Physiological and Mechanical Methods for Designing Appropriate Training for Short – or Long – distance Competitive Swimmers

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ABSTRACT: The design of appropriate physical training involves several factors, including the need to evaluate the intensity of training. In order to identify the best training plan intervals for short and long distances in juvenile swimmers we compare the two-speed (2V) and T30 tests. We compare competitive 16 years old swimmers (n=35.22 men) that were evaluated anthropometrically and following biochemical and hematological parameters. The swimmers underwent both tests to determine the appropriate speed regime for endurance training. After speed test determination, different protocols were studied: 80x25m to 2x1000m, all over a 2.000m course. For each test and protocol, maximum heart rate and heart recovery frequency; effort perception; mechanical efficiency and lactacidemy were measured. Our results show a significant difference in speed between tests 2V (1.36±0.12) and T30 (1.21 ± 0.12). We found a difference in the lactacidemy in most of the courses, except for the 200m course. In addition to the intensity demonstration, the importance of a complementary evaluation (heart frequency, mechanical efficiency and effort perception) was demonstrated. We did not found sex difference in the studied parameters. This study showed significant differences for the evaluation tests and protocols used to training design. Our data led to conclude that the use of 2V test with 40x50m and 20 x 100m series protocols are the best to evaluate the training velocity.

Keywords: training, lactacidemy, evaluation, frequency, mechanical
INTRODUCTION

Over the last decade the concentration of bloody lactate has been used with a purpose of controlling the efficiency from the sportiest ones (BROOKS, 2001; DOMAGALA, 2001; HOLLMAN, 2001). The valorization of the prescription from the training with a base on the lactate is in the existent correlation among the lactate production, the energetic metabolism and the swimming speed. This roll is determinate by the capability from the athlete on using the metabolic via ones and anaerobic ones (HOLLMAN, 2001; JACINTA, 2000).

Since the manifestation by Fletcher & Hopkins (1907) from the formation of the lactate during the muscular contraction, the mechanisms which control the production and removal of such metabolic during the exercise has been widely studied (AVLO-NOTOU, 1996; BONIFASI, 1996; CAREY, 2001; JUEL, 2001). On low intensity of strength, the concentration of bloody lactate is near to rest, enlarging progressively during the exercise. The threshold anaerobic is the point of exercise where the lactate is gathered quickly, due to a higher production of lactate’s acid than the capacity of removal. Many times is considered the fixed threshold anaerobic is the point of exercise where the lactate is near to rest, enlarging progressively during the exercise. The valorization of the prescription from the training with a base on the lactate is in the existent correlation among the lactate production, the energetic metabolism and the swimming speed. This roll is determinate by the capability from the athlete on using the metabolic via ones and anaerobic ones (HOLLMAN, 2001; JACINTA, 2000).

During the intense exercise, the pyruvic acid and the NADH is gathered on the muscle, which result in an elevated relation NADH/NAD+, supporting the reduction of pyruvate by the lactate dehydrogenate building the lactate. The reaction feeling of enzyme is regulated by the concentration intracellular from the pyruvate, lactate and the relation NADH/NAD+ (JUEL, 2001; REILLY, 1999; SARGENT, 2002; JUEL, 2001). Most part of the lactate acid produced during the exercise is diffused out of the attained muscles the blood circulation. This way, it is possible to estimate the participation of the anaerobic metabolism on the exercise by measuring the lactate, allowing the control of the training intensity (CHEN, 1998; CUNHA, 2000; HOWAT, 1992).

The prescription from the training with bases on the lactate threshold is delimitated per regions (NISHIBATA, 1993; REILLY, 1999; SILVA, 1999). The first one is defined as that which combines the aerobic training with the anaerobic, predominance the first, where the production and the elimination from lactate maintain the metabolic in an inferior concentration of 4mM. On the second region, and with amounts of concentration above of 4mM of lactate, is observed a higher speed of production than the inveigling (GLADDEN, 1997; NISHIBATA, 1993; RUSHALL, 1998). Great part of swimming work is guided to improving the training, seeking enlarging the amount of exercises necessary to reach an umbra anaerobic. To plan suitably the control and prescription of the training, the threshold must be suitable determinate (SACADURA, 1994; VALDIVIELSO, 2000; VON DUVILLARD, 2001).

