STUDY REGARDING THE VALIDATION OF AN ASSESSMENT PROTOCOL OF VO$_2$MAX ON CYCLE ERGOMETER

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Abstract. We set out to check the validity of an effort test that is aimed at assessing maximal aerobic power on electromagnetic brake bicycle with male subjects, aged between 20 and 30 years, untrained. The test was implemented at the Faculty of Physical Education and Sport with 8 untrained subjects with a mean age of 23.38 years, mean weight 80.9 kg and height 175.6 cm. The test protocol requires that the subject to follow the next steps: 5 minutes joint gymnastics, pedaling a bicycle at 133 W, then pedaling until exhaustion, the resistance increasing with 23.5 W/min. The evaluation was done using a Polar RS800 cardiofrecventiometer, gas analyzer FitMate PRO and pulse oximeter Contech WK 50D. The bike model used is the Vision Fitness E3200. Each subject has sustained two effort tests at an interval of rest for 2 hours. Following data statistical analysis it was found a strong correlation between the maximal oxygen consumption and the maximal aerobic power determined for each test.

Keywords: untrained, VO$_2$max, maximal aerobic power, protocol, FitMate PRO, Vision Fitness E3200 bike.

Rezumat. Studiu privind validarea unui protocol de evaluare a VO$_2$max pe cicloergometru. Ne-am propus să verificăm validitatea unui test de efort ce are scop evaluarea puterii maxime aerobe pe bicicletă cu frânare electromagnetică la subiecți masculini, cu vârsta cuprinsă între 20 și 30 de ani, neantrenati. Testul a fost pus în practică la Facultatea de Educație Fizică și Sport din Iași cu 8 subiecți neantrenati cu o medie a vârstei de 23,38 ani, greutatea medie de 80,9 kg și înălțimea de 175.6 cm. Protocolul testului presupune ca subiectul să parcurgă următoarele etape: 5 minute de gimnastică articulară, pedalează pe bicicletă la 133 W, după care pedalează până la epuizare, rezistența crescând cu 23.5 W/min. Evaluarea s-a făcut cu ajutorul unui cardiofrecventiometru Polar RS800, analizator de gaze FitMate PRO și pulsometru Contech WK 50D. Modelul de bicicletă folosit este Vision Fitness E3200. Subiecții au susținut câte două probe de efort la un interval de repaus de 2 ore. În urma analizelor statistice ale datelor s-a constatat o corelare puternică între consumul maxim de oxigen și puterea maximă aerobă determinată pentru fiecare test.

Cuvinte cheie: neantrenati, VO$_2$max, putere maximă aerobă, protocol, FitMate PRO, bicicletă Vision Fitness E3200.

Introduction

Maximum oxygen consumption is a parameter often measured in physiology. The history of assessing this parameter begins before 1923. Before World War II, the maximal aerobic capacity was assessed by intermittent exercise tests which lasted several days. After 1960 start to be accepted in the evaluation continuous efforts complemented by electronic devices determining instantaneous the composition of exhaust air.

The introduction of continuous efforts in evaluation led to a series of testing protocols for maximal oxygen consumption (VO$_2$max). The test protocols differed among themselves by the levels duration (constant effort intensity intervals), intensity difference between them and test duration. Froelicher et al. compared in 1974 three VO$_2$max evaluation tests: Bruce, Balke and Taylor with 15 subjects. The three tests have durations...
ranging from 3 to 31 minutes the VO₂max determined was significantly higher in the case of the Taylor protocol.

Three years later were compared four testing protocols: Balke, Bruce, Ellestad and Astrand, the subject number being 55 (Pollock et al., 1976). The two studies have concluded that long duration of the VO₂max test leads to the determination of a lower oxygen consumption.

