Continuous Glucose Monitoring before and after Exercise in Patients with Type 1 Diabetes on CSII

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Aim

- To assess the impact of an exercise challenge on the glucose profiles in the 21 hours thereafter in patients with type 1 diabetes managed by a continuous subcutaneous insulin infusion (CSII) regimen before and after a 14 day moderate or intense training program.

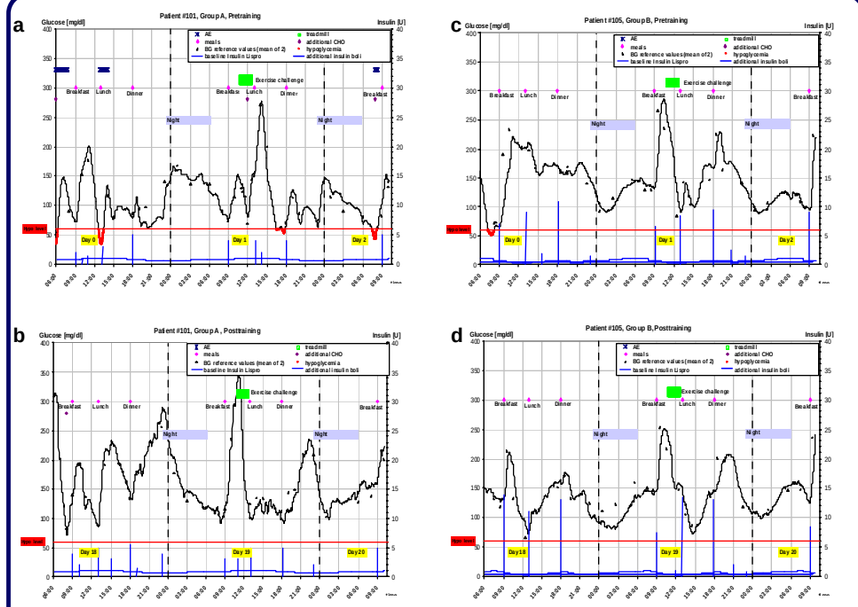
Methods

- Study Design: Mono-centric, randomized, open-label, clinical-experimental study according to GCP
- Patients 16 male patients with type 1 diabetes on CSII
- Age (years) 38±11 (mean±SD)
- Diabetes duration (years) 4.2±3.0
- BMI (kg/m²) 26.0±2.7
- HbA1c (%) 7.3±0.8
- fitness index 91.4±7.8
- Study performance: Patients were randomized to one of two groups (A or B; n=8 each)
- Patients underwent exercise challenges during two in-house periods before and after a 14 day moderate (Group A) or intense (Group B) training period
- In-house periods consist of two subsequent study days
- In the morning prior to the in-house periods microdialysis catheters were inserted for continuous glucose monitoring by means of a microdialysis system (SCGM system, Roche Diagnostics, Mannheim, Germany).
- On the first in-house day changes in glucose profiles were registered continuously (results were not displayed) while patients received standardized meals. On the second in-house day patients began at about 11:00 h for 45 minutes to perform exercise on a treadmill.
- The exercise challenge were sufficient to induce a sustained heart rate between 65 and 85% of the individual maximum heart rate (calculated as 220 minus age)
- The second in-house period had an identical experimental procedure.
- 13-point blood glucose profile was performed by collecting capillary blood samples at the fingertips. Glucose levels were measured with a glucose meter built into the Base Unit of the SCGM system
- For insulin therapy patients were instructed to keep basal insulin infusion rate at their usual dose. Doses of prandial insulin boli were determined by the patients according to their usual doses taken for meals according to carbohydrate content of the meals and self-measured pre-prandial blood glucose values.
- Snacks were allowed only in case of hypoglycemic events (blood glucose values <60 mg/dL, or symptoms)

Microdialysis System

- SCGM 1 (Roche Diagnostics) with a CMA 60 catheter (CMA, Sweden)
- Low pump rate (0.3 µl/min) of the perfusate, liquid GOD is added extracorporeally for glucose measurement
- ISF-Microdialysis measurements were calibrated taking all capillary blood glucose values measured in blood samples collected from the fingertips on both study days
- Prior to calibration the data of the SCGM 1 system were corrected for the physical lag-time (30 min)

Glucose profiles of one patient of Group A pre- (a) and posttraining (b) and one patient (#105) of Group B, pre- (c) and posttraining (d)



