The role of cardiopulmonary exercise test for individualized exercise training recommendation in young obese subjects

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Abstract

Obesity is affecting a growing segment of the population and should be considered a serious health problem which will lead to medical complications and decreased life span. Lifestyle changes by adopting healthy food and increase energy consumption through physical activity is the most important treatment for obesity. Cardiopulmonary exercise test (CPET) is considered the gold standard for exercise capacity assessment. *Purpose:* This study is aiming to demonstrate that individualized exercise training programs, designed using CPET results, leads to increase of physical fitness, aerobic capacity, ventilatory and cardiac exercise performance in young obese subjects. *Material and method:* We performed a prospective research study of 6 months. 43 sedentary subjects without contraindications to exercise, 21.3±3.1 years old, 93% female were included in the study. Assessments were made at baseline and after six months of intervention and consists of cardiopulmonary exercise test on bicycle ergometer. After we recorded oxygen uptake at aerobic threshold (AT), anaerobic threshold (in the range of respiratory compensation point - RCP) and maximal oxygen uptake (VO_2max) we designed the training program according to these parameters and individualized heart rate training zones of each subject. Exercise training (60 minutes/session, 3 sessions/week) was performed taking in consideration the training zones and using a circuit on cardio devices. Each subject was supervised by a physiotherapist and using heart rate monitors. The number of subjects evaluated at the end of the study was 27 (dropout rate 37%). *Results:* After six months of intervention we noticed an improvement of maximum oxygen uptake (VO_2max) (from 22.7±3.69 to 27.44±5.55), aerobic threshold (VO_2_AT) (from 15.48±2.66 to 20.07±4.64 ml/min/kg, p<0.0001) and anaerobic threshold (VO_2_RCP) (from 20.3±3.66 to 25.11±5.84 ml/min/kg, p<0.0001), cardiac performance during exercise evaluated trough maximal oxygen pulse (VO_2/HRmax) (from 10.05 ± 1.88 to 11.81 ± 2.77 ml, p=0.0004) and maximum ventilatory capacity (VE-VO_2max) (from 59.25±12.29 to 70.25±17.11, l/min, p=0.0001). *Conclusion:* Active and closely monitored intervention by individualized exercise training programs lead to improved circulatory and respiratory functions and cardiorespiratory fitness in young obese patients.

***Key words**: exercise training programs, cardiopulmonary exercise test, maximum oxygen consumption*

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Rezumat

Obezitatea afectează un segment al populației tot mai mare şi trebuie considerată o problemă de sănătate care conduce la afectiuni care determină scăderea duratei şi calității vieții. Modificările stilului de viață prin adoptarea unei alimentații sănătoase şi creşterea consumului energetic prin programe de exerciții fizice sunt cei mai importanți paşi în tratarea obezității. Testarea cardiopulmonară la efort este metoda considerată cea mai avansată metodă de evaluare a capacității de efort. *Scop:* Acest studiu doreşte să demonstreze că programele individualizate de antrenament fizic realizate în urma testării cardiopulmonare la efort duc la creşterea condiției fizice, anduranței şi performanței ventilatorii şi cardiace de efort la persoane tinere obeze. *Material şi metodă:* Am realizat un studiu prospectiv pe o perioadă de 6 luni. Au fost incluşi în studiu 43 subiecți sedentari, fără contraindicații de efort fizic, de 21.3±3.1 ani, 93% subiecți fiind de gen feminin. Evaluarea a fost realizată inițial şi la 6 luni de la includere şi a constat în evaluarea cardiopulmonară la efort realizat pe bicicleta ergometrică. S-a determinat astfel consumul de oxigen la prag aerob şi anaerob, respectiv consumul maxim de oxigen (VO_2max). Programul de antrenament fizic recomandat subiectilor fiind individualizat în funcție de aceşti parametrii. Programul de exerciții (60 minute/sesiune, 3 sedințe/săptămînă) a cuprins exerciții de tip cardio sub supravegherea unor kinetoterapeuti si utilizând pulsmetre pentru monitorizarea frecvențeicardiace de antrenament. Numărul subiecților rămaşi în studiu după cele 6 luni de intervenție a fost de 27 (rata de excludere fiind de 37%). *Rezultate*: După 6 luni de antrenament fizic am observat o îmbunătățire a consumului maxim de oxigen (VO_2max) (de la 22.7±3.69 la 27.44±5.55), a pragului aerob (VO_2_AT) (de la 15.48±2.66 la 20.07±4.64 ml/min/kg, p=<0.0001) şi anaerob (VO_2_RCP) (de la 20.3±3.66 la 25.11±5.84 ml/min/kg, p<0.0001), a frecvenței cardiace la efort maximal (VO_2/HRmax) (de la 10.05± 1.88 la 11.81±2.77 ml, p=0.0004) şi a capacităşii ventilatorii maxime (VE-VO_2max) (de la 59.25±12.29 la 70.25±17.11 l/min, p=0.0001). *Concluzii:* Intervenția activă şi monitorizată realizată prin programe de antrenament fizic duce la îmbunătățirea funcțiilor circulatorii şi respiratorii de efort, cre;terea fitnessului cardiorespirator şi îmbunătățirea calității vieții la pacienții tineri obezi.

