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Original Article

Aerobic workout on a rowing ergometer and blood sugar level

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Abstract:
Aim of this study was to investigate changes in blood sugar level after aerobic workout on rowing ergometer. Tested group consisted of Slovak rowers (n: 6, average age: 22.2±4.9 years, average height: 183.5±4.0 cm, average weight: 79.5±6.0 kg). Group undertook 4 tests: lactate curve, glycaemic profile, rowing exercise at intensity of anaerobic threshold (IANT) and rowing exercise at intensity of aerobic threshold (IAT). Blood sugar level was measured during 120 min. intervals before workout and after workout with Accu-Chek Active unit. We used nonparametric Wilcoxon signed-rank test ($p<0.05$) for dependent files for evaluation of the results. Results have shown that the difference between average fluctuation of blood sugar during 120 minutes post- and pre-workout is not significant. Difference of glycaemia (by 2.2 $mmol.l^{-1}$, 46% resp.) immediately before and after the IANT test was significant ($p<0.05$). Difference of glycaemia (by 0.4 $mmol.l^{-1}$, 7% resp.) immediately before the IAT test and after the test was not significant.
Keywords: blood sugar, aerobic endurance, rowing ergometer, rowing.

Introduction

Researchers nowadays mostly study glycaemic response to exercise in people with diabetes mellitus. This field of study in relationship with healthy people is relatively new and unexplored. We present this article regarding effect of aerobic workout on rowing ergometer on blood sugar level.

Blood sugar level (glycaemia) represents concentration of glucose in blood. Referential values of glycaemia after not eating (fasting for at least 8 hours) are 3.8 – 6.6 $mmol.l^{-1}$ in capillary blood. Stable blood sugar level is secured by autoregulation, hormonal and neural mechanisms. These mechanisms provide balance of glucose transport from blood plasma to cells and back. The most important is hormonal regulation. Katabolic hormones (glucagon, catecholamines, thyroxin and somatostatin) increase blood sugar level and anabolic hormone (insulin) reduces glycaemia. Insulin reduces blood sugar level by letting the glucose enter muscle and fat cells through their membranes (Bucci, 1983). Lowered blood glucose level which can occur between eating or as response to physical activity, evokes secretion of glucagon and glycogenolysis. Around 60% of glucose produced by liver to maintain blood sugar level comes from glycogen stores and rest comes from glucose synthesised from lactate, pyruvate, glycerol and amino acids including alanine (Hultman, Nilsson, 1971). Liver glycogen is primarily responsible for stabilization of glycaemia. On the other hand, muscle glycogen is source of energy for muscle work. Blood glucose is main source of energy for central nervous system and low level of blood sugar causes decrease of neural activity with increased irritation and decreased concentration (Benardot, 2012). Blood sugar level can be measured by very accurate laboratory test. However, more common testing is with blood glucose meters – machines designed for self-monitoring of blood sugar level (Fábryová, 2012).

Longer lasting aerobic physical activity uses energetic sources if there is enough oxygen uptake. Energy demands in working muscle during this type of physical activity are rising and body is trying to cover these demands by breakdown of glycogen and triglycerides of fat tissue. The main source of energy during initial minutes of activity is glucose from muscle glycogen stores and later glucose from liver, where glycogenolysis and gluconeogenesis takes place. Free fat acids from fat tissue start to breakdown after several hours of physical activity and they begin to be the main source of energy. Aerobic physical activity doesn't lead to gains of muscle mass but improves cardiovascular fitness (Pelikánová, Bartoš, 2010).

Rowing is considered strength-endurance sport. Structure of movement is cyclic. According to Schickhofer (2010) rowing competition is 2000 meters long and lasts from 5 min 40 s to 9 min with frequency of 200 - 250 strokes per minute depending on boat class. Aerobic threshold doesn't take big role in competition, however it is very important indicator of training intensity - elite rowers undertake up to 50 hours of training at aerobic threshold (Fikerstand, Seiler, 2004). Anaerobic threshold represents pace equivalent to middle 3 minutes of 2000 m rowing competition. Several studies (Ingham et al., 2002, Womack, 1996) suggest that anaerobic threshold performance correlates with 2000 m performance on rowing ergometer. Energy for 2000 m rowing race is created by aerobic and anaerobic system. Authors (Jannsen, 2001, Ingham et al., 2002, Nolte, 2005)

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suggest that approximately 80 - 84% of energy during race is created by aerobic system and 16 - 20% anaerobically. This is one of reasons why we were curious about differences in blood sugar regulation during aerobic performance on rowing ergometer in same volume but with different intensity. In first case at intensity of aerobic threshold and in second case at intensity of anaerobic threshold.

