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# Effects of endurance and endurance–strength exercise on biochemical parameters of liver function in women with abdominal obesity

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A R T I C L E I N F O

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*Introduction:* Obesity is a risk factor of nonalcoholic fatty liver disease. Although the standard therapy for obesity involves physical exercise, well-planned studies of the changes in liver function in response to different exercise intensities in obese subjects are scarce. The aim of the present study was to examine a question of how does exercise mode affect the liver function.
*Material and methods:* 44 women with abdominal obesity were randomized into two exercise groups: endurance (group A) and endurance-strength (group B). Women in each group exercised for 60 min 3 times/week for a 3-month period. Markers of liver function: serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), γ-glutamyltranspeptidase (GGT), alkaline phosphatase (ALP) activities, and bilirubin levels were quantified.
*Results:* We found significant differences in ALT ($p < 0.01$) and AST ($p < 0.05$) activities between group A and B after training exercise. Blood ALT and AST tended to decrease in group B, increase in group A. Significant reduction in serum GGT level after exercise in both groups was observed ($p < 0.001$, group A; $p < 0.01$, group B). Neither endurance nor endurance-strength exercise led to changes in serum ALP activity and *total* or *direct* bilirubin level. However, endurance-strength training resulted in significant decreases in serum *indirect* bilirubin ($p < 0.05$). Strong positive correlations between serum *indirect* bilirubin and body mass ($r = 0.615$; $p = 0.0085$) and BMI ($r = 0.576$; $p = 0.0154$) were found after endurance-strength exercise (group B).
*Conclusion:* The mode of exercise does matter: endurance-strength exercise led to a greater improvement, compared to endurance exercise, in the liver function in women with abdominal obesity.


*Abbreviations:* BMI, body mass index; NAFLD, nonalcoholic fatty liver disease; MS, metabolic syndrome; DM2, type 2 diabetes mellitus; CVD, cardiovascular disease; ALT, alanine aminotransferase; SBP, systolic blood pressure; HDL, high-density lipoprotein; DBP, diastolic blood pressure; HR, heart rate; WHR, waist-hip ratio; AST, aspartate aminotransferase; GGT, gamma-glutamyltranspeptidase; ALP, alkaline phosphatase; SD, standard deviation; NASH, nonalcoholic steatohepatitis; NS, not significant.

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## 1. Introduction

Obesity affects 500 million adults globally [1]. In high-income countries 18% deaths caused by increased BMI occur before the age of 60 [2]. In the United States, obesity is an independent cause of more than 300,000 deaths annually [3]. It is a risk factor of nonalcoholic hepatosteatosis–nonalcoholic fatty liver disease (NAFLD)–a condition that results from excessive accumulation of lipids in the liver and associated with oxidative stress [4]. NAFLD affects one-third of adults and 9.6% of children worldwide, and is highly prevalent in obese patients. Fatty liver is independently associated with metabolic syndrome (MS), type 2 diabetes mellitus (DM2) and cardiovascular disease (CVD) [5]. Serum alanine aminotransferase (ALT) activity is a marker of liver function that increases in NAFLD and is correlated with pathologies, such as insulin resistance, dyslipidemia, coronary atherosclerosis, and hypertension. ALT activity is a prognostic factor for DM2, independent of age, BMI, systolic blood pressure (SBP), alcohol consumption, triglycerides, high-density lipoprotein (HDL), and blood glucose, and an independent cardiovascular risk factor [6]. The standard therapy for obesity is based on physical activity, diet, and modification of lifestyle [7]. An optimal model of physical training in the treatment of obesity is debated. There is evidence that mixed endurance-strength training is more effective than endurance training alone in improving such parameters as waist circumference [8], total body fat percentage, total body lean mass, total body fat-free mass [8–10], resting diastolic blood pressure (DBP), SBP, and heart rate (HR) [11]. However, to the best of our knowledge, there is no strong evidence for the superiority of any type of physical training in the therapy of obesity. It is known that physical activity in obesity has a protective and ameliorating effect on liver function independent on the decrease in body mass [6,12]. Acute exercise significantly increases liver glucose output though hepatic glycolysis and gluconeogenesis. Chronic aerobic training increases hepatic and muscle glycogen storage. Long-lasting training leads to a reduction of hepatic triglycerides and increases hepatic protein synthesis. Endurance training leads to the decreased secretion of orexigenic proteins. Exercise exerts many positive effects on the liver on the molecular level, such as up-regulation of metabolic enzymes, decreased expression of lipogenic enzymes, and up-regulation of systems that protect against gene mutation and heat shock. Moderate physical training reduces hepatic oxidant stress and ameliorates the liver's functional clearance capacity. There is evidence that regular physical exercise can reduce serum amino-transferase concentration in patients with hepatic cirrhosis or even reduce the risk of hepatocellular carcinoma [5]. However, there is a relative dearth of studies comparing the effect of endurance versus endurance-strength training on liver function in obesity and it is not known whether intensity of physical exercise matters [5]. So far, there has been no credible evidence from well-planned, randomized trials that might serve as a basis for revising the recommendations on physical activity in the treatment of impaired liver function in obesity. This fact is complicated by data indicating that the response to physical activity is highly variable and, in some aspects, different in men and women [13,14]. It has been recently suggested that physical training plans should be designed differently for each gender [14]. The aim of the present study was to compare the influence of short-term endurance training and short-term endurance–strength training on liver function in a population of women with abdominal obesity.