Training period: Level of exercise and related effects (mean±SD)

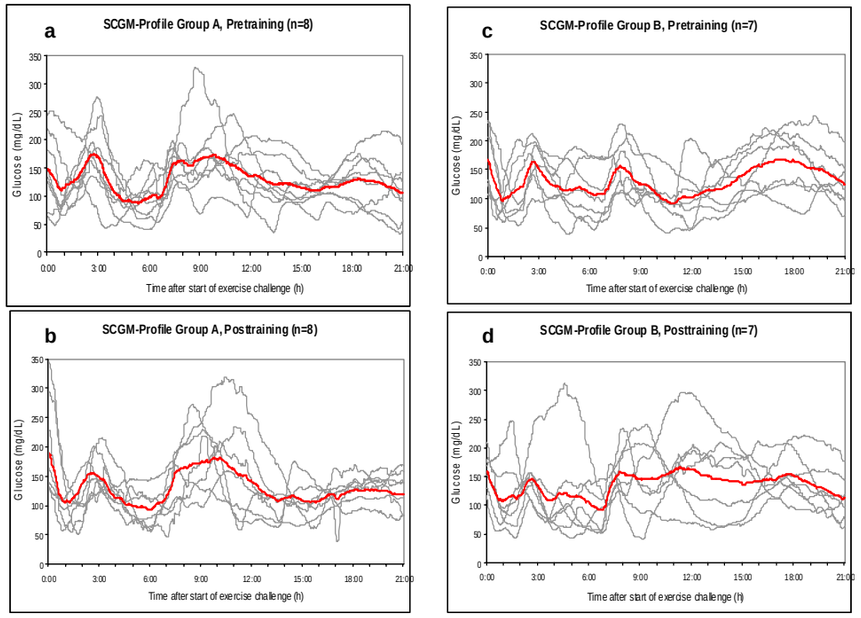
Parameter	Group A (moderate exercise, n=8)				Group B (intense exercise, n=7)				P-value[1)]
Training period									
No. of training sessions	7.6±0.5				14.4±0.8				< 0.0001
Total exercise time (min)	281±49				1046±234				< 0.0001
Time within heart rate limits (min)	234±50				853±100				< 0.0001
% time within heart rate limits	83.4±11.6				83.8±14.7				0.959
Heart rate (bpm)	135.9±11.8				132.7±10.0				0.582
Total energy consumption (kcal)	3062±614				10564±1838				< 0.0001
	Pretraining	Posttraining	Difference pre-post	P-value[2)]	Pretraining	Posttraining	Difference pre-post	P-value[2)]	P-value[3)]
Impedance measurements									
BFM (kg)	19.6±7.4	20.0±7.6	-0.4±2.8	0.711	22.2±5.7	22.5±4.0	-0.3±3.4	0.832	0.589
BFMP (%)	22.6±6.7	23.2±6.9	-0.6±3.2	0.605	25.5±4.8	25.9±2.2	-0.3±4.1	0.830	0.548
LBM (kg)	64.9±5.1	20.0±7.7	0.8±3.1	0.469	64.0±5.6	63.7±4.7	0.3±3.1	0.835	0.997
LBM (%)	77.4±6.7	23.2±6.9	0.6±3.1	0.578	74.5±4.8	74.1±2.2	0.3±4.1	0.830	0.521
H2O (kg)	47.5±3.8	64.0±5.9	0.8±2.2	0.340	46.9±4.1	46.6±3.4	0.2±2.3	0.800	0.922
H2O (%)	56.7±4.9	76.8±6.9	0.4±2.3	0.600	54.5±3.6	54.2±1.6	0.3±3.0	0.789	0.531
Self walk test									
Duration (min)	16.6±0.5	16.0±0.6	0.0±0.8	0.993	16.7±0.5	16.9±1.1	-0.2±1.5	0.711	0.082
Average heart rate (bpm)	135.9±13.1	132.5±11.4	3.4±9.5	0.349	131.9±19.6	135.7±15.7	-3.9±14.7	0.513	0.282
Energy consumption (kcal)	233±35	234±36	-0.5±7.6	0.858	242±33	245±24	-3.7±17.7	0.599	0.043
VO2max (mL/min/kg)	42.0±5.9	42.7±6.5	-0.7±3.6	0.593	39.9±3.1	37.7±3.5	2.2±4.9	0.268	0.449
Fitness-Index	94.9±9.6	96.5±14.8	-1.6±8.4	0.603	88.4±3.2	83.6±13.7	4.9±12.6	0.349	0.313