The sportive training seeks optimizing the performance from the athlete, and his evolution is linked to the capability of the usage from the energetic systems and to the competence of tolerating the high weights of work. (DANTAS, 2000; NISHIBATA, 1993; WAKAYOSHI, 1992). The aerobic endurance training has as a purpose of enlarging the aerobic metabolism contribution (COSTILL, 1991; ISSURIN, 2001; TREFFENE, 1981) allowing a decreasing lactate speed. (CUNHA, 2000; ISSURIN, 2001; KESKINEN, 1989).
On the swimming, there are used with frequency of two protocols to determine the training speed: the first proposed by Mader (1976) is a break test called two speed test (2V), which is characterized by swimming two times 400 meters, as they are 85% and 100% of personal time (NISHIBATA, 1993); and the second one, a continuous test called T30 (OLBRECHT, 1984) which consists on swimming 3000 meters in an uniform way and constant of 100% of maximum speed for the distance (BABER, 1997).

On this study, there were compared two techniques to the determination of the umbra anaerobic, based on distinct criteria, which includes the lactate (BISHOP, 2001), the physiologic answers (LAGALLY, 2002) and mechanics (SZMUCHROWSKI, 1999), besides the subjective perception from the strength by the athlete (RODRIGUES, 1992).

**MATERIALS AND METHODS**

Forty three athletes (16 years; 28 men and 15 women) from FARJ – Federation Aquatic from the State of Rio de Janeiro, federated ones from the year 2002, which followed the minimum required parameters from this Federation to standardize in state’s competitions, there were anthropometrically estimated, according to their stature, breadth, biepicondilian distance from the umero and femur, corporeal weight, cutaneous folding (chest, tricipital, subeschapular, suprailiacal, mesofemural, medium axilla and abdominal) on the raised points by Pollock and Jackson (1978) and by Faulken (1968), to the estimation from the percentage of corporeal fat. The somatotype was calculated according to a technique of Heath and Carter (1967) (CARTER; HEATH, 1990). Besides the anthropometry, the individuals were estimated hematological and biochemical regarding to: hemoglobin, hemacies, hematocrit, leukocyte, transferrine and seric iron, urea, Creatine, uric acid and cortical, glucose, insulin, alanine amine transferase (ALT), transferase amine aspirate (AST), gamma GT, cholesterol and triacilglicerol (Chart 1).

The speed determination to analyze the trainings was done using two protocols: 1) The test in two speeds (2V) by Mader (1976), which was based on swimming two times 400m, as being the first way done by 85% from the best time and the second one by 100% of maximum speed from the athletes; and 2) Test T30 by Olbrecht (1984), which is swim 3000m uniform and constantly the maximum speed from the distance, according with the following series: 80 x 25m; 40 x 50m; 20 x 100m; 10 x 200m; 5 x 400m; 4 x 500m and 2 x 1000m (2000m) (CHEN, 1998; COSTILL, 1991; GUGLIELMO, 2000; MEYER, 1988; RODRIGUES, 1992; TAYLOR, 2001; TOKMAKIDIS, 1998).

The cardiac frequency was checked rested, at the end of the activity and after three first minutes after the end of strength, using the analyzer of cardiac frequency Polar module – M 520 (Florida, USA).

The lactate was measured rested and at first, third, fifth, seventh and ninth minutes or even a higher concentration of lactate, using accusport equipment module Bereghim of analyze photo electric-enzymatic (Colony, Germany) (BISHOP, 2001; PINNINGTON, 2001).

The perception to the strength (PE) was estimated at the end of the tests (BORG, 1998).

During the task, there were measured the numbers and cycles of arms performed by the athletes (TAKEUCHI; KOKOBUN, 2000).

The results were analyzed statistically by qui-square to estimate the normal distribution from the found out related to the anthropometry, hematological and biochemical. The T test of Student was used to estimate the null hypothesis that the averages of