***Cuvinte cheie**: antrenament fizic, testare cardiopulmonară la efort, consum maxim de oxigen*

Introduction

Obesity has become a serious public health problem in most industrialized countries; it is affecting a growing segment of the population. Obesity should be considered a serious health problem which will lead to medical complications and decreased life span. This can be described as the most common nutritional disorder, a condition in which excessive fat accumulates in the body due to eating more than physiological needs and/or metabolic disorders. Thus, an obese person is prone to a range of medical complications: general, cardiovascular, pulmonary and metabolic disorders. [1-2]

Lifestyle changes by adopting healthy food and increase energy consumption through physical activity is the most important step in treating obesity. Studies showed that a moderate-intensity aerobic physical activity, (approximately 1000 kcal/week) is enough to achieve reduction of 20-30% mortality risk from all causes. [3]

Cardiopulmonary exercise test (CPET) is considered the gold standard for exercise capacity assessment. Upon completion of a maximal CPET we obtain data regarding aerobic capacity and maximum oxygen consumption (the most powerful predictors of death from any cause). [4]

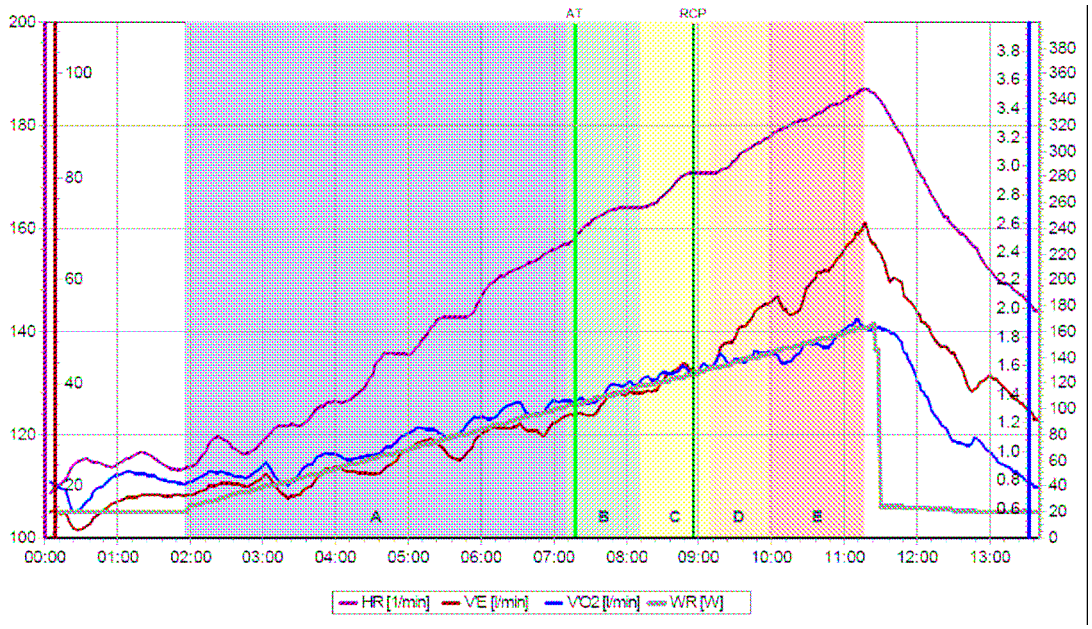
In order to prevent accidents and to increase the efficiency of the exercise training is recommended to individualize the training by adapting the exercise intensity according to the physical fitness of each subject. [5]

Purpose

This study is aiming to demonstrate that individualized exercise training programs, designed using CPET results, leads to increase of physical fitness, aerobic capacity, ventilatory and cardiac exercise performance in young obese subjects.

