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Original article

Ergospirometry in the assessment of cardiovascular risk and safe physical activity in obese persons

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Abstract

Background. Obesity is one of the most important health problems in the world and in our country and is the main risk factor for reduced functional capacity and therefore for cardiovascular diseases (CVD), so reducing body weight (TT) is important for a good management of the health system and impact on future adverse cardiovascular events. Therefore, a detailed assessment of the cardiopulmonary system in the obese is very important. he aim of our study was to examine the role of ergospirometry in the assessment of cardiopulmonary capacity in relation to the ordinary ECG exercise test in morbidly obese persons reffered for body weight reduction in our Center for obesity.

Methods. The study was conducted in the Laboratory for Ergospirometry, Cardiology Clinic, UCCS. Obese patients with a BMI >31 kg/m2 (mean BMI 45±6), aged >18 years, scheduled for the diet or bariatric surgery treatmentv of obesity participated in the research. The total number of patients was 196 (142 women and 54 men). All patients underwent a clinical examination and cardop-pulmonary exercise test (CPET, Bruce protocol) with simultaneous gas analyses. In accordance with guidelines, we used recommended cut off for the ventilatory anaerobic threshold ≥14 ml/kg/min for increased CV risk.

Results. During CPET, there was an adequate increase in heart rate and blood pressure compared to resting values. That optimal VAT was achieved by 152 patients, while 31 obese individuals had an anaerobic threshold below 14 ml/kg/min. Persons with a lower anaerobic threshold on the test were older, and the differences were only in the achieved CPET parameters, while the classical parameters of the physical load test did not differ.

Conclusion. Cardiopulmonary capacity, as a significant predictor of mortality and morbidity, is greatly influenced by obesity. Objective assessment includes determination of cardiopulmonary capacity and ventilatory anaerobic threshold by ergospirometry which is superior to standard exercise test parameters and VAT values are also the starting point for prescribing safe physical activity. Based on the parameters of CPET we can identify a high-risk patients independently of the BMI value.

Kew words obesity, ergospirometry, anaerobic threshold, cardiopulmonary capacity

Introduction

Historically, obesity is the most common and longest-known metabolic disorder, which was initially a status symbol and was not viewed as a health problem or an aesthetic defect. It is defined by the accumulation of excess body fat, as a result of an imbalance between energy intake and its expenditure, taking into account gender, age and body height. As a chronic disease, obesity has great social and economic importance, due to significant health complications that reduce the quality of life, shorten life expectancy, and the treatment of obese people has a high price [1-6].

Body mass index is the ratio of body mass in kilograms to the square of body height expressed in meters. However, one should be careful, because it is possible to be obese and have a good body mass index, or vice versa - not to have too much weight, but have an increased BMI. This means that body composition plays a more important role than body weight measured in kilograms [7]. BMI is calculated using a formula that relates an individual's height and weight, or more precisely, it represents weight (in kg) divided by height (expressed in meters squared). So it is expressed in BMI=kg/m2. The classification according to BMI is shown in Table 1. Obesity is one of the most important health problems in the world and in our country and is the main risk factor for reduced functional capacity and therefore for cardiovascular diseases (CVD), so reducing body weight

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Table 1. Degree of obesity stratified according to BMI values

	Male BMI (kg/m^2)	Female BMI (kg/m^2)
Malnutrition	< 20	<19
Normal body weight	20 - 25	19 - 24
Obesity, level I (increased body weight)	25 - 30	24 - 30
Obesity, level II	30 - 40	30 - 40
Morbid obesity, level III	> 40	>40

BMI - body mass index

(TT) is important for a good management of the health system and impact on future adverse cardiovascular events[1]. Therefore, a detailed assessment of the cardiopulmonary system in the obese is very important.

