UNIVERSITY OF TORONTO

Department of Nutritional Sciences

Mid-Term Examination 2009

November 5th, 2009

Advanced Nutrition

NFS 484H1 F/ 1484H1 F

Duration – 2 hours

General Instructions:

1. This is an open book examination; therefore students may use any aids that have been brought into the examination room.

2. The examination will be marked out of 50; however, it will constitute only 25% of your final grade.

3. Students must answer all questions in all parts of the examination.

4. All answers should be clearly written in the answer booklets provided. Please provide your answer on the right-hand side of the page only. It will be assumed that the left-hand side of the page is used for note making purposes only and material appearing on this side of the page will not be read or graded.

Study 1 (Value 20/50)

Background

Physical activity (exercise), in general is a major contributor to a healthy lifestyle. However, if there is an underlying medical condition, such as Type 2 diabetes, then the benefits of exercise are more significant. This also applies to the co-morbidities that are often associated with Type 2 diabetes: obesity, hypertension, and cardiovascular disease, which are components of the metabolic syndrome.

Current research includes focusing on the role of endurance training exercise in improving the ability of muscle to utilize different sources of energy. Exercise-induced contractions in skeletal muscle results in increased delivery of such fuels, including carbohydrate (CHO) in the form of glucose, into the muscle in order to adequately maintain various metabolic pathways. There is speculation that this increased delivery of glucose to the muscle may be regulated by glucose transporters (GLUT). GLUT4 is the principal isoform of glucose transporters in skeletal muscle, and thus the effect of exercise on GLUT4 function is of great interest.

Study

The purpose of this study was to investigate the responses in substrate- and energy-based properties to repetitive days of prolonged low-intensity endurance exercise and recovery. Twenty Type 2 diabetic subjects (mean age of 50 years old, with BMI 25-29 (overweight)) engaged in endurance training in the morning on three consecutive days (E1, E2, E3) followed by 3 days of recovery (R1, R2, R3). At 2 hours post-training (E1 and E3 only), or at lunchtime on recovery days, subjects were given a standardized 500mL meal replacement drink (1000kcal, 40% carbohydrate, 30% protein and 30% fat content), and blood glucose was measured at 0, 15, 30, 60, and 120min. The change in blood glucose levels over the 120 minutes was expressed as glucose area under the curve (gAUC) [**Table 1**]. Tissue samples were extracted from the quadriceps muscles at 120min post-drink and were analyzed for changes in total cellular GLUT4 protein expression and muscular concentrations of glucose (this does not include glucose in the form of glycogen) and glycogen [**Figure 1**].

<u>Questions</u>:

1) Describe the effect of the exercise regimen on blood glucose, GLUT4 protein expression, and muscle concentrations of glucose and glycogen in Table 1 and Figure 1. (Value 5/50)

2) Using the information provided in this examination, discuss **<u>how</u>** exercise influences the glucose pool (blood glucose versus glycogen) used for glucose oxidation and its potential impact on glycogen reserves 1) during exercise training and 2) during the post-training periods. (Value 7/50)

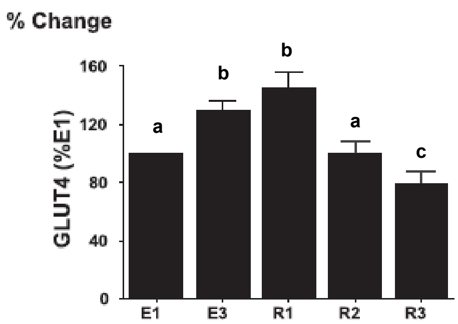
3) Two friends of similar age, weight and physical condition have decided to join the Nutritional Sciences Graduate Student's Association's new jogging club, as a way to train for the next GSU volleyball match in 6 weeks. Their schedule consists of a light to moderate jog 3 times a week. Mr. Smithers stays with the schedule for 6 weeks, while Mr. Burns decides to quit after 2 weeks. At the time of the volleyball game, Mr. Burns does not play and watches from the stands, while Mr. Smithers plays. If both men consume the meal replacement drink used in this study, at the end of the game, what do you expect their blood glucose response to be and how would this be reflected in muscle glucose and glycogen levels. [Assume that the response to exercise is similar in both healthy adults and those with type 2 diabetes. Remember to not introduce data / ideas from outside sources.] (Value 8/50)