Material & Methods

Participants

A group of 6 Slovakian rowers (age: 22.2±4.9 years, sport age: 10±2.3 years, height: 183.5±4.0 cm, weight: 79.5±6.0 kg) performed four tests on rowing ergometer. This study was approved in advance by Ethic committee of Faculty of Physical Education and Sport, Comenius University in Bratislava. Each participant voluntarily provided written informed consent before participating.

Procedure

First test - lactate test - was performed to set the base values of intensity at aerobic and anaerobic threshold. We used Clementis-Schickhofer (2014) protocol. Lactate Scout+ (measurement error ±3%). Test was performed on Concept 2 model D rowing ergometer. Garmin HRM premium heart rate belt was used to measure heart rate during the test.

Glycemic profile was performed to rule out any unnatural fluctuation of glycaemia and to confirm that participant can perform other tests. We used 8-point glycemic profile: measurement at the evening before sleep, next day in the morning fasting glucose, 2 hours after breakfast, before lunch, 2 hours after lunch, before dinner, 2 hours after dinner, before sleep. Participants didn't do any intensive physical activity during the day.

Next measured were the changes in blood sugar level before and after performance at anaerobic threshold. Glycaemia was measured in the morning (fasting glucose), 30, 60 and 120 minutes after breakfast (before the test). Then after the test, when participant wasn't able to hold the intensity of anaerobic threshold, glucose, lactate and heart rate was measured. Measurement of glycaemia was done 5, 10, 30, 60 and 120 min after activity. Participant wasn't allowed to eat or drink sweet drinks between breakfast and 120 min after the test. Next test was performed at intensity of aerobic threshold. Volume (distance in meters) of test was set according to volume performed in test at anaerobic threshold. Conditions (measurement of glycaemia, same breakfast, measurement of lactate and heart rate) of test were same as in the test before.

Tests were performed on rowing ergometer Concept 2 model D. There was interval of 72 hours rest before both tests, which consisted only of low intensity aerobic trainings, to prevent influence on tests. Measurement of blood glucose levels was done with Accu-Chek Active glucose meter (measurement error ±4%). Results were calibrated to plasma.

Statistical analysis

Results were evaluated with Wilcoxon signed-rank test. The significance level was set to $p<0.05$.

Results& Discussion

Lactate test

Participants performed lactate test on rowing ergometer which was used to create graph of relation between lactate and intensity of workout (lactate curve) and to set individual aerobic and individual anaerobic thresholds (IAT, IANT) of tested rowers. We used Clementis-Schickhofer (2014) experimental protocol. This protocol wasn't used in any other studies, so it was tested in our work if it is suitable to set IANT. Measured values during IANT test were not significantly different to those set by lactate test. We confirmed that Clementis-Schickhofer protocol is eligible to be used for diagnostics of aerobic capabilities of rowers with lactate threshold test. Values of IAT fluctuated from 1.6 $mmol.l^{-1}$ to 2.2 $mmol.l^{-1}$ and values of IANT from 4.8 $mmol.l^{-1}$ to 6.5 $mmol.l^{-1}$. Lactate curves were created based on measured data (fig. 1). Figure 1 shows individual differences and average curve.