The problem of optimal duration for the maximum oxygen consumption determination was not put until 1983, when Buchfuhrer et al. tested different exercise protocols on 12 subjects, with levels of 1 minute, on the cycle ergometer and treadmill. Durations outside the range 8-17 minutes give lower values (> 17 min.) or higher values (< 8 min. of VO₂max (Yoon et al., 2007).

In 1982, Myles & Toft, used in a test for assessing maximal aerobic power one minute levels, with growth of 37.5W, their study subjects pedaling at a rate of 75 revolutions/minute (RPM).

Another charging model was used for 36 cyclists and triathletes by Meyer et al. in 1999, they used 3 minutes levels, where the increase was of 50W, departing from 100W. Untrained healthy individuals were subjected to an exercise test in evaluation steps of the maximal aerobic power, the load being of 16.3W/min (100kpm/min).

On 16 untrained subjects aged between 19 and 27 years, Lattanzio et al. (1997) conducted a study in which they evaluated the maximal aerobic power using a progressive test with a load of 20 to 25 W/min.

In 2002, Vercruyssen et al. conducted a study in which eight triathletes were evaluated in terms of maximal aerobic power. The cycling test involved a 6-minutes warming at 100W, then the resistance growing with 30W/min. The test was done in such a way as to bring the subject to exhaustion in 8-12 minutes.

A study by Buchfuhrer et al. (1983) demonstrated by testing the maximal aerobic power with different loads (15, 30 and 60W) that higher values of VO₂max are recorded when using small loads. They suggest that the progressive period of the test to be of approximately 10 minutes.

Monedero & Donne (2000) used in the evaluation of the maximum aerobic capacity of a group of 18 cycling a test with a load of 120W, for 3 minutes at the beginning of the test. After three minutes the resistance had increased by 40W, followed by the steps of 8W/s. Subjects performing physical exercise to exhaustion.

Two assessment tests were compared (Amann et al., 2004): T1: 150W + 50W/min and T2: 20W + 25 W/min. Both tests have been supported by the same lot of riders (15) at a recovery period of 48 hours. Significant differences between the results of two tests were not identified.

**Material and Methods**

The determination of the maximum oxygen consumption can be carried out with priority through direct measurement devices when they are available. Thus, using a professional gas analyzer (FitMate Pro) we tried to determine the maximum effort consumption and maximum aerobic power, on a bicycle with electromagnetic brake, whose features we know from practical use.

We reported the testing protocol to the tests described in the specialized literature. Nieman et al. have tested in 2006 the analyzer FitMate Pro, by comparison with the
Douglas system of VO$_2$max assessment. Their study demonstrated no significant differences between the two assessment methods.

In our study, 8 subjects participated, male, with a mean age of 23.38 ± 0.89 years (± standard deviation), mean weight of 80.09 ± 8.84 kg and height 175.63 ± 7.45 cm.

The study subjects were clinically healthy at the time of the effort testing, each declaring on their own responsibility (by declaration) that they are fit for exercise. During the exercise tests the subjects were assisted by skilled health personnel. In the study did not enter subjects who: have made intense effort the day before evaluation; have consumed alcohol or caffeine the day before evaluation; health problems (especially cardiovascular); age outside the range 19-30 years.

The first evaluations were: the height, the weight and arterial tension. After these evaluations, the subjects have entered the test room, where they were explained the testing protocol.

For each subject the chair height was adjusted according the individual particularities. The bike model used in this study is Vision Fitness E3200. The chair height (the distance between the highest point of the saddle and the axis center of the pedals arms) is calculated by multiplying with 0.885 the interior length of the interior member.

After the chair adjustment the cardio belt of the watch Polar RS800 is fixed, the gas mask of the FitMate PRO device and the pulsoximeter Contech WK 50D after 5 minutes of articular gymnastics.

The personal data of the subject are introduced in the FitMate device. The devices are simultaneous turned on to record the followed parameters: the heart rate, the oxygen consumption and the oxygen saturation of the blood (SpO).

