CARDIOPULMONARY FUNCTION OF ELITE BASKETBALL AND SOCCER PLAYERS DURING THE PRESEASON

by

ARTURAS ANDZIULIS [*], **AUDRIUS GOCENTAS** [**],
NIJOLE JASCANINIENE [***]

The aim of the study was to investigate the oxygen consumption of athletes before the beginning of the preseason. Oxygen consumption parameters were established on VMAX29 with the Marquette 3.01 system during a standard exercise test protocol, modified by Balke. The research included 32 male athletes (age 18-25), basketball and soccer players [VO_{2max} – average 47ml/kg/min. (std 11, CI {43: 51}, $p<0.05$) and VO_{2AT} – 55-68% of VO_{2max} level, VO_2/W average 13.1 L/kg/m (std 1.4, CI {12.6; 13.6}, $p<0.05$)]. Short recovery duration (90% of VO_2 consumption, heart ratio and pulmonary ventilation decreasing during 3 minutes) indicates good preparation of athletes to anaerobic work. Time series curves of achieved oxygen consumption in steady state condition and high METS level indicate good usability of standard exercise test protocol for evaluation of health and the estimation of work capacity during the preseason.

Key words: exercise tolerance, oxygen consumption, anaerobic threshold, and oxygen debt.

Introduction

The adaptation during endurance physical training has an external expression, in the form of oxygen consumption by increasing aerobic work, and various integrated internal expressions with different interpretation (Fox et al. 1993, Powers et al. 1990, Mangham et al. 1997, Kolchinskaja 1999). The best indicator of aerobic work potential is the maximal oxygen consumption (Fardy et al. 1995, Fletcher et al. 1990, Astrand 1986). Aerobic adaptation is highly

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[*] Dr – Vilnius University, Lithuania,

[**] Dr – Vilnius, Institute of Experimental and Clinical Medicine, Lithuania,

[***] Dr – Vilnius, Pedagogical University, Lithuania.

dependent on training characteristics (sports specificity), training stage and duration, individuality of athlete, age and many other factors. These specific relations are well discussed in abundant literature (Kliusiewicz 1992, Fox et al. 1993). Unfortunately, we have no data about using specific parameters and constructed verified norm curves based on oxygen transport systems functions quantitative changes during standard exercise tests due to the athlete's selection for the specific kinds of sport. The data from great number of publications of other countries exist about various highly trained athlete's oxygen consumption parameters, specified to different sports and healthy subjects (Jones et al. 1983, Fletcher et al. 1990). There are no publications about these in Lithuania, regardless of great achievements in several disciplines, as basketball, rowing, track and field and others.

The aim of this study was to estimate the oxygen transport function capacity, as maximal oxygen consumption and quantitative changes during standard exercise tests, anaerobic threshold and achieved power, aerobic efficiency of highly trained athletes and establish norms for particular phases of the season in team sports.

Material and methods

A total of the 32 highly trained male athletes (age 18-25 years) – basketball and soccer players, candidates and members of national team were investigated during the preseason.

Cardiopulmonary exercise tests were performed on electronically braked ergocycle (ERGOLINE 9000), using modified BALKE protocol. Ventilation and gas exchange was assessed by breath-by-breath method, using VMAX229 metabolic card with paramagnetic oxygen and infrared carbon dioxide analyzer and Sensor Medics gas flow analyzer. Anaerobic threshold estimation was measured directly by V-slope method, related with other usual parameters and performed on Sensor Medics VMAX229 analysis program. Heart rate and arterial blood pressure parameters were established during continuous ECG monitoring and analysis integrated VMAX and Marquette 3.01 system with electrocardiograph CORINA. Quantitative changes of heart rate, blood pressure, double rate product and other parameters, as oxygen consumption and work rate, as well as workload level at anaerobic threshold and maximal oxygen consumption were calculated or established by VMAX application algorithm. Criterions for exercise terminating were oxygen consumption plateau (1 min. steady state interval with 5% deviation), considerable heart rate and work ratio increasing with deviation from Jones formula limited interval for trained persons (decreasing of aerobic heart work efficiency with 10% deviation), double rate product increasing absence. AHA determined criterions for exercise termination were not established (ECG and others).