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M (n=28)</th>
<th>W (n=15)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cells (10^6/mm³)</td>
<td>5.4 ± 0.8</td>
<td>4.7 ± 0.4</td>
<td>4.5 to 6.5</td>
</tr>
<tr>
<td>Hematocrits (%)</td>
<td>47 ± 3</td>
<td>41 ± 3</td>
<td>40 to 50</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>15.9 ± 1.2</td>
<td>14.1 ± 0.8</td>
<td>13.5 to 18 (H) - 11.5 to 16 (W)</td>
</tr>
<tr>
<td>Leukocytes (mil/mm³)</td>
<td>6.92 ± 1.2</td>
<td>6.8 ± 1.3</td>
<td>5.0 to 10.0</td>
</tr>
<tr>
<td>Uric Acid (mg/dl)</td>
<td>4.5 ± 1.3</td>
<td>5.0 ± 1.5</td>
<td>3.4 to 7.0</td>
</tr>
<tr>
<td>ALT (U/l)</td>
<td>25.2 ± 10.0</td>
<td>20.0 ± 5.7</td>
<td>&lt; 60.0</td>
</tr>
<tr>
<td>AST (UI/l)</td>
<td>25.0 ± 8.5</td>
<td>18.3 ± 6.3</td>
<td>&lt; 45.0</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>158.4 ± 32.0</td>
<td>149.5 ± 32.1</td>
<td>&lt; 200.0</td>
</tr>
<tr>
<td>Cortisol (µg/dl)</td>
<td>13.6 ± 3.8</td>
<td>12.9 ± 3.3</td>
<td>5.0 to 25.0</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>0.93 ± 0.20</td>
<td>0.8 ± 0.2</td>
<td>0.5 to 1.5</td>
</tr>
<tr>
<td>Serum Iron (µg/dl)</td>
<td>149.6 ± 35.8</td>
<td>159.4 ± 33.7</td>
<td>50 to 200</td>
</tr>
<tr>
<td>Gamma GT (mU/ml)</td>
<td>26.6 ± 10.4</td>
<td>13.6 ± 4.8</td>
<td>0 to 30</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>86.3 ± 10.3</td>
<td>87.6 ± 8.7</td>
<td>6.0 to 110</td>
</tr>
<tr>
<td>Insulin (µU/ml)</td>
<td>13.16 ± 3.9</td>
<td>16.66 ± 5.5</td>
<td>6.0 to 27.0</td>
</tr>
<tr>
<td>Transferrin (mg/dl)</td>
<td>257.3 ± 33.8</td>
<td>261.9 ± 32.8</td>
<td>200 to 300(M) 200 to 350 (W)</td>
</tr>
<tr>
<td>Triacylglycerol (mg/dl)</td>
<td>89.1 ± 17.6</td>
<td>80.7 ± 17.5</td>
<td>40.0 to 140</td>
</tr>
<tr>
<td>Urea (mg/dl)</td>
<td>34.9 ± 5.9</td>
<td>36.5 ± 6.4</td>
<td>5.0 to 50.0</td>
</tr>
</tbody>
</table>

The blood from the male (M) and female (W) athletes was collected after 12 hours without food, seven days before the beginning of the tests for subjects’ selection. Average ± SD.
each parameter measured from the group were even, on both experimental conditions, versus the alternative hypothesis that the averages were different. The comparative analyze from the average amounts was done using the score Z, through which was estimated the existence of functional relations among the variables studied. The significant level used in all the cases was at 5% ($\alpha = 0.05$).

**RESULTS**

To determine the speed of the aerobic endurance, the tests of two speeds and the T30 were used. The 2V speed was around 12% higher than the one from T30 (Chart 2). The differences among the speed given by the tests may cause distinctions on the behavior metabolic during the training.

With a goal on investigation the differences between the mechanical efficiency during the both tests, the number and cycle of crawl stroke were measured during the training. There weren’t any differences for both parameters among the first part (85%) from the 2V test, if we compare to the T30, although they are distinct from the second part (100%) from the 2V test. These found out ones may indicate that during the first part from the 2V test, the exercise strength by the athlete is similar to the one required by the T30, although this difference is intensified after words (Chart 3).

A possible difference caused by the most relative strength from the 2v test is reinforced by the difference founded on the FcF and FcR. The FcF from the 2V test was from 6-7% higher during the second part of the test, and the FcR was around 10% more elevated when compared with the T30 (Chart 4).

The perception of strength was obtained through the interview from the athletes and estimated, according to a scale by Borg (1993). The athletes, men and women, referred to a similar strength on both tests (Chart 5).
However it is a subjective way, the PE may reflect the sensation from the athlete at the work performed. With a slight difference founded on the speed, mechanical efficiency and the cardiac performance, it is comprehensible on the strength during both tests.

To estimate the metabolic strength on both tests, the lactate was measured on distinct times on different protocols. The genesis of lactate was always superior (35-85%) on the calculated speeds by the 2V test, if we compare with the T30 of that measuring in 2 x 1000m (Graphic 1). The increment of the relation strength/rest provoked an enlargement of the lactate on both tests (Graphic 1, inset). On distinct protocols, the lactate grew up to four times, with a diminishing on the relative rest.

With an aim on measuring the efficiency among the intensities from the different tests and protocols, the obtained results were compared using the score Z. The informations has displayed that the tests and protocols with a threshold of lactate (Graphic 2). The results have displayed that the low scores were obtained by the 2V test on the protocols of 40 x 50m and 20 x 200m.

**DISCUSSION**

The training must take on considering the gesture efficient on the activity, the highest strength for the less possible energetic waist (DANTAS, 2000; VALDIVIELSO, 1998). The founding displays that, on the protocol used, as the most will be the requirements about the athlete on maintaining the intensity from the strength, the less will be the technical efficient. The suitable training comes to be so important on the maintenance of the mechanical gesture and energetic, getting a better performance.