The subject starts the pedaling on the Vision Fitness E3200 bike, at a frequency of 75 RPM (rotations/min.), with a load of 133W (corresponding to level 4 of the bicycle resistance), this rate was maintained for 6 minutes. It is a progressive exercise test on levels of a minute, the power increasing on each floor with 23.5W, from 6 minutes into the test.

The subject has to perform the levels maximum of which he is capable. The subject has the task of maintaining the pedaling frequency of 75 rpm for the whole duration of the test. The subject ceases the effort when they can’t keep the pace in the last landing reached.

The support on the bicycle horns is based on subjective preference, except the one on the forearms. The leg contact with the pedal is made on the sole.

Subjects were encouraged to reach the moment of exhaustion and maintain a constant respiratory rate. At the end of the test, the subject remains on the bike for 3-5 minutes to assess the return of post-exercise cardiorespiratory function.

The exercise tests were conducted at a temperature of 24°C, 33% humidity and atmospheric pressure of 751.5 mmHg in the gym of the Faculty of Physical Education and Sport, in Iaşi.

For some subjects it was difficult to reach the highest point of exhaustion throught the fact that they have accused inferior limb pain, which may be associated with lack of accommodation with cycling specific effort.

The statistical indicators are according to Tintiuc et al. (2011).
Results and Discussion

After the effort tests each subject’s charts were analyzed with the used devices software, determining the parameters at several points of the effort. Through the following figures we represent the data of the study.

Following the stress test applied, the subjects achieved a maximal oxygen consumption of 47.81 ml/kg/min (± 8.49 ml/kg/min. ± SD) (Table 1).

The individual results and the test durations are shown in Figures 1 and 2.

The Pearson asymmetry coefficient ($C_{AS}$) of the data sequence has a value of 0.43, which is a small negative asymmetry, predominantly high values of $VO_2$ max.

The homogeneity of the group is good in respect of height and age, and in the case of weight the homogeneous is average, which confers a compact group character of evaluated subjects.

Instead, between the heart rate (FC) reached in the $VO_2$ max moment and $VO_2$ max, respectively PMA is a weak correlation.

Table 1. Statistical indicators.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard deviation</th>
<th>Asymmetry coefficient ($C_{AS}$)</th>
<th>Coefficient of variation ($C_{V}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$VO_2$ max (ml/kg/min)</td>
<td>47.80</td>
<td>8.49</td>
<td>-0.43</td>
<td>17.76</td>
</tr>
<tr>
<td>Heart rate $VO_2$ max (beats/min)</td>
<td>176.12</td>
<td>8.47</td>
<td>-0.46</td>
<td>4.81</td>
</tr>
<tr>
<td>Maximal aerobic power (W)</td>
<td>351</td>
<td>51.13</td>
<td>-0.85</td>
<td>14.57</td>
</tr>
<tr>
<td>Expiratory flow $VO_2$ max (l/min)</td>
<td>125.70</td>
<td>24.72</td>
<td>-0.24</td>
<td>19.67</td>
</tr>
<tr>
<td>Respiratory frequency $VO_2$ max (resp/min)</td>
<td>45.93</td>
<td>7.31</td>
<td>0.57</td>
<td>15.91</td>
</tr>
</tbody>
</table>

Figure 1. Maximum oxygen consumption ($VO_2$-1 - $VO_2$max determined in the first test; $VO_2$-2 - $VO_2$max determined in the second test; $VO_2$ - ml/kg/min; T - min).
Figure 2. Time of exhaustion (T1 - the test moment of achieving VO2max in the first test; T2 - the test moment of achieving VO2max in the second test; T - min).

In Figures 3 and 4 we have graphically represented the FC when reaching VO2max in each test as well as the maximal aerobic power determined (PMA).

As with VO2max, FC has a small negative asymmetry (Cas = -0.46) and PMA has a pronounced negative asymmetry, which means that their high levels prevail.

