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# Effects of physical activity on carbohydrate and lipid metabolism in women with abdominal obesity

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**Introduction.** The incidence of metabolic disorders in obese people is not only determined by the amount of adipose tissue but mainly by its distribution. Metabolic disorders may lead to the development of occupational metabolic diseases. **Aim of Study.** The aim of the study was to estimate the effects of increased physical activity in women with abdominal obesity on carbohydrate and lipid metabolism and glucose tolerance. **Material and Methods.** The study was carried out on a group of 32 physically active women aged  $59.1 \pm 5.39$  years. Somatic traits were measured and physiological and biochemical tests ( $VO_2$  max, lipid profile, glucose and insulin levels) were carried out at rest while fasting. The BMI, WHR and  $HOMA_{IR}$  indices were calculated. **Results.** The following results were obtained for the sample: BMI ( $32.9 \pm 4.57$  kg/m<sup>2</sup>), WHR ( $0.88 \pm 0.04$ ),  $VO_2$  max ( $33.6 \pm 8.19$  ml/kg<sup>-1</sup>/min<sup>-1</sup>), total cholesterol ( $226.3 \pm 45.12$  mg/dl), LDL-cholesterol ( $140.6 \pm 37.79$  mg/dl). **Conclusions.** The results confirm positive effects of physical activity on the lipid profile and the homeostatic model assessment insulin resistance index ( $HOMA_{IR}$ ).

**KEY WORDS:** abdominal obesity, physical activity, lipid profile,  $HOMA_{IR}$ .

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### What is already known on this topic?

Disorders of carbohydrate and lipid metabolism increase the risk of cardiovascular diseases. A higher fasting blood glucose level is associated with a higher triglycerides level, lower HDL-cholesterol and higher LDL-cholesterol. The disturbances of lipid metabolism and hyperglycemia lead to cardiovascular diseases.

### Introduction

Modern societies face currently two opposite kinds of dietary problems. On the one hand, an alarmingly large part of humanity suffers from malnutrition and hunger; on the other hand, people tend to consume food with energy values vastly exceeding the actual energy demands, which leads to excessive deposition of body fat [1]. Obesity is observed to be genetically determined only in 10% of cases, while its main cause remains a positive energy balance [2]. Depending on adipose tissue distribution, the consequences of obesity may vary [3]. Abdominal obesity, unlike gynoid obesity, involves serious disorders of carbohydrate and lipid metabolism as well as development of insulin resistance [4]. These consequences may lead to a number of diseases such as ischemic heart disease, hypertension, or non-insulin dependent diabetes mellitus. A change in a lifestyle may significantly reduce the risk of metabolic disorders in obese persons.

### Aim of Study

The study aimed to determine the effects of a lifestyle of physically active women on their carbohydrate and lipid metabolism and insulin resistance index ( $HOMA_{IR}$ ).

### Material and Methods

The study sample consisted of 32 women, members of the Polish Society for the Promotion of Sport and Physical Activity (TKKF), aged  $59.1 \pm 5.39$  years. The women declared they practiced physical activities of moderate intensity (cycling, swimming, Nordic walking) for five

hours a week. All anthropometric measurements and physiological and biochemical tests were taken at rest while fasting. The body mass index (BMI) and waist-hip ratio (WHR) were calculated. Body composition (fat mass – FM, free fat mass – FFM and total body water – TBW) was estimated by way of bioelectrical impedance analysis, using the Bodystat 1500 analyzer. The obtained measurements were given as percent values of total body mass. Maximal oxygen uptake ( $VO_2\text{max}$ ) was estimated using the Åstrand-Rhyming nomogram [5]. Parameters of carbohydrate and lipid metabolism: glucose concentration, total cholesterol, HDL-cholesterol and triglycerides were marked in venous blood with Cormay tests. The LDL-cholesterol level was estimated with the Friedwald Equation [6], and insulin concentration with the radioimmunological test (Brodata-Serono, Italy). The  $HOMA_{IR}$  index was calculated using Mathews' equation [7]. The subjects provided their written consent to participate in the tests and the study was approved by the Bioethical Commission of the University of Medical Sciences in Poznań.

