Interrelation of speed-strength abilities and indicators of maximum aerobic power

UDC 612.2

V.V. Volkov[1]
Dr. Biol., Professor **R.V. Tambovtseva**[1]
Dr. Biol., Professor **A.B. Miroshnikov**[1]
[1]Russian University of Sport (SCOLIPE), Moscow

Corresponding author: fitclub@list.ru

Abstract

Objective of the study was to evaluate the relationship between the maximum aerobic power demonstrated in tests with different duration of the load and the maximum anaerobic power.

Methods and structure of the study. The experiment involved 13 highly qualified professional single combat athletes (9 men, 4 women, age 26.6±6 years, weight 72±11.7 kg, height 176.2±10.5 cm). The study was conducted in the department of functional diagnostics of the clinic "International Center for Health Protection" (Moscow). All tests were performed on a bicycle ergometer Lode Excalibur (Netherlands). The maximum aerobic power was defined as the load that the subject completed at least 3/4 of the duration of the step before giving up work.

Results and conclusions. It is shown that the absolute maximum aerobic power depends on the rate of load increase in the step test and significantly correlates with the absolute maximum anaerobic power (r=0.68-0.84). For a reliable relationship between the relative indicators of aerobic and anaerobic power, a step test of a shorter duration may be required.

Keywords: *maximum oxygen consumption, Wingate test, speed-strength abilities, aerobic abilities.*

Introduction. Most sports place high demands on both aerobic and anaerobic performance. Therefore, for an informative assessment of the athlete's physical fitness, the battery of tests should include the appropriate samples. In laboratory conditions, tests with increasing load during work of a global nature are used to determine the aerobic capacity, in which the maximum oxygen consumption (MOC) is determined. Anaerobic abilities are assessed in terms of power when performing short maximum tests, usually on a bicycle ergometer [3]. To determine the MOC, it is recommended to choose such a protocol for increasing the load so that the test corresponds to a certain "correct" time duration [5]. That is, a test duration that is too short or too long can result in subjects not reaching their maximum oxygen uptake rate. At the same time, it has been shown that it is not necessary to meet the recommended test duration in order to demonstrate MOC [1] and that shorter protocols can be used. But with a decrease in the duration of the test, the maximum power of the work that the subject demonstrates increases [9, 10]. It is also well known that the shorter the duration of the maximum load, the greater the contribution of anaerobic energy sources [7, 8].

Objective of the study was to evaluate the relationship between the maximum aerobic power demonstrated in tests with different duration of the load and the maximum anaerobic power.

Methods and structure of the study. The experiment involved 13 highly qualified professional single combat athletes (9 men, 4 women, age 26.6±6 years, weight 72±11.7 kg, height 176.2±10.5 cm). The study was conducted in the department of functional diagnostics of the clinic "International Center for Health Protection" (Moscow). The subjects visited the clinic twice with a break between visits of 24-72 hours. During two visits, subjects were required to complete five maximal exercise tests to determine aerobic capacity and one test to determine maximal anaerobic capacity.

All tests were performed on a bicycle ergometer Lode Excalibur (Netherlands). During the experiment, to determine the maximum aerobic power, the subjects performed five tests with a stepwise increasing load to failure with different duration of the load step. Each test began with a three-minute warm-up with 60 watts of power and 80 rpm pedaling. Further, depending on the protocol, at the same pace of pedaling, the power of work increased by 30 W every 15, 30, 60, 120 and 240 seconds. The test was performed to failure, that is, until the subject was unable to maintain the required pace of pedaling. The maximum aerobic power was defined as the load that the subject completed at least 3/4 of the duration of the step before giving up work. If this volume was not performed, the value of the last completed stage was taken as the maximum power.

To determine the maximum anaerobic power, sprint acceleration was performed on a bicycle ergometer for 5 seconds. The test was performed on the move (from 100 rpm) with a load of 1.4 Nm per kg of the subject's body weight.

First visit

During the first visit, subjects completed a cardiological examination for admission to exercise testing and two tests to determine maximum aerobic power with a duration of exercise steps of 60 and 120 seconds.

Second visit

During the second visit, the subjects completed the remaining three tests with load step durations of 15, 30, and 240 seconds, as well as the maximum sprint test. Between the experimental protocols, the subjects passively rested for 40-60 minutes, drank a sweet drink containing 50 grams of carbohydrates, and then drank clean water without restrictions. Planning multiple maximal tests on the same day has not been shown to affect maximal aerobic power [6].

Results of the study and their discussion.