There was observed that the threshold of lactate is related to the training intensity (COSTILL, 1991; GRAY, 2001; REILLY, 1999). Making use of the correct speed for the training from the aerobic endurance, the athlete is capable to enlarge the capacity on support the effects of the lactate acid. The lactate is so important for the prescription and estimate from the training, so this can be indicator of the metabolic strength getting better the development from the athlete of swimming (COSTIL, 1991; RODRIGUES, 1992).

The enlargement of the threshold of lactate may occur many factors, among them: a higher capacity of elimination of lactate produced and a less production of lactate for a less production happens due to an adaptive mechanism which provokes an enlargement of enzymes linked to the production of energy (VON DUVILLARD, 2001; WAKAYOSHI, 1992).

The physiological adaptations regarding to the training are specifically to the nature of the activity of training (KISKENEN, 1989; SACADURA, 1994; VALDIVIELSO, 1996). Beyond that, the more specific is the training program for the intensities of this sport, the better of the sportive development from the athlete. Related among both protocols of training are based on the threshold lactate, it was to be hopped that the different tests and protocols would reveal distinct metabolic moments from the athletes (DOMAGALA, 2001; NISHIBATA, 1993; TAYLOR, 2001). The comparison from the obtained results by the tests with a higher lactate, the 2V test was reliable than the T30 during the protocols that produced

**Chart 2 – Difference from the average speeds of swimming in the T30 and 2V tests**

<table>
<thead>
<tr>
<th></th>
<th>T30 (m.s.)</th>
<th>2V (m.s.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1.21 ± 0.12*</td>
<td>1.36 ± 0.07</td>
</tr>
<tr>
<td>Women</td>
<td>1.16 ± 0.09*</td>
<td>1.30 ± 0.07</td>
</tr>
</tbody>
</table>

The subjects swam 3000 m (T30) or 400m at 85% and 100% of the maximum individual speed (2V), conditions in which the average speed from the athletes was measured and its lactacidemy evaluated in the times: 0.60, 180, 300, 420 and 540 s. Average ± SD. *Unlike between T30 and 2V.

**Chart 3 – Recuperation and final cardiac frequencies after the tests**

<table>
<thead>
<tr>
<th></th>
<th>T30</th>
<th></th>
<th>400 (85%)</th>
<th>400 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FcF</td>
<td>FcR</td>
<td>FcF</td>
<td>FcF</td>
</tr>
<tr>
<td>Men</td>
<td>175 ± 14*</td>
<td>99 ± 13*</td>
<td>182 ± 11*</td>
<td>101 ± 8*</td>
</tr>
<tr>
<td>Women</td>
<td>175 ± 15*</td>
<td>97 ± 15*</td>
<td>180 ± 11*</td>
<td>100 ± 8*</td>
</tr>
</tbody>
</table>

The final cardiac frequency (FcF) as measured after the tests’ end and the recuperation frequency (FcR) measured after the 300s from the test’s end. Values in beats per minute (bpm). Average ± SD. *Different between T30 and 400 (100%); # Unlike between 400 (85%) and 400 (100%).

**Chart 4 – Number and cycle of strokes in the different tests**

<table>
<thead>
<tr>
<th></th>
<th>T30</th>
<th></th>
<th>400 (85%)</th>
<th>400 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NBr</td>
<td>CBr</td>
<td>NBr</td>
<td>CBr</td>
</tr>
<tr>
<td>Men</td>
<td>77 ± 6</td>
<td>39 ± 4</td>
<td>75 ± 7</td>
<td>39 ± 4</td>
</tr>
<tr>
<td>Women</td>
<td>77 ± 7</td>
<td>39 ± 4</td>
<td>77 ± 7</td>
<td>40 ± 5</td>
</tr>
</tbody>
</table>

The athletes were submitted to the different protocols when the number (NBr) and cycle (CBr) of strokes were measured in total duration of the tests. The values represent the average findings for 100m. Average ± SD. * Unlike T30 and 400 (85%) to the 400 (100%).

**Chart 5 – Measurement of the perception to the effort (PE)**

<table>
<thead>
<tr>
<th></th>
<th>T30</th>
<th></th>
<th>400 (85%)</th>
<th>400 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>18 ± 1</td>
<td>14 ± 2*</td>
<td>19 ± 0</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>18 ± 1</td>
<td>14 ± 2</td>
<td>19 ± 1</td>
<td></td>
</tr>
</tbody>
</table>

The PE was inquired in the end of the different tests and evaluated according to the Borg scale (1993). Average ± SD. * Different from 400 (85%) of T30 and 400 (100%) (p <0.05).
lactate on less concentrations (80 x 25m; 40 x 50m; 20 x 100x) (JACINTA, 2000; KEKISNEN, 1989).

The investigation, has displayed that the protocols of 40 x 50m and 20 x 100m from the test of two speeds are the most suitable ones to the prescription of the training on the displayed conditions.

REFERENCES