The following variables were taken for statistical analysis:

- Workload level at anaerobic threshold (W);
- Workload level at maximal oxygen consumption (W);
- METS (maximal oxygen consumption and rest oxygen consumption, established until exercise test by indirect calorimetry using VMAX29 metabolic card ratio);
- Work and MET product;
- Oxygen consumption on anaerobic threshold achieving point (ml/kg/min.);
- Values of oxygen consumption each 30 s (ml/kg/min.);
- Differences of oxygen consumption between each 30 s.
- Oxygen consumption and achieved workload ratio.

Standard statistical analysis were performed. The data was described by measures of central tendency, variability and shape were described. The calculation of mean values, variability, standard deviation, standardized kurtosis and skewness were performed. The standardization procedures were performed. All samples of normality and goodness-of-fit tests were performed with 95% confidence level. Oxygen consumption for each 30 seconds sample, hypothesis t-test equality to null with standard confidence was performed. All not verified time series points were excluded from graphics. Unknown quantities were modeled with central graphical tendency.

Results

Distribution of frequency histograms of P_{AT} and P_{VO2max} are shown in fig. 1. Normality of distribution of other series was proved (at standard level). Determined variables achieved in athletes are given in Table 1.

Table 1

Developed aerobic power variables in high level athletes (in the beginning of preparatory period of training):

Variable	Mean	SD	Confidence level	P	Minimum	Maximum
METS	13.4	3.1	12.3; 14.5	<0.05	7.8	19.7
METW	1273.3	235.1	1188.5; 1358.0	<0.05	736	1828
VO_{2AT} ml/kg/min.	25.9	8.7	22.8; 29.0	<0.05	13.6	48.0
VO2max ml/kg/min.	46.8	10.9	42.9; 50.7	<0.05	27.5	69.0
$VO_{2/}W$ L/kg/m	13.1	1.4	12.6; 13.6	<0.05	10.5	16.7

Comparative VO_{2max} data (Table 2) was recalculated according to the recommended formula for extreme age, height, and body mass.

Table 2

Oxygen consumption levels according to various sources.

VO_{2max} normal	VO_{2max} ml/kg*min^{-1}
According to Pollock (for healthy people)	>36
Jones (recommended for healthy subjects)	43-60
According to American Heart Association's recommendation (for healthy subjects)	>43
According to Shepard (for athletes, peak data), 1992	70-85
According to Blackie (peak data)	55-70
According to IOC recommendation (peak data), 1990	55-85
Subjects of present study	43-51

It may be concluded, that peak oxygen consumption level in the investigated group was similar to healthy subjects and non-training subjects.

Mean change in oxygen consumption during regular physical workload, are presented in fig. 2. The changes at rest are presented in fig.3 and aerobic effectiveness is shown in Fig. 4