Maximum aerobic power and time to failure

Of the 65 planned measurements, only 63 were obtained. In order to plot and analyze the differences, the lost data were replaced with averages from other protocols performed by the same subject. The maximum aerobic power was 15, 30, 60, 120 and 240 seconds for protocols with the duration of the loading stage 365±58,5, 302±49,7, 257,5±41,6, 226±39,9 and 214±36.4 watts, respectively.

Table 1 shows the average maximum aerobic capacity and the average time to failure for each protocol.

Maximum anaerobic power

The average absolute maximum anaerobic power (MAP) was 1121.4±283.4 W, and the average relative power was 15.4±2.5 W/kg.

Relationship between maximum aerobic power and MAP

The correlation coefficients of the maximum aerobic power achieved in the protocols with different duration of the loading stage and the maximum anaerobic power are shown in Table 2 and 3.

For all cases, the correlation coefficients of absolute MAP and absolute maximum aerobic power are statistically significant ($p<0.05$).

The correlation coefficients of relative MAP and relative maximum aerobic power are not statistically significant, but show a tendency to increase with decreasing protocol duration.

The results of this work demonstrate that the maximum aerobic power depends on the rate of load increase in the step test. Our data are consistent with the work of Adami et al. [1], in which 16 young healthy men performed six progressive exercise tests in incre-

Table 1. Average values of maximum aerobic power and work time to failure in protocols with different duration of the loading stage. Values are in watts and seconds (±SD)

Data	Protocols				
	15 seconds	30 seconds	60 seconds	120 seconds	240 seconds
Maximum power, W	365±58,5	302±49,7	257,5±41,6	226±39,9	214±36,4
Test time, sec	152±30,4	241±50,9	395±86,6	653±156,9	1172±289,4

Table 2. Correlation coefficients of absolute maximum aerobic power and absolute maximum anaerobic power

Data	Maximum power, W				
	15 seconds	30 seconds	60 seconds	120 seconds	240 seconds
MAP, W	0,84	0,74	0,78	0,69	0,68

Table 3. Correlation coefficients of relative maximum aerobic power and relative MAP

Data	Maximum power, W				
	15 seconds	30 seconds	60 seconds	120 seconds	240 seconds
MAP, W/kg	0,45	0,29	0,28	0,21	0,09

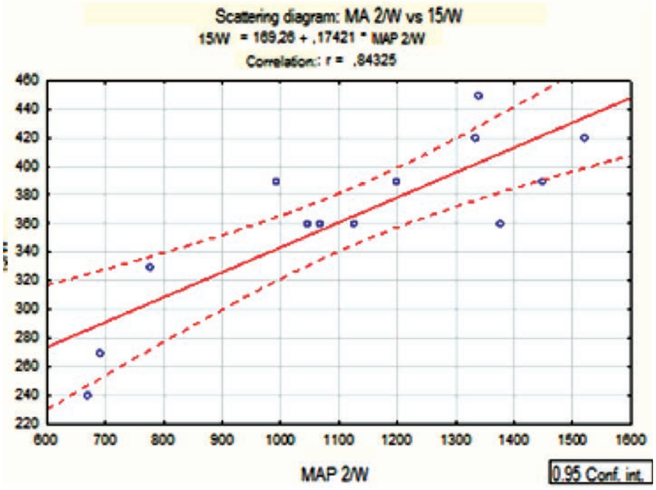

Figure 1. *An example of the relationship between the absolute maximum aerobic power obtained in the 15 sec protocol and MAP*

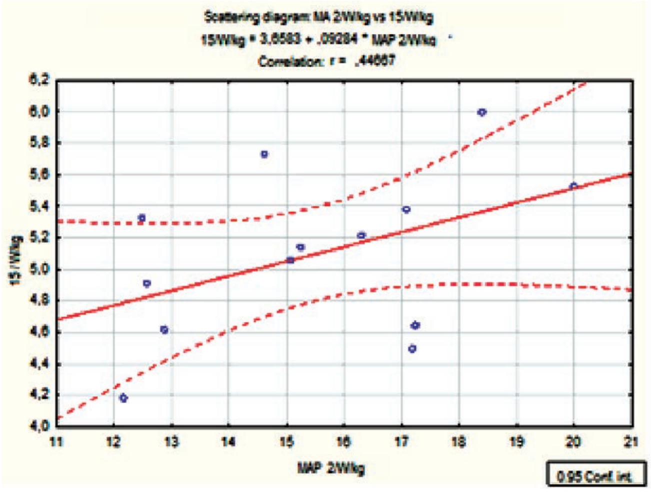

Figure 2. *An example of the relationship between the relative maximum aerobic power obtained in the 15 sec protocol and the relative MAP*

ments of 25 W. The step durations were 15, 30, 60, 90, 120 and 180 seconds and the inverse dependence of failure power on test duration was shown.