Table 1. Blood glucose concentrations before and during consumption of the meal replacement drink (expressed as glucose area under the curve (gAUC)) during (E1, E3) or after (R1, R2, R3) exercise training.

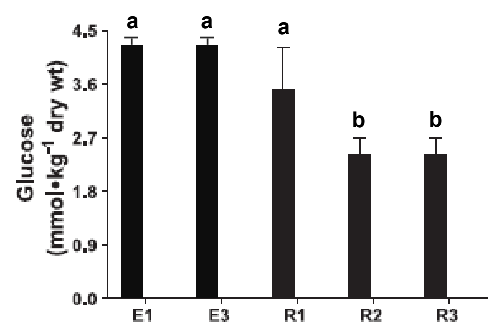
Treatment Day	Blood glucose (mmol/L)	
	0min	$gAUC_{0\text{-}120min}$
E1	8.84 ± 0.32^{a}	541.3 ± 25.9^{a}
E3	7.26 ± 0.32^{b}	482.1 ± 23.3^{b}
R1	7.34 ± 0.25^{b}	489.3 ± 24.7^{b}
R2	8.20 ± 0.19^{c}	589.4 ± 29.3^{c}
R3	8.41 ± 0.14^{c}	600.1 ± 23.1^{c}

[abc]Data (mean ± SEM) in columns with different superscripts are significantly different from each other at $p<0.05$.

A. Total Glut4



B. Glucose



C. Glycogen

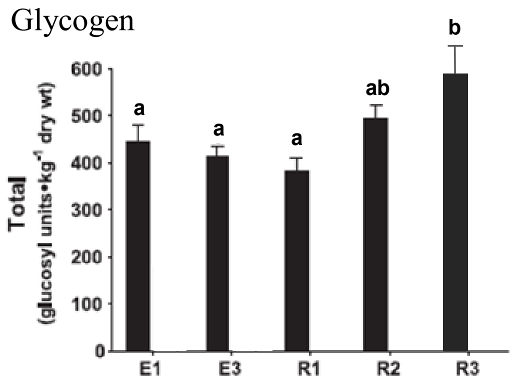


Figure 1. Data presented are means ± SEM.

A. The % change in total GLUT4 protein during the exercise regime. Values for E1 were arbitrarily set at 100 and all other days' values were expressed relative to E1.

B. Total glucose concentrations in quadriceps muscle after consumption of the meal replacement drink.

C. Total glycogen concentrations in quadriceps muscle after consumption of the meal replacement drink.

[abc]Bars with different letters are significantly different from each other at $p<0.05$.

Study 2 (Value 30/50)

Background

Abnormal lipid utilization, including availability and oxidation, is prevalent in diabetes, obesity, hyperlipidemia, and the metabolic syndrome. Diet-induced weight loss has been shown to improve markers of lipid metabolism, however, the effect of endurance exercise training on improving lipid oxidation is not known. Thus the effect of exercise on lipid oxidation is of great interest.

Study

The purpose of this study was to examine the effect of a 3-month low-intensity endurance training intervention on markers of glucose and lipid metabolism, as well as lipid oxidation in adults with type 2 diabetes (n=65, mean age of 50 years, overweight weight with BMI 25-29) while on a low fat (LF) diet or an isocaloric high fat (HF) diet (energy for both diets: 2000 kcal and was not associated with weight loss). Baseline data was collected, and then subjects were randomized to either the LF or HF diet before beginning their 3-month exercise regimen (LF baseline and HF baseline data). At the end of the 3 months, glucose and lipid data were collected **[Table 2]**. Also, maximal lipid oxidation was calculated as subjects exercised under increasing workloads of 30, 60, 90, 120, and 150 Watts at the end of the 3 months [**Figure 2]**.