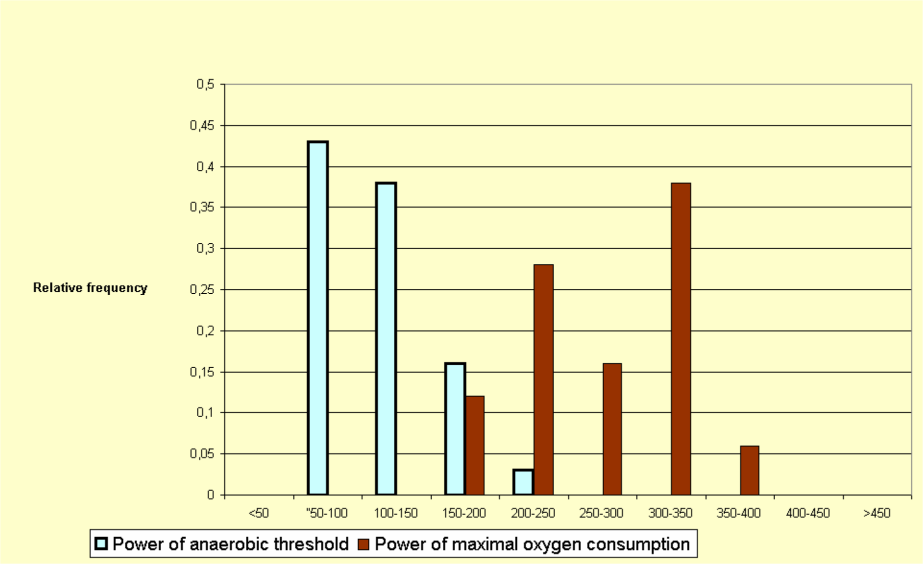

Fig. 1. Freguency histogram of developed power

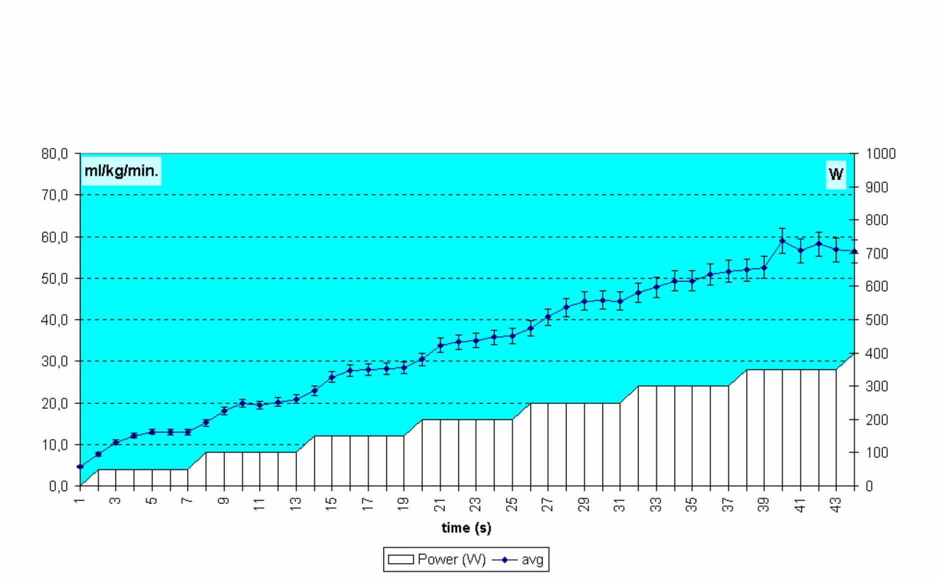

Fig 2. Oxygen consumption

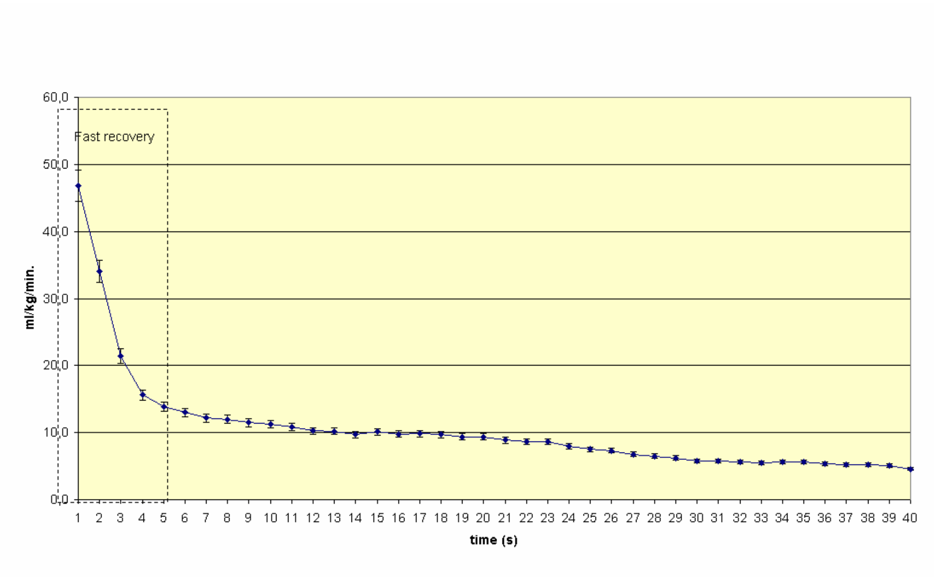

Fig 3. Oxygen consumption at recovery

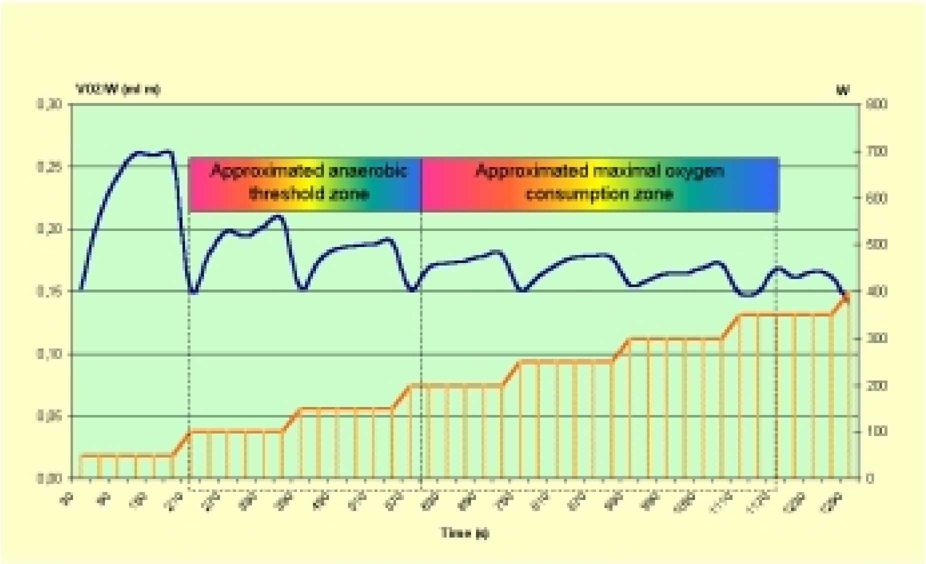

Fig. 4. Effectiveness of aerobic work during exercise test

Vital energy for human physical activities is produced by means of biochemical transformations, collected and released from phosphate groups bonds. Certainly, energy is obtained while the body is breathing, i.e. by oxidation of energy substrates and by intermediary buffer depositing energetic mechanisms. Capability of an organism to release higher quantities of energy during the period of time allows elaborating more intensive physical activities (Astrand, 1986, Fox et al. 1993, Richardson et al. 1998). This seems very important to majority of athletes and, what is more, it could be even decisive for one's championship level (Kolchinskaja, 1999, Weisman at al, 1994, Powers et al. 1990). It is generally agreed that aerobic capability is best reflected on the cardiopulmonary function and other components of oxygen transport capacity (i.e. capability to consume oxygen to produce energy) (Fleck et al. 1988)]. However, aerobic capabicity has a different effect on the results in various kinds of sport (Astrand 1986, Shephard 1992). For instance, high aerobic threshold maintenance abilities are more important for the endurance athletes, such as nordic skiers, long distance runners, swimmers, cyclists, rowers etc. On the contrary, high anaerobic potential is more important for those athletes who need speed or force, for example, discuss and javelin throwers, sprinters, jumpers etc. However, in certain sport disciplines aerobic capacity is less important than technical and tactical preparation. Finally, certain athletes (basketball, football, soccer, handball players) are in the need for all types of aerobic capabilities, although characteristics of the needs are different.

Although investigation in athletes was carried out before the preparation training cycle, taking into account VO_{2max} in the best Lithuanian athletes, these seems that value should be slightly higher. The majority (63%) of the investigated athletes elaborated workload output higher than the one given by Jones (1983). The achieved METS level (12-15) is slightly higher than the one given by AHA (American Heart Association) for healthy people (>10-12).