1) t-Test for between-group difference ; 2) t-Test for within-group change (pre-post) ; 3) F-test for between-group differences in change. P-values indicating significant differences (< 0.05) are underlined

Results (1)

- Training period: Patients in Group A trained less intensive than the patients in Group B (training workload was >3times higher in B; see Table).
- Exercise challenge: Treadmill exercise led to a comparable level of challenge in both patient groups (Table). Neither heart rate nor energy consumption differed within the groups nor between the groups.
- Patients in both groups had an identical basal insulin infusion rate. Prandial insulin doses were higher pretraining than posttraining in both groups. Identical amounts of additional carbohydrates were consumed by the patients in both groups during the 21 hours after the exercise challenge.

Individual glucose profiles of patients in Group A / B pre- (a / c) and posttraining (b / d). Mean glucose profile highlighted in red.



Summary statistics of exercise challenge and parameters 21 hours post challenge before and after the 14-day training period (mean±SD)

Parameter	Group A (moderate exercise, n=8)				Group B (intense exercise, n=7)				P-value[2)]
	Pretraining	Posttraining	Difference pre-post	P-value[1)]	Pretraining	Posttraining	Difference pre-post	P-value[1)]	
Exercise challenge									
Duration (min)	43.1±5.3	44.3±2.1	-1.1±6.0	0.612	44.3±2.4	45.0±0.0	-0.7±2.4	0.454	0.037
Average heart rate (bpm)	125.4±9.7	126.8±13.7	-1.4±10.5	0.722	128.3±12.1	126.6±7.6	1.7±10.2	0.673	0.965
Time within heart rate limits (min)	35.9±8.9	37.1±6.3	-1.2±8.7	0.714	35.4±4.2	36.6±4.4	-1.2±4.8	0.534	0.177
Energy consumption (kcal)	428±86	458±105	-30.4±92.7	0.385	430±55	444±32	-14.0±65.4	0.591	0.412
Insulin treatment									
Basal insulin (IU)	17.5±3.7	17.2±3.2	0.3±0.6	0.229	18.3±4.5	17.9±4.6	0.5±0.7	0.124	0.638
Bolus insulin (IU)	23.3±8.9	19.9±5.4	3.4±6.3	0.168	25.9±5.7	23.1±5.4	2.8±8.5	0.413	0.452
No. of bolus administrations	4.5±1.6	4.3±1.0	0.3±1.3	0.598	2.9±0.9	3.6±1.5	-0.7±1.5	0.253	0.690
Glucose (SCGM)									
AUC (mg/dL*h)	2716±270	2726±211	-9.5±341	0.940	2729±368	2846±456	-117±575	0.610	0.199
CV (%)	34.7±9.8	34.8±9.9	-0.1±12.1	0.988	32.3±8.4	36.0±10.1	-3.7±11.8	0.434	0.962
Hypoglycemia									
Time in hypo (min)	60.9±54.8	28.6±29.3	32.3±42.7	0.070	56.4±70.0	57.4±47.3	-1.0±57.5	0.965	0.457
No. of hypoglycemic episodes	1.0±1.1	1.4±1.2	-0.4±1.6	0.528	1.0±1.2	1.1±0.9	-0.1±0.9	0.689	0.183
Carbohydrates									
Additional CHO (g)	42.8±34.8 (n=7)	39.2±55.4	-2.0±57.8 (n=7)	0.929	48.7±67.0	52.5±57.8	-3.7±60.2	0.875	0.925
No. of add. CHO administrations	2.6±1.9	2.0±2.9	0.6±3.3	0.608	2.4±3.0	2.6±2.7	-0.1±2.0	0.859	0.262

1) t-Test for within-group change (pre-post) ; 2) F-test for between-group differences in change
P-values indicating statistically significant differences (<0.05) are in bold.

Results (2)

- Glucose profiles: Individual recordings from a patient of Group A / B are shown in the left figures, showing all relevant parameters.
- Mean glucose profiles of the 21 h after the challenges together with all individual profiles are shown in the right figures.
- No differences in the glucose profiles with respect to the training intensity could be observed within and between the groups.
- Patients in Group A tended to spent a shorter period of time in hypoglycemia after the exercise challenge posttraining compared to pretraining, but not the patients in Group B. The number of hypoglycemic episodes was not different between the groups.

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