## Results

The results are presented in Tables 1-4 as means, standard deviations and maximal and minimal values. Table 1 shows the somatic characteristics of the examined women. The WHR (0.82 – 1.0) and waist circumference measurements (86 – 100 cm) indicated visceral obesity. The women's mean body mass was about 25 kg above the reference value (59 kg) calculated using Potton's weight formula. Large body mass also affected the BMI values, i.e.  $34.6 \pm 11.41 \text{ kg/m}^2$  (Table 1). The examined women featured high aerobic capacity as indicated by their maximal oxygen uptake values ( $33.6 \pm 8.19 \text{ ml/kg}^{-1}/\text{min}^{-1}$ ) and normal systolic ( $133.4 \pm 17.53 \text{ mmHg}$ ) and diastolic blood pressure ( $84.2 \pm 8.87 \text{ mmHg}$ ) (Table 2).

The lipid profile is shown in Table 3. The concentrations of total cholesterol ( $226.3 \pm 45.12 \text{ mg/dl}$ ) and LDL-cholesterol ( $140.6 \pm 37.79 \text{ mg/dl}$ ) were higher than the ranges recommended by the International Diabetes Federation (IDF). However, the levels of HDL-cholesterol and triglycerides were within the reference range. The parameters of carbohydrate metabolism, i.e. insulin level, glucose concentration in venous blood and the insulin resistance index are shown in Table 4.

The statistical analysis revealed a positive correlation between subjects' BMI values and triglycerides level ( $r = 0.38$ ;  $p < 0.05$ ), and a negative correlation between BMI and  $VO_2\text{max}$  ( $r = -0.60$ ;  $p \leq 0.001$ ).

## Discussion

The study analyzed the results of anthropometric measurements and physiological and biochemical tests of women with abdominal obesity, who declared practicing physical activities for five hours a week. Despite their obesity (BMI  $26.7 - 44.8 \text{ kg/m}^2$ ), the women featured high aerobic capacity – as expressed by  $VO_2\text{max}$  values – and normal systolic and diastolic blood pressure (Table 2). The blood pressure values and  $VO_2\text{max}$  relative to the women's age and body mass were arguably the results of the impact of regular physical activity on body composition, skeletal muscle and heart capillarization and the activity of catalysts of aerobic processes, despite no changes in the women's body mass [8, 9].

The positive effects of physical activity declared by the studied women can be also seen in the obtained lipid profile values. Despite the fact that the concentrations of total cholesterol and LDL-cholesterol were 10% higher than recommended by the IDF [10] (Table 3), the HDL-cholesterol and triglycerides levels were within the reference range. Although oxidized LDL-cholesterol plays a crucial role in the development of atherosclerosis [11], the relatively high HDL-cholesterol (20% higher

**Table 1.** Descriptive statistics of somatic parameters

	Body mass (kg)	Body height (cm)	BMI ( $\text{kg/m}^2$ )	Fat mass (%)	Lean mass (%)	Total water (%)	WHR	Waist circumference (cm)
$\bar{x} \pm \text{SD}$	$83.8 \pm 12.54$	$159.7 \pm 4.73$	$32.9 \pm 4.57$	$46.01 \pm 4.25$	$53.09 \pm 4.28$	$42.4 \pm 3.45$	$0,88 \pm 0,04$	$99,8 \pm 7,89$
min.	66.5	152.0	26.7	36.9	45.9	36.3	0,82	86
max	119.0	170.0	44.8	54.1	63.1	50.3	1,0	118

BMI – body mass index, WHR – waist-hip ratio, SD – standard deviation, min. – minimum, max – maximum

**Table 2.** Physiological parameters

	VO <sub>2</sub> max (ml/kg <sup>-1</sup> /min <sup>-1</sup> )	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
$\bar{x} \pm SD$	33.6 ± 8.19	133.4 ± 17.53	84.2 ± 8.87
min.	16.74	98.0	66.0
max	48.38	176.0	109.0