Method

We performed a prospective research study of 6 months. The study group consisted of 43 young sedentary subjects (21.3±3.1 years old) without contraindications to exercise, body mass index over 25 kg/m^2, 93% of them were female. Assessments were made at baseline and after six months of intervention and consists of CPET (using a Metalyzer 3B gas exchange device) on bicycle ergometer in which subjects were monitored in terms of cardiac and respiratory parameters. We recorded oxygen uptake at aerobic threshold (AT), anaerobic threshold (in the range of respiratory compensation point - RCP) and maximal oxygen uptake (VO_2max). We individualized the training program according to these parameters and established the training zones according to the heart rate achieved at every threshold. An example of recommended training zones are presented in figure 1.



Zone	HR 1/min	WR W
Top Zone	>178	>143
Development Zone	171-178	133-143
Intensive Endurance	164-171	118-133
Extensive Endurance	158-164	101-118
Compensation Zone	<158	<101

Figure 1. Example of training zones obtained after performing CPET; we used for exercise training the extensive and intensive training zones along with short intervals of 1 minute in development zones.

Exercise training was performed in the physical therapy room oft the Faculty of Physical Education and Sport using a circuit on cardio devices (cycle ergometer, cross trainer, stepper and treadmill).

Each subject was supervised by a physiotherapist and using heart rate monitors (Polar F6, Finland). The exercise training programs consisted in 3 sessions/week of 60 minutes activity (5 minutes warming up, interval exercise training and 5 minutes recovery).

Dropout rate at the end of the study was 37% - the number of subjects evaluated at the end of the study was 27.

Results

After six months of intervention we noticed an improvement of all parameters recorded. (Table 1) Physical fitness (VO_2max) increased significantly from 22.7±3.69 to 27.44±5.55 ml/min/kg, p=<0.0001 (figure 2).

The same changes was noticed regarding aerobic exercise capacity evaluated by aerobic threshold (VO_2_AT increased from 15.48±2.66 to 20.07±4.64 ml/min/kg, p=<0.0001) and anaerobic threshold (VO_2_RCP increased from 20.3±3.66 to 25.11±5.84 ml/min/kg, p<0.0001) respectively (figures 3, 4).

Table 1. Trend of CPET parameters after 6 months of interval exercise training.

Parameters	Baseline evaluation	Standard deviation at baseline	6 months evaluation	Standard deviation at 6 months	p value
VO_2max (ml/min/kg)	22.7	±3.69	27.44	±5.55	<0.0001
HR _VO_2max (b/min)	181.7	±12.7	180.03	±14.63	0.6579 (ns)
VO_2/HRmax (ml)	10.05	±1.88	11.81	±2.77	0.0004
VE_VO_2max (l/min)	59.25	±12.29	70.25	±17.11	0.0001
VO_2_AT (ml/min/kg)	15.48	±2.66	20.07	±4.64	<0.0001
VO_2_RCP (ml/min/kg)	20.3	±3.66	25.11	±5.84	<0.0001

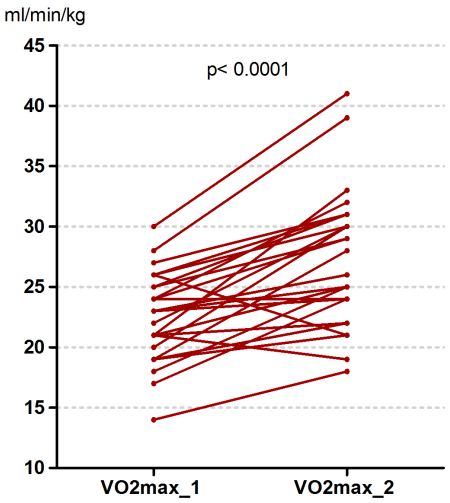


Figure 2. Evolution of maximum consumption of oxygen parameter after 6 months of individualized exercise training