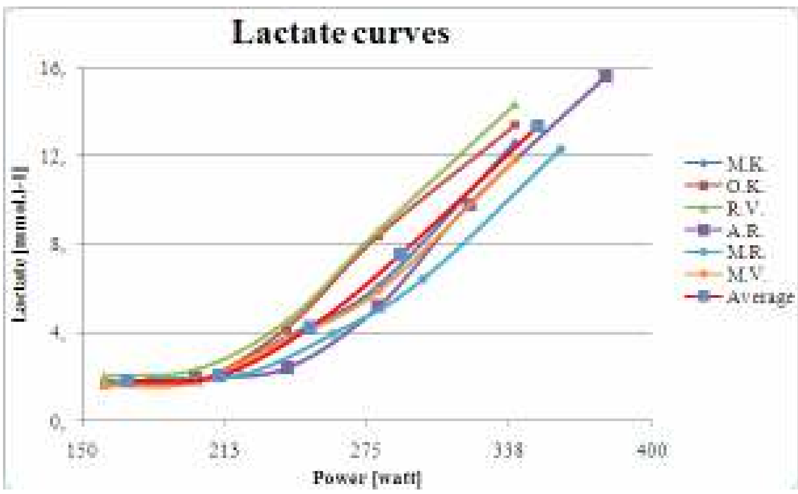

Fig. 1 – Lactate curves.

Glycemic profile

Evaluation of big glycemic profile showed that participants fit in reference values of fasting glucose 3.8 – 6.6 mmol.l^{-1}. Test confirmed appropriateness of participants for further tests.

Blood sugar level and workout at individual anaerobic threshold.

Average glycaemia of tested sample was 5.3 mmol.l^{-1} before workout. During the recovery phase it settled at 5.7 mmol.l^{-1} in average. Difference 0.4 mmol.l^{-1} presents 9 % increase of blood sugar level. Comparison of values immediately before (5.0 mmol.l^{-1}) and after workout (7.2 mmol.l^{-1}) showed 2.2 mmol.l^{-1} increase(46%). Average power during the test was 269 watts and average lactate level after the test was 6.9 mmol.l^{-1}. Participants rowed 9964 meters in average. Figure 2 shows average values of blood sugar level before and after the workout. Blood sugar level and workout at IANT proved statistically significant ($Z=-1,962$, $p<0.05$) increase of glycaemia immediately after the workout.Significant increase of blood sugar level after test can be credited to activation of sympathicus. Sympathicus has stimulatory effect on glucagon secretion and glycogenolysis. Glucagon can also stimulate glyconeogenesis. Approximately 60 % of glucose produced by liver to retain level of blood glucose is from glycogen stores and rest if from glucose synthesized from lactate, pyruvate, glycerol and amino acids including alanin. Other two catabolic hormones effect blood sugar level. Adrenalin is stress hormone which initiates extremely fast depletion of liver glycogen to rapidly increase level of blood sugar. Cortisol is stress hormone too and supports catabolism of muscle proteins. This protein breakdown preserves glycogenic amino acids for gluconeogenesis and results in increase of glycaemia. Therefore vigorous workout indirectly effects increase in blood sugar levels (Brun, Dumortier, Fedou, Mercier, 2001).

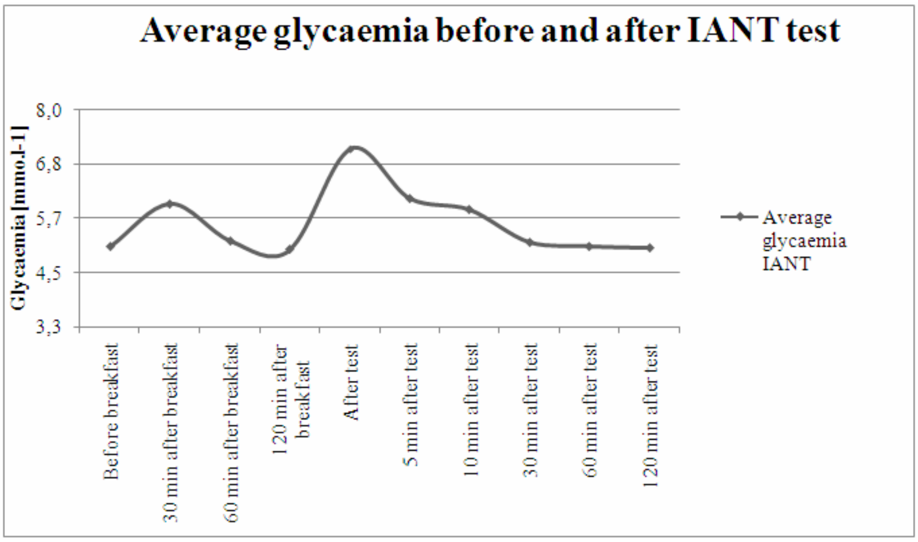

Fig. 2 – Average values of blood glucose level before and after IANT workout on rowing ergometer

Blood sugar level and workout at individual aerobic threshold.