VO<sub>2</sub>max – maximal oxygen uptake, SD – standard deviation, min. – minimum, max – maximum

**Table 3.** Mean ( $\bar{x} \pm SD$ ) concentrations of blood serum lipids and lipoproteins

	Total cholesterol (mg/dl)	LDL-cholesterol (mg/dl)	HDL-cholesterol (mg/dl)	Triglycerides (mg/dl)
$\bar{x} \pm SD$	226.3 ± 45.12	140.6 ± 37.79	59.8 ± 11.12	129.3 ± 44.34
min.	154.6	70.5	38.8	66.9
max	352.3	218.7	81.2	261.7

LDL-cholesterol – low density cholesterol, HDL-cholesterol – high density cholesterol, SD – standard deviation, min. – minimum, max – maximum

**Table 4.** Biochemical parameters and insulin resistance

	Insulin ( $\mu$ IU/ml)	Glucose (mmol/l)	HOMA <sub>IR</sub>
$\bar{x} \pm SD$	10.0 ± 6.23	4.7 ± 0.79	2.1 ± 1.21
min.	5.0	2.8	0.83
max	30.5	6.4	5.8

HOMA<sub>IR</sub> – homeostatic model assessment of insulin resistance, SD – standard deviation, min. – minimum, max – maximum

than recommended) appears to prevent atherosclerosis. The anti-sclerotic activity of HDL-cholesterol is not only related to the reverse transport of free cholesterol to the liver, but it also protects the endothelium cells, enhances blood coagulation, and inhibits the activation and adhesion of leucocytes to the endothelium [12]. Physical activity is also associated with the observed normal range of triglycerides (TG). A higher TG level is an independent risk factor of atherosclerosis and thrombosis [13].

No disturbances in carbohydrate metabolism were observed in the examined women (Table 4). The fasting insulin and glucose levels were normal, and the mean HOMA<sub>IR</sub> corresponded to the ranges of

Wallace et al. [14]. This all can be attributed to the effects of moderate physical activity on carbohydrate metabolism, which – on the one hand – are associated with reduced insulinemia and increased insulin-independent glucose transportation [15], and – on the other hand – with increased utilization of fatty acids by muscle cell mitochondria [16]. Fujioka et al. and [17] Leenen et al. [18] showed that a 40-50 min of physical activity a day contributes to the loss of visceral fat and improvement of metabolism; i.e. better glucose tolerance, blood profile and insulin blood level, in people with abdominal obesity. Moderate physical activity was also shown to reduce the volume of both visceral and subcutaneous fat in people with abdominal obesity, known to induce insulin resistance independently of each other [19, 20]. The visceral adipose tissue has a particularly negative effect resulting in the

treatment of waist circumference as an independent risk factor of ischemic heart disease as well as type 2 diabetes, especially with elevated TG in blood plasma [21]. Moreover, visceral fat synthesizes proinflammatory cytokines, e.g. TNF  $\alpha$  or interleukin 6, whose levels are positively correlated with insulin resistance and the risk of cardiovascular diseases [22].

The statistical analysis also revealed a positive correlation between the subjects' BMI with triglycerides level ( $r = 0.38$ ;  $p < 0.05$ ), and a negative correlation with VO<sub>2</sub>max ( $r = -0.60$ ;  $p \leq 0.001$ ). These results, however, are not useful as regards the aim of the study.

It must be asserted that recreational physical activity has a positive influence on carbohydrate and lipid metabolism in women with visceral obesity, and plays an important role in prevention of metabolic disorders.

#### What this study adds?

Visceral obesity elevates the risk of cardiovascular diseases and diabetes. The present study shows that despite abdominal obesity in studied women, and therefore higher total cholesterol and LDL-cholesterol blood levels, their HDL-cholesterol and triglycerides (considered an independent risk factor of ischemic

heart disease) concentrations were normal. Also the insulin level and insulin resistance index ( $HOMA_{IR}$ ) were within the reference range. The obtained values of biochemical parameters point to the beneficial effects of regular physical activity.

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