VO_2max_1: the average of maximum consumption of oxygen at baseline; VO_2max_2: the average of maximum consumption of oxygen after 6 months;

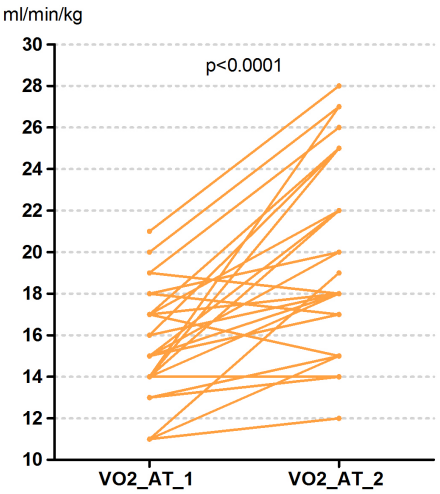


Figure 3. Evolution of aerobic threshold parameter after 6 months of individualized exercise training;

VO_2_AT_1: the average of aerobic threshold at baseline;
VO_2_AT_2: the average of aerobic threshold after 6 months;

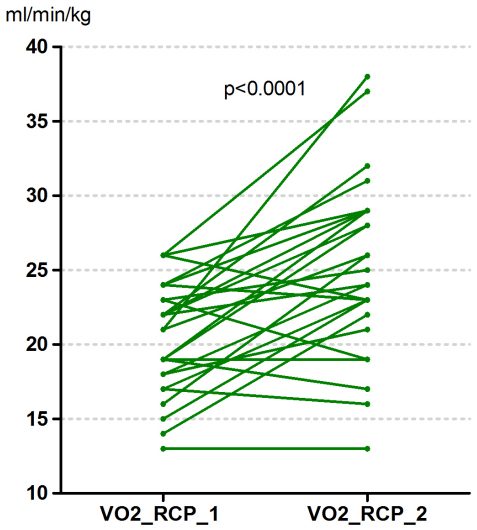


Figure 4. Evolution of anaerobic threshold parameter after 6 months of individualized exercise training

VO_2_RCP_1: the average of aerobic threshold at baseline;
VO_2_RCP_2: the average of aerobic threshold after 6 months;

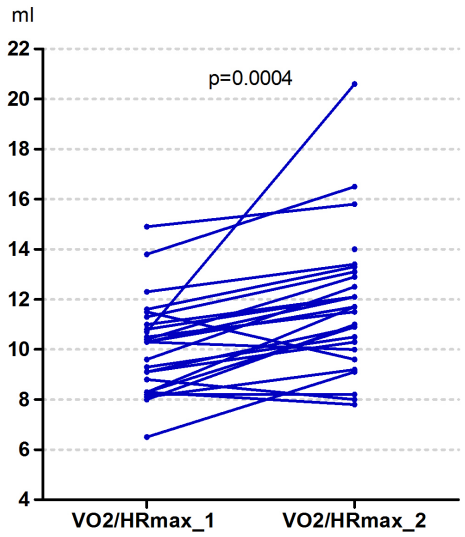


Figure 5. Evolution of oxygen pulse parameter after 6 months of individualized exercise training

VO_2/HRmax_1: the average of cardiac performance during exercise evaluated trough maximal oxygen pulse at baseline;
VO_2/HRmax_2: the average of cardiac performance during exercise evaluated trough maximal oxygen pulse after 6 months;

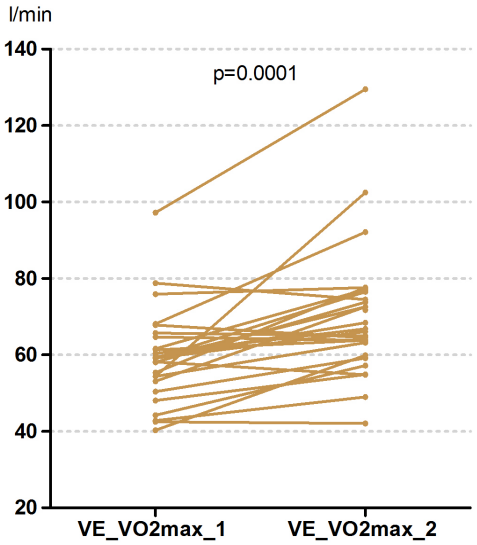


Figure 6. Evolution of maximum ventilatory capacity parameter after 6 months of individualized exercise training;

