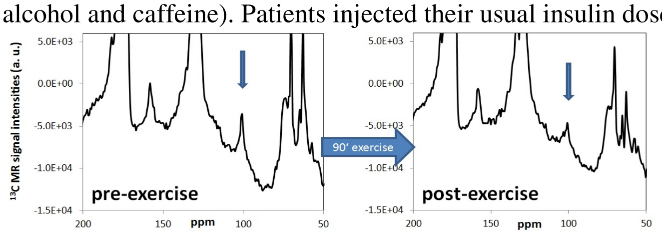

***Fig. 1: ^{13}C MRS spectra in liver** at baseline and after exercise (CONT). The decrease in glycogen (peak at 100.5 ppm) reflects exercise-related glycogen consumption. Note that the spatial saturation suppresses the signal from glycogen (on the center frequency) in the abdominal muscle yet not of creatine (chemical shift displacement of the spatial saturation).*

RESULTS: Regarding the comparison (see Fig. 2) between the two exercise interventions (CONT vs. IHE), mean±SEM glucose required to maintain glycemia was significantly lower in IHE (16.3±5.8 g) compared to CONT (47.4±9.6 g; p=0.006). Mean±SEM glycemia during IHE was 8.33±0.22 vs. 7.62±0.15 mmol/l during CONT. Lactate concentrations were significantly higher during IHE compared to CONT (mean±SEM: 6.2±0.6 vs. 2.4±0.2 mmol/l, p=0.014). Mean change in hepatic glycogen content following IHE was -25.1% ± 10.1% compared to -9.8% ± 12.7% following CONT (see Fig. 3). Regarding myocellular glycogen consumption, IHE lead to a mean change in glycogen content of -40.0% ± 6.4%, whereas mean change following CONT was -41.0% ± 4.4%.

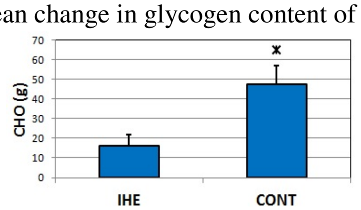

***Fig. 2: Supplied carbohydrates** (mean±SEM) to maintain euglycemia during the interventions (*p=0.006). Carbohydrates were provided by 10% glucose drinks.*

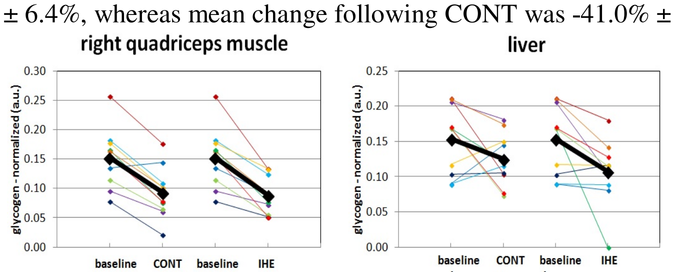

***Fig. 3: Myocellular and hepatic glycogen** at baseline and after exercise (n=10). Black symbols indicate mean glycogen content. Note that baseline data has only been determined once, prior to the first visit. Variations after the standardized preparation were minimal.*

DISCUSSION AND CONCLUSION: IHE provides a feasible strategy to reduce glucose requirements during exercise in the absence of pre-exercise insulin adaptations. The reduced amount of exogenous glucose required to maintain euglycemia during IHE may be related to an increased consumption of endogenous glucose stores, predominantly hepatic glycogen.

REFERENCES: [1] Iscoe KE et al. DiabetMed. 34:e109 (2011), [2] Guelfi KJ et al. Am J Physiol. 292:E865-870 (2007)

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