

Aerobic Threshold for Exercise Prescription

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ABSTRACT

The Aerobic Threshold (AerT), is an aged cardiovascular parameter not commonly used to evaluate the heart's performance in athletes. It indirectly evaluated by ventilator parameters during Cardio Pulmonary Test (CPT). Considering that "exercise as prescription therapy" for the diseases, includes training normally established around at the 40% of the peak VO_2 , this parameter could be taken in care as initial level for the effort prescribed. The aim of the study was to estimate the behavior of the AerT and also Anaerobic Threshold (AT), VO_{2max} in sedentary people. A group of athletes coming from different sports at the same and highest dynamic component were enrolled as control. A group of 41 athletes (16 soccer, 10 basket and 15 cyclists) and 9 healthy subjects were submitted to a CPT. The AerT, AT (assessed by V-slope method) and VO_{2max} were evaluated. The statistical analysis was performed with T student test ($P < 0.05$ significant). As expected in sedentary all the values were lower than athletes, however for Aer T value appears to be not significantly inferior respect of this one, with the exclusion of the comparison with the cyclists. In sedentary the AerT measure seems to give additional information in evaluating the cardiovascular performance. The VO_{2max} and AT remain the main parameters in defining the athletes performance. Therefore we cannot exclude any further utility of the AerT in normal subject but regularly trained.

Keywords: Sedentary, Exercise as Prescription, Intensity of Exercise, Cardio Pulmonary Test

1. Introduction

The Cardio Pulmonary Test (CPT) is currently considered the best tool to determine the production of physical energy by the measurement of the aerobic metabolism.

Several variables are usually considered in the CPT, however among them the main parameter for the assessment of the heart performance, is the maximum oxygen uptake (VO_{2max}) expressed in ml/kg/min [1].

Particularly in athletes this parameter is used to estimate the physical performance and different values of this one normally typify diverse kinds of sports [2].

The degree of the VO_{2max} depends in fact on the cardiovascular workload that is strictly related to a specific sport discipline. The regular training determines a progressive enhancement of the parameters directly associated with the athletes performance and therefore the sports are consequently classified in a major "static or dynamic" component [3].

Literature reports however some other parameters derived from CPT, like the anaerobic threshold (AT) [4] and the aerobic threshold (AerT) [5] expressed as a percentage of VO_{2max} .

While the AT determination is employed particularly in athletes to classify the fitness level and to follow the

effects of physical training [6], on the contrary the AerT is not currently used in athletes population for the poor relationship with an high performance level, but it is use among the deconditioned patients where the 20% to 40% of their VO_{2max} should be the initial intensity of exercise [7].

The last one has been recently considered in evaluating non-athletes subjects, even if regularly trained, where the physical exercise is prescribed as therapy to contrast the risks factors derived from an improper life style.

2. Aim

The main aim of this study it is to compare VO_{2max} , AT and AerT values of the three different kinds sports, included into the same class, in order to better discover any possible difference among them.

3. Materials and Method

Sample: The study was conducted on a sample of 9 healthy non-athletes subjects (6 male, 3 female) similar for the general characteristics (Table 1) matched with a control group of 41 subjects athletes from three different kinds of sport (16 soccer players, 15 cyclists and 10 basketball players).

Table 1. Anthropometrics measures of sample

	Age	Weight	Height
Sedentary	30.11 ± 5.66	74.67 ± 20.51	178.00 ± 4.95
Basket	23.80 ± 7.00	92.00 ± 12.55	194.90 ± 9.25
Soccer	24.94 ± 2.89	77.25 ± 5.84	181.44 ± 4.24
Cycling	17.80 ± 3.10	62.40 ± 7.95	172.87 ± 10.13

Note: Anthropometrics data are expressed as mean as SD for each group analyzed. None statistical difference among them for these parameters.

Following the Sport Classification [3], cycling, basketball and soccer are all included in the group with high dynamic component, with static component at high level for the first, moderate level for the second and low level for the third. Therefore global cardiovascular load shows some slight differences for each sport [3].

Experimental design: All the examinations were performed at the Sports Medicine Centre, of the University of Florence - Italy. All the subjects enrolled, following our ethical internal committee, gave their oral consent to participate to the study; the research protocol was approved by the Ethics Committee of the Faculty of Medicine and Surgery of Florence. Every subject enrolled has undergone to a incremental and maximal cardiopulmonary test (CPT).

For the football players, basketball players and the healthy subjects the treadmill test was used, while for cycling the cycle ergometer was preferred considering the specificity of athletic movements [8].

Before to start, all the subjects were examined by a physician using a dynamic spirometry test and electrocardiogram (ECG) performing to confirm normal lung and heart function.