On the other hand, determined oxygen consumption level ranging within 23-29 ml/kg/min anaerobic threshold condition equals to 55-68% of VO_{2max}. It is generally accepted that the range should match 60-70% of that level, and its reduction shows relative de-training of cardiovascular function (normally the left ventricle of the heart) reduction [Wasserman et al. 1994, Gregg et al. 1998, Jones et al. 1983). It should be noted that the lowest aerobic threshold level and the smallest VO_2max were discovered in the same person and this had a considerable negative effect on the extreme intervals (this person was sent for further detailed health check). On the contrary, in the athletes who had their VO_{2max} at the maximum ranges, their anaerobic threshold was around 70%. It may suggest the higher de-training capability in other athletes. It seems that reduction of cardiovascular function could not be possible due to high double rate product ratio – 4.2 (std – 1.0; confidence level (Powers et al. 1990, Wasserman et al. 1994) and oxygen pulse in 6 cases (19%) being within 12-18 ml range, in majority cases (19 cases – 60%) being within 18-24 ml interval, and, furthermore, in 7 cases (21%) above 24 ml. However, according to the AHA and some other authors oxygen pulse for healthy people at peak physical workload may reach 10-15 ml, and for trained athletes it could be as high as 20 ml., high double rate product ratio >3 for healthy people indicates very high capability of the heart muscle. In addition there is one more important value – aerobic activity coefficient of physical activity that according to Wasserman (1994) may be around 10.3, could indicate aerobic load maximum level intensiveness. The greater values determined in the investigated may suggest it was usual with the trained people.

The following items could be yielded from the VO_2 time series and differential curve:

- In the interval of achieving anaerobic threshold VO_2 peak value is achieved at the beginning of load step in 60-120 s and clearly reducing to steady state condition interval formation (i.e. workload is of small intensiveness);
- In the interval of peak oxygen consumption, VO_2 growth was being late for about 30 s, and peak consisted of two phases. It is likely that common growth delay indicates creation of oxygen ‘debt’, and bi-phased of peak indicates that ventilation or cardiovascular function were not switching on simultaneously;
- Peak physical workload interval (not represented as a separate item) did not reached steady state conditions

With reference to the recovery represented in Fig.3 it could be suggested that:

1. Fast and slow recovery phases (each 3-4 min) could be distinguished in the recovery period. VO_2 changes in 30 s intervals is statistically denied.
2. During the fast recovery phase VO_2 reduces to as low value as 90 % of peak value.

The fast recovery phase is very short comparing to literature data (according to the AHA length of the whole phase is about 10 min), consequently, it may be accepted that the athletes were well prepared for physical activities at anaerobic conditions.

Discussing the aerobic work effectiveness graph given in Fig. 4, it could be noted that when physical workload was increasing, bioenergy contribution from aerobic sources were decreasing (aerobic ratio fall). Oxygen consumption peaks are bi-phased. Taking into account that such apparent peaks are not usual for pulse grasps, it may be concluded that the latter peak represented the effect of slowest switching on of the total lungs ventilation. Interestingly, this process could not be discovered without performing analysis on both the consumption of gases and lungs' ventilation. Both compensating waves were going only after the 2nd minute of the load. If one wave only is observed, the impression could be formed that the load of the standard test protocol was of insufficient intensiveness.

Conclusions

The investigated athletes were healthy subjects, they could participate in the training process, although they were not elite athletes of international level or they did not pay sufficient attention to maintaining their fitness until the preparatory period, taking into account low VO_{2max} values ranging from 43 to 51 ml/kg/min.

Special attention should be paid to the increase in aerobic threshold (i.e. for the aerobic training) in athletes during the first training cycle.

Modified BALKE protocols are suitable to check athletes' health, because load steps achieve steady state phases and sufficient METS is developed.

Modeling oxygen consumption curves are suitable for evaluation of course of the training process investigating athletes by means of ergometry according to standard and modified protocols

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