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Original Research Article

Relationship between regular aerobic physical exercise and glucose and lipid oxidation in obese subjects – A preliminary report

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ABSTRACT

Introduction: The worldwide epidemic of obesity is due to the imbalance between physical activity and dietary energy intake. This is a major contributor to various diseases including type 2 diabetes, dyslipidemia, coronary heart disease, hypertension, sleep apnea, and some kinds of cancer. In obese individuals disturbances in glucose and lipid oxidation are observed, which probably could be improved upon after exercise training. However, the influence of exercise performed by obese individuals on their glucose and lipid metabolism is not clearly understood.

Aim: This study examined whether the intervention of aerobic exercise influences the rates of lipid and glucose oxidation at rest and after an insulin-stimulated state in obese women.

Materials and methods: We examined five obese (BMI > 30 kg/m^2) females without diabetes, aged 31–62, who participated in a 12-week program of aerobic exercise (5 days/week, 30 min/day). Insulin sensitivity was evaluated by the euglycemic hyperinsulinemic clamp (EHC) technique and whole-body lipid and glucose oxidation rates were measured by indirect calorimetry (IC) using the ventilated hood technique. EHC and IC were performed before and after the 12-week exercise program.

Results and discussion: During our investigation, the measurements of body weight, BMI, waist and hip circumferences, body fat (%), fat-free mass (kg), insulin sensitivity, rates of lipid and glucose oxidation, non-oxidative glucose metabolism and increase in the respiratory exchange ratio were taken before and after the exercise intervention. However, the statistical evaluation did not show any significant differences between corresponding results taken before and after the training program. We observed that fat mass decreased and insulin sensitivity increased in three subjects; whereas, in two cases we did not observe any changes after the aerobic training program.

Conclusions: The results obtained indicated that a 12-week aerobic training program was not sufficient to improve insulin sensitivity and substrate metabolism in each obese

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woman. Perhaps some individuals need training of a longer duration to improve their insulin sensitivity and metabolic flexibility.

1. Introduction

The worldwide epidemic of obesity is due to the imbalance between physical activity and dietary energy intake. Obesity concerns an excess of adipose tissue that results from a mixture of genetic predisposition, environmental influences and behavioral components.[18] This is a major contributor to various diseases including type 2 diabetes, hyperuricemia, dyslipidemia (elevated triglycerides and lowered high-density lipoprotein cholesterol), coronary heart disease, hypertension, sleep apnea, some kinds of cancer and a reduced quality of life.[5] The influence of exercise on the glucose and lipid metabolism of obese individuals is not clearly understood. In obese individuals a loss of metabolic flexibility is observed.[21] In this condition, in the skeletal muscle, glucose oxidation (GOx) increases under basal conditions and decreases under insulin-stimulated circumstances, whereas lipid oxidation (LOx) behaves in an opposite manner.[12]

Due to the high prevalence of obesity, interventions such as exercise to promote weight loss have become increasingly important to reduce morbidity in the general population. The current physical activity guideline for adults recommending 30 min of moderate intensity activity daily is of importance for limiting risk factors for a number of chronic diseases.[1,16]

2. Aim

This study examined whether the intervention of physical activity influences the rates of LOx and GOx at rest and after an insulin-stimulated state in obese women.

3. Materials and methods

3.1. General study protocol

We examined five, previously untrained, obese (BMI > 30 kg/m^2) weight-stable females, aged 31–62, who participated in a 12-week program of aerobic exercise. We performed an euglycemic hyperinsulinemic clamp (EHC) to evaluate insulin sensitivity and indirect calorimetry (IC) to assess substrate oxidation before and after a 12-week exercise program. None of the volunteers had type 2 diabetes, morbid obesity, cardiovascular disease, hypertension, infections or any other serious medical problems. None reported taking anti-inflammatory drugs (within the previous 3 months) or any drugs known to affect glucose and lipid metabolism. Before the onset of the study, physical examinations were performed. All subjects underwent an oral glucose tolerance test (OGTT) and did not have diabetes according to the World Health Organization (WHO) criteria. All subjects provided written informed consent before their inclusion in the study. The study protocol was approved by the Ethics Committee in the Medical University of Białystok, Poland.

3.2. Anthropometric measurements

BMI was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). The waist circumference was measured at the smallest circumference between the rib cage and the iliac crest, with the subject in the standing position. Percent of body fat was estimated by bioelectric impedance analysis using the Tanita TBF-511 Body Fat Analyzer (Tanita Corp., Tokyo, Japan).

3.3. Insulin sensitivity

Insulin sensitivity was evaluated by the EHC technique as described by DeFronzo et al.[4] Insulin (Actrapid HM, Novo Nordisk, Copenhagen, Denmark) was given as a primed, continuous intravenous infusion for 2 h at 40 mU $\times$ m^{-2} $\times$ min^{-1}, resulting in a constant hyperinsulinemia of approximately 75 mU/L. Arterialized blood glucose was obtained every 5 min and a 20% dextrose (1.11 mol/L) infusion was adjusted to maintain plasma glucose levels at 5.00 mmol/L. The glucose infusion rate approached stable values during the final 40 min of the study and the rate of whole-body glucose uptake (M value) was calculated as the mean glucose infusion rate from 80 to 120 min, corrected for glucose space and normalized per kilogram of fat-free mass (M_{fffm}).

3.4. Lipid and glucose oxidation

Whole-body LOx and GOx rates were measured by IC using the ventilated hood technique (Oxycon Pro, Viasys Healthcare GmbH–Erich Jaeger, Hochberg, Germany) in order to calculate LOx and GOx from respiratory gas exchange (oxygen consumption and carbon dioxide production). The device was calibrated before each test using reference gases. Measurements were performed while the subjects were lying in a supine position at baseline (in the fasting state) and during the last 30 min of the clamp study. Each study was performed in a thermoneutral environment, after relaxing for 15 min. Non-oxidative glucose metabolism (NOGM) was calculated by subtracting the GOx rate during hyperinsulinemia from the whole-body glucose disposal rate. An increase in the respiratory exchange ratio (delta RER) in response to insulin was used as the measure for metabolic flexibility.

3.5. Exercise training protocol

The exercise program was performed utilizing a stationary bicycle. Subjects were asked to participate in exercise sessions 5 days a week, lasting 30 min per session for 12 weeks.