## 2. Material and methods

### 2.1. Study patients

Obese women (n = 163) were screened at the outpatient clinic of the Department of Internal Medicine, Metabolic Disorders, and Hypertension, University of Medical Sciences, Poznań, and 44 were enrolled in the study. The inclusion criteria were: age 18–65 years; simple obesity (BMI $\geq$ 30 kg/m$^2$); waist circumference >80 cm; stable body weight in the month prior to the trial (permissible deviation was $\pm$1 kg); body fat content $\geq$33%, as assessed by electrical bioimpedance measurements using a Bodystat analyzer (1500 MDD; Bodystat®, Isle of Man). The exclusion criteria were: DM2; secondary form of obesity or secondary form of hypertension; poorly controlled hypertension (mean SBP > 140 mmHg or mean DBP > 90 mmHg) during the month prior to the trial or the necessity to modify antihypertensive treatment in the three months prior to the trial; history of coronary artery disease; stroke; congestive heart failure; clinically significant arrhythmias; malignancy; history of use of any dietary supplements within three months before the study; lipid disorders requiring the implementation of drug treatment in the three months prior to the trial or during the trial; abnormal thyroid gland function; clinically significant acute or chronic inflammatory process within the respiratory, digestive, or genitourinary tract, or in the oral cavity, pharynx, or paranasal sinuses, or connective tissue disease or arthritis; history of infection in the month prior to the study; nicotine, alcohol, or drug abuse; pregnancy, childbirth or lactation at enrollment or in the three months prior to enrollment; or any other condition that, in the opinion of the investigators, would make participation not in the best interest of the subject, or could prevent, limit, or confound the efficacy of the study. The occurrence of any of the above exclusion criteria during the trial resulted in immediate removal of that participant from the study.

An informed consent was obtained from each subject. The study was approved by Ethics Committee, the Poznań University of Medical Sciences (case no. 1077/12 with supplement no. 753/13). The study complied with the ethical guidelines of the Declaration of Helsinki, adopted by the 18th World Medical Assembly, Helsinki, Finland, June 1964, and recently amended at the 59th World Medical Assembly, Seoul, Korea, October 2008.

### 2.2. Study design

The study was designed as a prospective randomized trial. Subjects were randomized into two groups: A, endurance and B, endurance-strength exercise. Both groups performed physical exercise of comparable exercise volume for three months. Aside from the exercise, all subjects were instructed to maintain their normal physical activity and diet that they have been practicing so far. At baseline and after three months of physical exercise, blood samples were taken for laboratory analyses and anthropometric measurements were performed for both groups.

### 2.3. Anthropometric measurements

Anthropometric measurements were conducted with the subjects wearing light clothing and no shoes. Weight was measured to the nearest 0.1 kg and height to the nearest 0.5 cm. BMI was calculated as weight divided by height squared (kg/m$^2$). Obesity was defined as BMI $\geq$ 30 kg/m$^2$. Waist circumference (cm) was measured at the level of the iliac crest at the end of normal expiration, to the nearest 0.5 cm. Hip circumference was measured at the maximum protuberance of the buttocks, to the nearest 0.5 cm. WHR (waist–hip ratio) was calculated as waist circumference divided by hip circumference.

### 2.4. The intervention

The 3-month intervention consisted of a physical exercise program of three sessions per week. Women in each group participated in a total of 36 training sessions in a period of 3 months. During each session exercise was performed in a professional training room under supervision of a certified fitness instructor and a physician. Women in group A underwent endurance exercise on cycle ergometers (Schwinn Evolution, Schwinn Bicycle Company®, Boulder, Colorado, USA). Exercise sessions consisted of 5-min warm-up (stretching exercise) at low intensity (50–60% of maximum heart rate), 45-min exercise