<u>Questions</u>.

4) Describe the effect of the diet and 3-month endurance training regimen on the metabolic parameters [Table 2] and the intervention's impact on lipid oxidation at the end of the exercise training regimen [Figure 2]. (Value 5/50)

5) In one or two sentences, state the key points of Table 2 and Figure 2, and their integration. (Value 5/50)

6) Propose a mechanism to explain <u>**how**</u> the different diet and endurance exercise treatments altered the metabolic parameters presented in Table 2. Use only data from Studies 1 and/or 2 to defend your answer. (Value 8/50)

7) Suppose you are the new nutritional counselor at Jacques Huot Elementary School. The Ministry of Education is about to implement a province-wide physical activity program modeled after the "Take 5" program from the U.S. Ontario's version would be 15 minutes of cycling on stationary bikes 4 times a day for a total of 60min (equivalent to low-intensity endurance exercise) as a means to combat <u>both childhood obesity and insulin resistance/type 2 diabetes risk</u>. Based on the data from lectures and this midterm examination, do you believe that Ontario's "Take 15" program is enough? Please justify your answer. (Value 12/50)

Table 2. Subject characteristics before and after 3 months of exercise training.

	Baseline		Post-training	
Measure	**LF**	**HF**	**LF**	**HF**
Fasting glucose (mmol/L)	9.2 ± 0.2^a	9.4 ± 0.1^a	8.5 ± 0.2^b	9.5 ± 0.1^a
HbA1c (%)	7.3 ± 0.3^a	7.5 ± 0.4^a	6.9 ± 0.1^b	7.4 ± 0.1^a
Triglycerides(mmol/L)	2.5 ± 0.1^a	2.7 ± 0.2^a	2.0 ± 0.1^b	2.2 ± 0.2^b
Total Cholesterol(mmol/L)	5.2 ± 0.2^a	5.3 ± 0.1^a	4.8 ± 0.1^b	5.0 ± 0.1^b

Data presented are means ± SEM. [abc]Data with different letters are significantly different from each other at $p<0.05$.

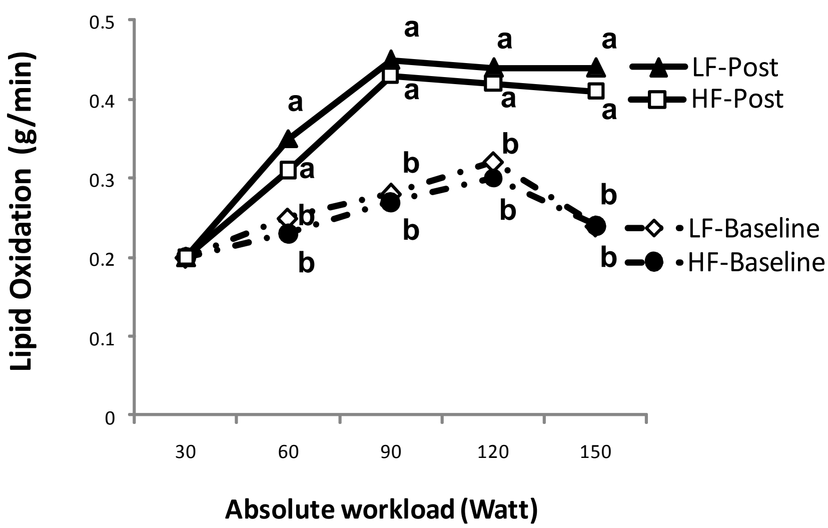


Figure 2. Whole-body lipid oxidation at the end of three months of endurance exercise. Data presented are means ± SEM. [abc]Data with different letters in the same workload are significantly different from each other at $p<0.05$.