Average glycaemia of tested sample was 5.2 mmol.l^{-1} bezfore workout. During the recovery phase it settled at 4.9 mmol.l^{-1} in average. Difference 0.3 mmol.l^{-1} presents 4% decrease of blood sugar level. Comparison of values (fig. 3) immediately before (5.3 mmol.l^{-1}) and after workout (4.9 mmol.l^{-1}) showed 0.4 mmol.l^{-1} decrease (7%). Average power during the test was 194 watts and average lactate level after the test was 1.9 mmol.l^{-1}. Volume of workout was the same as in IANT test.

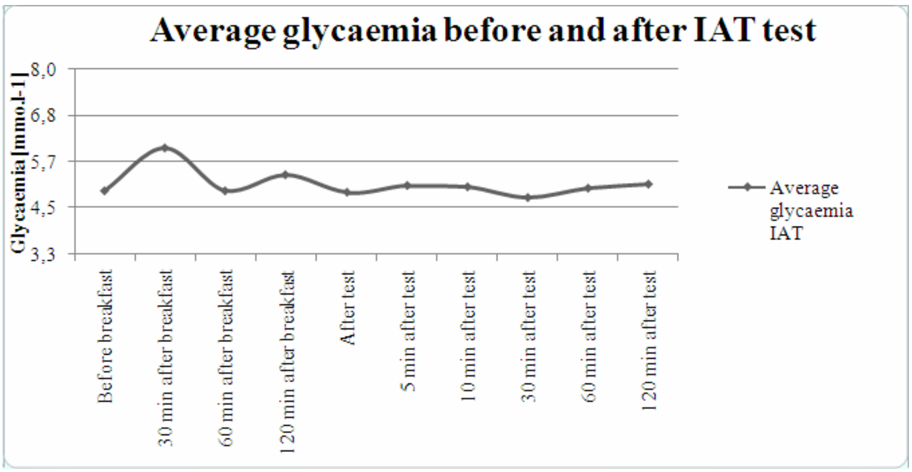

Fig. 3 – Average values of blood glucose level before and after IAT workout on rowing ergometer

Blood sugar level before both tests peaked at 30 minutes after breakfast and then stabilized. Glycaemia immediately after tests was different. IANT test showed 2.2 $mmol.l^{-1}$ (46%) increase and IAT test showed 0.4 $mmol.l^{-1}$ (7%) decrease. Values of blood sugar level during recovery phase after tests got to similar level 30 minutes after workout. The difference between blood sugar level 30 min after these two tests was 0.3 $mmol.l^{-1}$ (6%). Figure 4 shows difference in glycaemia during IANT and IAT tests.

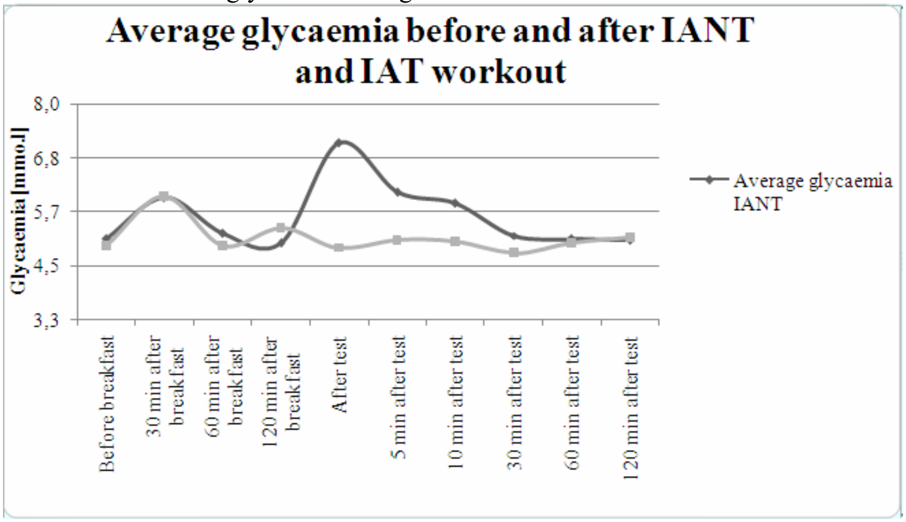

Fig. 4 – Average values of blood glucose level before and after IANT and IAP workout on rowing ergometer

Differences of average values of blood sugar level during 120 min before and after the workout was not statistically significant in either of cases (fig. 5). Comparison of differences of average values of glycaemia immediately before and after the tests showed that there was statistically significant ($Z = -1,962$, $p<0.05$) difference in IANT test (fig. 6).