VE_VO_2max_1: the average of maximum ventilatory capacity at baseline;
VE_VO_2max_2: the average of maximum ventilatory capacity after 6 months;

Significant improvement occurred regarding cardiac performance during exercise evaluated trough maximal oxygen pulse (VO_2/HRmax) - it is significantly increasing from 10.05±1.88 ml la 11.81±2.77 ml, p=0.0004 (figure 5).

Physical training conducted had a positive effect on maximum ventilatory capacity (VE_VO_2max). This was demonstrated by increasing VE_VO_2max from 59.25±12.29 to 70.25±17.11 l/min, p=0.0001 (figure 6).

Discussion

Significant improvement of maximum oxygen uptake means that subjects have on average a better exercise capacity. Decreased heart rate at maximal effort is therefore a better adaptation of the heart during exercise through more intense contractions and cardiac output but less beats per minutes which lead to decrease of cardiac work.

Subjects showed a significant improvement of oxygen pulse implying greater efficiency of the cardiovascular system (heart and circulation), this has a direct influence on significant growth of maximum oxygen uptake recorded. Respiratory system had increased the efficiency by providing a better adaptation to exercise. Ventilatory capacity presented a statistically significant improvement which shows a better adaptation of the subjects in terms of respiratory effort. Oxygen consumption at aerobic and anaerobic threshold increased significantly as a consequence of exercise training individualization and performing of exercise in the range of these two thresholds, by using the training zones. Increase of VO_2 may be due to a possible decrease of weight bur other parameters are weight independent.

We have demonstrated that individualized physical training based on CPET has a very good influence on young obese patients modifying aerobic and anaerobic threshold and also maximum ventilator capacity. Similarly results were shown by another recent study in which after 12 weeks of aerobic training (jogging), maximal oxygen uptake increased by 6.2±2.4 ml/kg/min [6]. This results are superior as intervention time (4 months comparing to 6 months in our study), but we consider that outdoor jogging in obese patients may be harmful for musculoskeletal system. Some time due to their need of more energy output to move total body mass, morbidly obese subjects have a reduced aerobic capacity and even brisk walking could reach the anaerobic threshold.

Conclusions

Cardiopulmonary exercise testing together with training zones determinations is a useful tool in assessing the physical capacity and drawing up individual workouts. By using training zones we can increase programs efficiency and improve the effect of physical training.

Active and closely monitored intervention by individualized exercise training programs lead to improved circulatory and respiratory functions and cardiorespiratory fitness in young obese patients.

References

1. Fotheringham M.J. Rebecca L., Wonnacott and Nevile Owen (2000) *Computer use and physical inactivity in young adults: Public health perils and potentials of new information technologies.* Annals of Behavioral Medicine, Springer New York, Volume 22, Number 4/December.
2. World Health Organization: http://www.who.int/diabetes/facts/world_figures/en/index.html, accessed in 19 March 2010;
3. Gaita D., Avram A., Avram C. (2007) *Antrenamentul fizic in recuperarea cardiovasculara.* Editura Brumar, Timisoara, 23-34;
4. Wasserman K., Hansen J.E.., Sue D.Y. et al. (2007) *Principles of exercise testing and interpretation.* Philadelphia: Lippincott Williams & Wilkins, 2005; S. A. Ward, P. Palange: „Clinical exercise testing", Editura ERS Journals, UK, 45-47;
5. Claudiu Avram, Mihaela Oraviţan et al. (2008) *Testarea cardio-pulmonară de efort – prioritate în evaluarea performanţei fizice*, Timisoara Physical Education and Rehabilitation Journal, vol. 1, issue 1, 16-20;
6. Masashi Miyashita, Miki Eto, et al. (2009) *Twelve-Week Jogging Training Increases Pre-Heparin Serum Lipoprotein Lipase Concentrations in Overweight/Obese Middle-Aged Men,* Journal of Atherosclerosis and Thrombosis, Vol.17, No.1.