Ergospirometry and obesity

Peak VO_2 is the highest myocardial oxygen consumption achieved during CPET and is the most reproducible index of cardiorespiratory fitness or aerobic capacity. If the consumption curve shows a plateau at the maximum load, then the consumption can be marked as maximum VO_2max. PeakVO_2 and anaerobic threshold (AT) are also expressed according to the unit of body weight as ml/kg/min. Conversion of PeakVO_2 to MET units is achieved by dividing by 3.5 mL/kg/min. Normal consumption declines with age 8% to 10% over each decade in non-athletes, and 5% over each decade in persistent exercisers. It is also 10% to 20% higher in men, due to higher hemoglobin concentrations, greater muscle mass, and greater stroke volume. Functional capacity is decreased in obese persons, but this is not the rule, as in this population it also depends on the condition, level of obesity and age[8,9].

Anaerobic threshold

When the metabolic needs during exercise exceed the supply of oxygen to the working muscles, anaerobic metabolism is activated. Anaerobic - ventilatory threshold (VAT) is detected with a metabolic increase in VCO_2 and VE relative to VO_2. Typically, AT occurs between 47% and 64% of the predicted VO_2max of untrained healthy individuals and increases with training. VAT is important in prescribing training and rehabilitation because VO_2 at VAT indicates our ability to perform daily (submaximal) activities, but also the degree of fitness and decreases with deconditioning. It is also important because the activities up to the threshold are mild and that is the zone of predominantly fat consumption which is important body weight reduction. The most important parameter for evaluating risk of CV events is VAT with the cut off value for obese persons 14 ml/kg/min[7-9].

The aim of our study was to examine the role of ergospirometry in the assessment of cardiopulmonary capacity in relation to the ordinary ECG exercise test in morbidly obese persons reffered for body weight reduction in our Center for obesity.

Methods

The study was conducted in the Laboratory for Ergospirometry, Cardiology Clinic, UCCS. We analyzed 196 patients (142 women and 54 men, average age 39±10 years) with BMI 45±6kg/m^2 who were referred for assessment in Obesity center. All patients underwent a clinical examination and CPET. Patients with uncontrolled hypertension blood pressure, ischemic heart disease, significant valvular disease, severe chronic obstructive pulmonary disease or syncope were excluded. All patients signed an informed consent before the test. Testing was approved by the UCCS ethics committee.

Test protocol and monitoring

The Shiller CS-200 system was used for the analysis of expiratory gases during CPET. Ergospirometry was performed on a treadmill (standard Bruce protocol). During the test, oxygen consumption (VO_2) was continuously monitored and consumption at ventilatory anaerobic threshold (VAT) was determined, as well as peak consumption (peakVO_2) with monitoring of ventilatory parameters and respiratory reserve. A 12-channel ECG and blood pressure were continuously monitored. Pressure measurements and ECG recordings were performed at rest, at the end of each level and during recovery. Indications for discontinuation were: respiratory gas exchange index RER = 1.1, fatigue, dizziness, intense chest pain, horizontal or descending ST depression/ elevation >1 mm lasting 0.08 s after the J point, hypertensive response (240/ 120mmHg), serious rhythm disorders.

Statistical analysis

The complete statistical analysis of the data was done using SPSS, version 17. All attributive variables were presented in the form of frequencies of individual categories, and the statistical significance between individual categories was tested with the Chi-square test. All continuous variables are presented as mean ± standard deviation, while for differences in continuous variables we will use Student's t test for independent or dependent causes or Mann-Whitney test or Wilcoxon test, depending on the normality of the distribution, which will be tested by Kolmogorov-Smirnov test. All analyzes will be evaluated at a statistical significance level of $p<0.05$. After the statistical processing of the data, the results will be presented tabularly and graphically.

Results

Obese patients with a BMI >31 kg/m2 (mean BMI 45±6), aged >18 years, scheduled for the diet or bariatric surgery treatmentv of obesity participated in the research. The total number of patients was 196 (142 women and 54 men). Table 2 shows the prevalence of classic risk factors for CVD.