The respiratory gas measurements were obtained using a Schiller Cardiovit Ergo-Spiro CS 200 (Schiller AG, Baar, Switzerland). Calibrations of flow transducer and gas analysers were performed daily. The transducer with mouthpiece detecting breath by breath registrations of oxygen uptake (VO_2), expired CO_2 (VCO_2), minute ventilation (VE).

The treadmill test: The CPT was performed by the Schiller Cardiovit Ergo-Spiro CS 200 treadmill (Schiller AG, Baar, Switzerland). The exercise test was performed following the modified Bruce protocol (**Table 2**). In this context the slope and the velocity of the ramp increase at a lower workload than the standard test. The protocol is a protocol appositely modified to guarantee a progressive enhancement of the effort.

The first two stages of the Modified Bruce Test are performed at a 2.7 km/h and 0% grade and 2.7 km/h and 5% grade, and the third stage corresponds to the first stage of the Standard Bruce Test protocol.

The ramp treadmill protocols offers also the advantage of steady gradual increases in work rate for a better estimation of the functional capacity [9].

Table 2. Modified Bruce test protocol

Step	Time(min)	Speed (km/h)	Slope(%)
1	0	2.74	10%
2	3	4.02	12%
3	6	5.47	14%
4	9	6.76	16%
5	12	8.05	18%
6	15	8.85	20%
7	18	9.65	22%
8	21	10.46	24%
9	24	11.26	26%
10	27	12.07	28%

Note: The example of the modified Bruce protocol where the slope and the velocity of the ramp increase at a lower workload than the standard test.

The cycle ergometer test: The cycling exercised on a Schiller Cardiovit Ergo-Spiro CS 200 cycle ergometer (Schiller AG, Baar, Switzerland). During exercise the cadence should be held at a constant 70 rep/min, the first workload was 25 W and increasing 25 W every 2 minutes to subjective exhaustion.

AerT measurement: As literature reports the presence of two points of discontinuities during an incremental effort correspond to the AerT and AT. These discontinuities are observed in ventilator curve response or in the lactate plasma level curve response (correspond 2 mmol and 4 mmol respectively).

They substantially are the transition from aerobic to anaerobic metabolism [5,10].

The first of these points of the curve discontinuities is coincident with AerT. It is associated with the correspondent workload value and it is coincident with the first sustained increase in VE (expressed L/min) as a response of increasing of exercise intensity [11]. AerT were also evaluated that 2 mmol of blood lactate [12]. However few data are now available in literature about the current employment of the AerT, and few results are present about the comparison of this one with the other parameters obtained during CPT, mainly if it is measured in normal subjects but regularly trained [13].

The second discontinuities corresponds to the AT. It is an equilibrium period between the lactate production and the lactate elimination (maximal lactate steady state, MLSS) [14], and it is generally associated with the blood lactate concentration of 4 mmol [12].

Measure of Aerobic Threshold: Following the literature, the AT values were obtained during the CPT by V-Slope method: this method identify AT as the VO_2 at which the change in slope of the relationship of VCO_2 to VO_2 occurs [15]. *VO_2 max measurement:* Achieving a clear plateau in VO_2 has traditionally been used as the best evidence of VO_2 max. VO_2 max is the best index of aerobic capacity and the gold standard for cardio respiratory fitness. It represents the maximal reachable level of oxidative metabolism involving a large group of mus-

cles. However, mainly in some clinical testing situations, a clear plateau may not be achieved before symptom limitation of exercise [16,17].

The value of maximum oxygen uptake (VO_2max), anaerobic threshold (AT), aerobic threshold (AerT) are expressed in ml/kg/min.

Statistical analysis was performed using the SPSS 13.0 package for Windows XP. All data are expressed as mean \pm Standard Deviation (SD). The groups were compared using ANOVA test. A probability value (p) of < 0.05 was considered statistically significant.

Confidence intervals of 95% percent for difference between methods were calculated.

4. Results

All the values of the AT and Aer T are expressed in $\text{mlO}_2/\text{kg}/\text{min}$ and in percent of VO_2max (Table 3).

The results show an increase of the parameters calculated either in sedentary or in control subjects.

Particularly for the AerT, the averaged value is $18.36 \pm 3.35 \text{ mlO}_2/\text{min}/\text{kg}$ in sedentary, $22.76 \pm 5.34 \text{ mlO}_2/\text{min}/\text{kg}$ in basket, $24.00 \pm 4.72 \text{ mlO}_2/\text{min}/\text{kg}$ for soccer and $28.47 \pm 7.52 \text{ mlO}_2/\text{min}/\text{kg}$ for cycling. These values correspond around to a 40% of VO_2max in all sample and they are significantly higher in the cyclist group compared to the healthy one ($p < 0.05$).