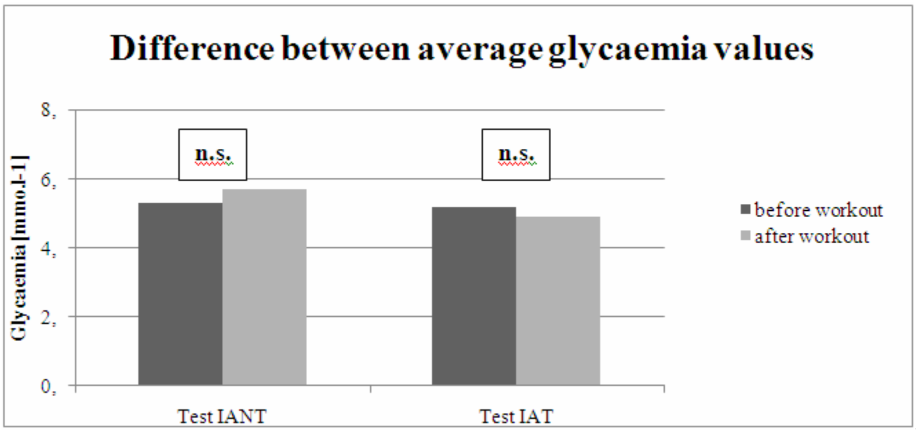

Fig. 5 – Difference between average values of glycaemia during 120 min interval before and after the workout (IANT and IAT).

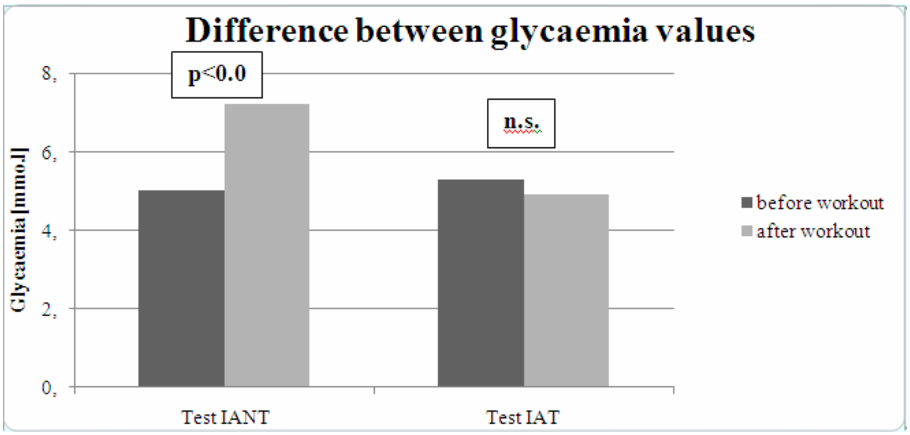

Fig. 6 – Difference between values of glycaemia immediately before and after the workout (IANT a IAT).

Conclusions

Based on the results it can be said that the increase of blood glucose level will be more significant after same volume workout at individual anaerobic threshold intensity than at individual aerobic threshold intensity. Increase of blood glucose level after IANT (2.2 $mmol.l^{-1}$) was higher than after IAT (-0.4 $mmol.l^{-1}$). Increase of glycaemia after IANT workout was statistically significant ($Z = -1{,}962$, $p<0.05$).

We can recommend aerobic workout of low and high intensity to recreational athletes which want to reduce or stabilize their weight based on our results. However, physical activity is used as therapy for people with type 2 diabetes or metabolic syndrome. In this case the hyperglycemia that occurs after IANT workout could cause worsening of health. Therefore we recommend use of lower intensity workout for patients with type 2 diabetes.

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