Vinetti et al [9] came to the same conclusion when they tested seven healthy, moderately active young adults (six men, one woman). During the month, the subjects performed a battery of load tests on a bicycle ergometer with different rates of load increase to failure. Work power was increased by 25 watts every 30, 60, 90, 120, and 300 seconds, and the dependence of maximum aerobic power on the test protocol was also shown. Also in this work, a significant relationship was shown between maximum aerobic power and MAP in all cases, which increased with a decrease in the duration of the test and reached a correlation coefficient of r=0.84.

Zarzeczny et al. [11] showed a strong relationship between maximum anaerobic power and absolute oxygen consumption, but, unfortunately, the authors did not study the relationship with maximum aerobic power.

Koziris et al. [4] also show a correlation between maximal oxygen consumption and power during the Wingate test, but MOC was measured on a treadmill, making it difficult to assess aerobic power.

It is also known that maximum aerobic power is associated with maximum oxygen consumption and sports performance [2].

At the same time, the maximum oxygen consumption can be obtained already at the 60th second of the maximum test “with might and main” on a bicycle ergometer [7].

These observations lead the authors to suggest that it is possible to develop a testing protocol that would allow both aerobic and anaerobic capacity to be assessed simultaneously. Based on the data obtained, the absolute values of maximum aerobic and anaerobic power reach a strong level of connection, especially when using a protocol with a load step of 15 seconds. Correlations of relative power indicators did not reach an acceptable level of significance. One of the reasons for the weak relationship between these indicators may be the duration of even the “shortest” protocol (152 ± 30.4 s), since it is known that the contribution of aerobic sources with a similar duration is already 66% or more [8].

Conclusions. A significant correlation was demonstrated between the absolute values of maximum aerobic and maximum anaerobic power with a tendency to increase the relationship (r=0.84) with a decrease in the duration of the loading step to 15 seconds. The correlation between relative scores did not reach statistical significance (r=0.45) even when using a short step.

References

1. Adami A, Sivieri A, Moia C, Perini R, Ferretti G. Effects of step duration in incremental ramp protocols on peak power and maximal oxygen consumption. Eur J Appl Physiol. 2013 Oct; 113(10):2647-53.
2. Hawley JA, Noakes TD. Peak power output predicts maximal oxygen uptake and performance time in trained cyclists. Eur J Appl Physiol Occup Physiol. 1992; 65(1):79-83.
3. Horswill CA, Miller JE, Scott JR, Smith CM, Welk G, Van Handel P. Anaerobic and aerobic power in arms and legs of elite senior wrestlers. Int J Sports Med. 1992 Nov;13(8):558-61.
4. Koziris, L. Perry; Kraemer, William J.; Patton, John F.; Travis Triplett, N.; Fry, Andrew C.; Gordon, Scott E.; Knuttgen, Howard G.. Relationship

of Aerobic Power to Anaerobic Performance Indices. Journal of Strength and Conditioning Research 10(1): p 35-39, February 1996.

5. Midgley A.W., Bentley D.J., Luttikholt H. [et al]. Challenging a dogma of exercise physiology: does an incremental exercise test for valid VO2max determination really need to last between 8 and 12 minutes? Sports Med. 2008. Vol. 38(6). pp. 441-447.
6. Scharhag-Rosenberger F., Carlsohn A., Lundby C., Schüler S., Mayer F., Scharhag J. Can more than one incremental cycling test be performed within one day? Eur J Sport Sci. 2014;14(5):459-67.10.
7. Serresse O., Lortie G., Bouchard C., Boulay M.R. Estimation of the contribution of the various energy systems during maximal work of short duration. Int J Sports Med. 1988 Dec;9(6):456-60.
8. Spencer M.R., Gastin P.B. Energy system contribution during 200- to 1500-m running in highly trained athletes. Med Sci Sports Exerc. 2001 Jan;33(1):157-62.
9. Vinetti G., Fagoni N., Taboni A., Camelio S., di Prampero P.E., Ferretti G. Effects of recovery interval duration on the parameters of the critical power model for incremental exercise. Eur J Appl Physiol. 2017 Sep;117(9):1859-1867.
10. Weston S.B., Gray A.B., Schneider D.A., Gass G.C. Effect of ramp slope on ventilation thresholds and VO2peak in male cyclists. Int J Sports Med. 2002 Jan;23(1):22-7.
11. Zarzeczny R., Podleśny M., Polak A. Anaerobic capacity of amateur mountain bikers during the first half of the competition season. Biol Sport. 2013 Sep;30(3):189-94.