During CPET, there was a significant increase in heart rate and blood pressure compared to resting values. Table 3. And CPET variables are shown in table 4.

Table 2 . Risk factors in morbidly obese persons in the studied population

	n	%
Sedentary	135	68
HTN	99	50
OSA	6	3
Cigarette smoking	42	21
DM	56	28
Insulin resistance	24	12
CHO	21	10
TG	19	9
Statin therapy	17	8

HTN – hypertension; OSA- obstructive sleep apnea; DM – diabetes; CHO – cholesterol; TG- triglycerides

Table 3. Hemodynamic changes during CPET

Rest HR (bpm)	97±12
Peak HR (bpm)	165±75*
Rest SBP (mmHg)	136±12
Peak SBP (mmHg)	180±25*
Rest DBP (mmHg)	87±12
Peak DBP (mmHg)	98±10*

***p<0.0001,** HR-heart rate; SBP-systolic blood pressure; DBP- diastolic blood pressure

In accordance with guidelines, we used recommended cut off for the ventilatory anaerobic threshold ≥14 ml/kg/min for increased CV risk. That VAT was achieved by 152 patients, while 31 obese individuals had an anaerobic threshold below 14 ml/kg/min . Persons with a lower anaerobic threshold on the test were older, and the differences were only in the achieved CPET parameters, while the classical parameters of the physical load test did not differ.

Disscusion

It is known that obesity is one of the leading risk factors for CV diseases whereas a special importance has cardiopulmonary capacity [1-6].

Chronic, morbid obesity leads to a series of changes in the CV and pulmonary system that jeopardises health and reduce the possibility of adequate supply of organs and tissues with oxygen, especially in conditions of increased needs [8,9]. Peak VO2 is a precise indicator of cardiopulmonary capacity and patients with low consumption have a higher risk of intervention[10-12.] In our study, peak VO2 was significantly higher in patients who had an optimal anaerobic threshold ≥14 ml/kg/min compared to the group of patients who had an anaerobic threshold lower than 14 ml/kg/min, while ventilatory efficiency was higher in group of patients who had an anaerobic threshold of less than 14 ml/kg/min. This result indicates the importance of objective assessment and the existence of a certain percentage of obese people with a reduced ability to tolerate submaximal effort[7, 10,11,12]. We have also shown that the parameters of CPET in this group of patients are superior to the classic parameters of the exercise ECG test which is in concordance with previous studies and guidelines[7,9]. According to the recommendations, it is a good starting point for physical activity, because up to that level of activity, they are mild and in the zone of fat consumption, which is also an additional therapy in addition to diet therapy[10,11].

For patients who have an adequate threshold, more intensive activities can be prescribed, and the risk of side effects is also lower[9,10]

Table 4. CPET parameters in obese persons

Peak VO_2 (ml/kg/min)	19.7±3.9
VAT (VO_2) (ml/kg/min)	17.2±3.5
VE/VCO_2 slope	27±4

Peak VO^2 – Peak myocardial oxygen consumption; VAT (VO_2) – oxygen consumption on anaerobic threshold; VE/VCO_2 slope – ventilatory efficiency

Table 5. Ergospirometry parameters in relation to the value of the anaerobic threshold

	≥14 ml/kg/min N=51	<14 ml/kg/min N=14	p
Age (y)	**37±10**	**46±9**	**<0.0001**
BMI (kg/m2)	46±6	47±6	0.06
Test duration (sec)	**345±107**	**259±114**	**<0.0001**
Rest HR (bpm)	98±12	93±15	0.09
Peak HR (bpm)	**169±83**	**148±63**	**0.005**
Rest SBP (mmHg)	136±12	138±14	0.277
Peak SBP (mmHg)	180±26	179±23	0.880
Rest DBP (mmHg)	87±13	87±10	0.829
Peak DBP (mmHg)	98±10	100±10	0.221
Peak VO_2 (ml/kg/min)	**20.6±3.3**	**15.6±2.8**	**<0.0001**
VE/VCO_2 slope	**26±4**	**28±3.7**	**<0.0001**