Figure 3. The heart rates (FC - beats/min) in the moments of achieving VO2max1 in the first test (FC - VO2max1); VO2max2 in the second test (FC - VO2max1).
Figures 4. PMA1 - maximal aerobic power determined in the first test; PMA2 - maximal aerobic power determined in the second test; (PMA - W).

Expiratory flow (VE) and expiratory rate (FR) were represented in Figures 5 and 6. The VE data string presents small negative asymmetry, while the FR average positive asymmetry.

Figure 5. Expiratory flow at VO2max (VE1 - Expiratory flow in the moment of achieving VO2max in the first test; VE2 - Expiratory flow in the moment of achieving VO2max in the second test; VE - l/min).
By calculation a strong correlation can be observed between VO$_2$max and the time to reach VO$_2$max within the exercise test (r1 = 0.84. r1 = 0.85).

Also it shows a strong correlation between PMA and VO2max in each test (r1 = 0.80. r2 = 0.83).

VO$_2$max presents an average correlation with VE and FR. except the second test. where the correlation is medium. but lower than the others (r = 0.41).

The two tests data shows a strong correlation for VO$_2$max (r = 0.89) and MAP (r = 0.97) and the difference between the results of the subjects two evaluations was not statistically significant (p = 0.97). These things validate the proposed exercise test.

Amann et al. (2004) tested 15 riders by two progressive exercise tests (T50x3:100 W + 50W/3 min. T25x1:20W +25 W/min). The results of the two effort tests were different: 66.6 ml/kg/min and 67.6 ml/kg/min. Jeppesen et al. (2003) determined on a group of 18 healthy sedentary subjects the maximum oxygen consumption of 39.4 ± 2 ml/kg/min. 18 trained cyclists (25 ± 0.9 years. muscle mass 72 ± 1.6 kg) were tested by Monedero & Donne (2000) and it was determined a VO$_2$max of 68 ± 1.7 ml/kg/min and MAP 364 ± 9W. To a group of 31 volunteers (25.4 ± 5.2 years. 70.2 ± 8.0 kg. 174 ± 7 cm. 16.8 ± 4.8% body fat) it was determined a VO$_2$max of 52.7 ± 6.1 ml/kg/min in the research of Myles & Toft (1982). Through a cycle ergometer test and one on the field. Vercruyssen et al. (2002) determined in a group of eight well-trained triathletes (24.0 ± 3.0 years. 71.1 ± 6.5 kg and 180.6 ± 8.1 cm) VO$_2$max values of 68.7 ± 3.2 ml/kg/min. respectively 69.9 ± 5.5 ml/kg/min. Through a progressive exercise test (100W + 50W/3min) a group of 36 cyclists and triathletes (24.9 ± 5.5 years and 71.6 ± 5.7 kg) was assessed with a maximum oxygen consumption of 62.2 ± 5.0 ml/kg/min in the study by Meyer et al. (1999).

The study revealed a VO$_2$max of 47.80 ± 8.49 ml/kg/min and a MAP of 351 ± 51.13W.

It is difficult to compare the results with those of previously published research. given the difference between the groups studied and the conditions for evaluation. However. the results qualify the study group in the category of the untrained individuals. It can be observed a difference not very large between the untrained subjects PMA and that of those trained: 351 ± 51.13 W vs 364 ± 9W - Monedero & Donne (2000).
Conclusions

The group homogeneity and the strong correlations established between the VO2 max, PMA and exhaustion time validates the test statistically for our group of subjects. The proposed test can be used among untrained people to determine the maximum oxygen consumption and hence the PMA, on the Vision Fitness E3200 bike, by male subjects, aged between 20 and 30 years, able to exercise.

The proposed protocol can be validated not only through the values obtained, but also because it falls within other similar research findings. By comparing the results with those of other studies, our protocol can be considered valid.

There is the possibility of extending the evaluation sample and its characteristics and taking into account different parameters than those presented by us.

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References