On the other hand the AT value is a percent of VO_2max estimated around the 70% of VO_2max for basket and soccer, around 76% VO_2max for cycling while it is around 65% for sedentary subjects. It demonstrates the same trend of AerT parameter, with a lower value in healthy subjects, highest in cycling and approximately in the middle for basket and soccer.

The AT values are statistically higher in athletes vs. sedentary ($p < 0.01$), however no difference is evident between soccer and basketball group ($p = 0.25$).

Table 3. Data of AerT, Aerobic Threshold; AT, Anaerobic Threshold by V-slope method; VO_2max , maximum oxygen uptake of samples

	AerT	Anaerobic Threshold (AT)	VO_2max
Sedentary	18.36 ± 3.35	27.62 ± 6.15	43.25 ± 9.30
% VO_2max	43.0	63.9	100
Basket	22.76 ± 5.34	40.46 ± 9.37	58.23 ± 5.25
% VO_2max	39.1	69.5	100
Soccer	24.00 ± 4.72	43.98 ± 5.27	61.96 ± 5.94
% VO_2max	38.7	70.9	100
Cycling	28.47 ± 7.52	55.43 ± 8.64	72.40 ± 9.65
% VO_2max	39.3	76.6	100

Note: data of the AT and AerT are expressed in $\text{mlO}_2/\text{kg}/\text{min}$ and in percent of VO_2max ; all the values increase during the effort either in sedentary or in control group (athletes). The behaviour of the AerT showed in the former a particular trend to enhance respect of the other parameters that remains significantly lower than in athletes.

As expected the VO_2max parameter reports a progressive and significant increase ($p < 0.01$) of the values in athletes globally considered ($64.20 \pm 6.95 \text{ mlO}_2/\text{min}/\text{kg}$) respect of the healthy group ($43.25 \pm 9.30 \text{ mlO}_2/\text{min}/\text{kg}$).

However, in addition to this feature, the selected analysis of the behaviour of VO_2max for each sport considered in the study, demonstrates a statistical difference among them (VO_2max in basket is $58.23 \pm 5.25 \text{ mlO}_2/\text{min}/\text{kg}$, in soccer $61.96 \pm 5.94 \text{ mlO}_2/\text{min}/\text{kg}$, in cycling $72.40 \pm 9.65 \text{ mlO}_2/\text{min}/\text{kg}$ with $p = < 0.05$) with the exclusion of the comparison between soccer and basketball ($p = 0.12$).

5. Discussion

There are practical reasons for assessing a subject by CPT. AerT, AT and VO_2max are the main indexes of exercise intensity to provide guidelines for exercise training. The intensity of training resulting from these parameters may optimize the intensity-duration relationship. AT is highly related to the performance in a various endurance activities, in many cases the relationship is stronger than those between VO_2max and performance [18].

AerT actually is less frequently considered during an incremental effort because CPT is mainly used in evaluating patient with heart disease where a decrease of VO_2max is considered as a universal marker of reduced exercise capacity and therefore it represents the onset in assessing the reduction of the exercise tolerance [19]. It is note that athletes may attain values of VO_2max over 20 times their resting values [20].

On the contrary the AerT, enclosing a restricted application in athletes, it has been more commonly linked to a people with a low intensity of physical activity, in fact the intensity of effort required for treatment is generally between 60% and 80% of the maximum heart rate. The results of this study show the AerT has a peculiar trend in healthy subject's respect of athletes, supporting the hypothesis to play an important role to set protocols training for people where the physical activity can be used as a therapy. We cannot therefore exclude any further importance of the AerT in normal subject regularly trained where this parameter could be appreciated as the minimum intensity of the effort executed. This could be crucial point to decide the term of the "exercise as prescription".

The VO_2max and AT remain however the main parameters in defining the athletes performance. Cyclist have the highest value for every CPT parameters, the static component of the effort may have an additional role in the chronic cardio – pulmonary sport adaptation.

Moreover particularly for the general population where the exercise can be prescribed with therapeutical impact the AT could represent the upper limit of the working range.

6. Limits of the Study

The study involves a quite small cohort of subjects and therefore the results obtained cannot be considered definitive. The correct use of the AerT instead of AT in non-athletes subjects to establish the degree of physical exercise, will need further assessment of a possible relationship of this parameter with other factors characterizing the body composition. Moreover to verify the effective clinical utilization of these parameters on the general population in terms of exercise as prescription, it will need more investigations in future.

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