BMI – body mass index; rest HR- resting heart rate; Peak HR – peak heart rate; rest SBP – resting systolic blood pressure; peak SBP- peak systolic blood pressure; rest DBP- rest diastolic blood pressure; peak DBP – peak diastolic blood pressure; Peak VO2 – peak myocardial oxygen consumption; VE/VCO2 slope – ventilatory efficiency.

Conclusion

Cardiopulmonary capacity, as a significant predictor of mortality and morbidity, is greatly influenced by morbid obesity. Objective assessment includes determination of cardiopulmonary capacity and ventilatory anaerobic threshold by ergospirometry which is superior to standard exercise test parameters and VAT values are also the starting point for prescribing safe physical activity. Based on the parameters of CPET we can identify a high risk patients independently of the BMI value.

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Sažetak

Ehokardiografija u proceni kardiovaskularnog rizika i sigurne fizičke aktivnosti kod gojaznih osoba

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Uvod. *Gojaznost je jedan od najvažnijih zdravstvenih problema u svetu i kod nas i glavni je faktor rizika za smanjenje funkcionalnog kapaciteta, a samim tim i za kardiovaskularne bolesti (KVB), pa je smanjenje telesne težine (TT) važno za dobro lečenje. zdravstvenog sistema i uticaj na buduće neželjene kardiovaskularne događaje. Zbog toga je veoma važna detaljna procena kardiopulmonalnog sistema kod gojaznih. Cilj našeg istraživanja bio je da ispitamo ulogu ergospirometrije u proceni kardiopulmonalnog kapaciteta u odnosu na obični EKG test vežbanja kod morbidno gojaznih osoba upućenih na smanjenje telesne težine u našem Centru za gojaznost.*

Metode. *Istraživanje je sprovedeno u Laboratoriji za ergospirometriju Klinike za kardiologiju UKCS. U istraživanju su učestvovali gojazni pacijenti sa BMI >31 kg/m2 (srednji BMI 45±6), starosti >18 godina, predviđeni za dijetu ili barijatrijski hirurški tretman gojaznosti. Ukupan broj pacijenata je 196 (142 žene i 54 muškarca). Svi pacijenti su podvrgnuti kliničkom pregledu i ergospirometriji (CPET) (Bruce protokol) uz istovremene analize gasa. U skladu sa smernicama, koristili smo preporučeni cutoff za ventilacioni anaerobni prag ≥14 ml/kg/min za povećan rizik od KV.*

Rezultati. *Tokom CPET-a, došlo je do adekvatnog povećanja srčane frekvencije i krvnog pritiska u poređenju sa vrednostima u mirovanju. Taj optimalni PDV postigla su 152 pacijenta, dok je 31 gojazna osoba imala anaerobni prag ispod 14 ml/kg/min. Osobe sa nižim anaerobnim pragom na testu bile su starije, a razlike su bile samo u postignutim CPET parametrima, dok se klasični parametri testa fizičkog opterećenja nisu razlikovali.*

Zaključak. *Kardiopulmonalni kapacitet, kao značajan prediktor mortaliteta i morbiditeta, ima veliki uticaj gojaznosti. Objektivna procena obuhvata određivanje kardiopulmonalnog kapaciteta i ventilacionog anaerobnog praga ergospirometrijom koja je superiornija od standardnih parametara testa opterećenja, a vrednosti PDV-a su takođe polazna tačka za propisivanje bezbedne fizičke aktivnosti. Na osnovu parametara CPET-a možemo identifikovati visokorizične pacijente nezavisno od vrednosti BMI.*

Ključne reči: *gojaznost, ergospirometrija, anaerobni prag, kardiopulmonalni kapacitet*