73 - DETERMINATION OF TIME UNTIL EXHAUSTION IN THE CRITICAL FORCE INTENSITY

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Introduction
In cycle ergometer exercise, the relationship between power and time to exhaustion (TTE) is described by a hyperbolic model (Montani et al 1981). This term was originally proposed for use with synergistic muscle groups and has been adapted to total body work in sporting activities such as cycling (Jenkins, 1992). This model is the basis of the critical power concept (Hill 1993). With regard to total body work in swimming and running, critical velocity (Vcr/t) is defined as the speed which can theoretically be maintained indefinitely without exhaustion (Wakayoshi, 1992). In isotonic strength, to generate a force-duration (F-D) graph, a volunteer is asked to maintain different isometric force levels (e.g., using biceps muscle with elbow at 90°) for as long as possible on separate occasions. The curve shows a horizontal asymptote at about 15% of maximal voluntary contraction. This asymptote represents critical force (CF). Theoretically, forces below this value can be held indefinitely. Of course there will be unique mechanical and physiological limitations at either extreme of the F-D relation. Above CF, there is a limit to how long force can be maintained. However, for resisted exercises (dynamic force), yet there are no research determining time until for exhaustion in the intensity of the dynamic critical force.

Lactate threshold (LT) is defined as the submaximal exercise intensity that invokes a sudden and sustained increase in blood lactate concentration (Kumaga, 1982). Increased lactate acid production results from the onset of anaerobic glycolysis to supplement aerobic energy production at an individual specific exercise intensity. The associated increase in H+ with increasing lactic acid results in metabolic acidosis, a primary vehicle of fatigue. The underlying mechanics of LT clearly indicate that at exercise intensities up to the LT, where minimal energy is supplied by anaerobic glycolysis, exercise could be maintained for a prolonged period of time without fatigue.

During the accomplishment of resisted dynamic contractions, the energy can be supplied by aerobic mechanisms, since the solicitation keeps below 30% of the maximum force (1RM) (VILLIERS et al 1995). Thus, it was certain for DE AGOSTINI & BALDIESERA (2000), which lactato threshold it situates in 30% of the 1RM, intensity this enough to cause occlusion of the capillary by the elevated inter-muscular pressure (PETROFSKY, 1984). This hypoxia caused muscular accelerates for glcólise causing in the initiate of lactate accumulation (WASSERMAN etAI. 1986).

In cycling, swimming, and running, several researches demonstrated that the intensity of the speed and/or of the critical power is supplies lactate threshold, indicating how the same will not be able to be kept for a long time. Martin and Whyte (2000), determined in atletes of elite, that critical velocity was greater than the velocity of lactate threshold in swimming.

Although the aims of the investigation were not to validate Vcr/t from a theoretical perspective, the findings of the study of Martin and Whyte (2000) have resulted in the need to question the physiological meaning of critical velocity from the current definition.

Based in these data, the purpose of this study is to determine the critical force intensity and the number of repetitions made until the exhaustion of it.

Methods - Subjects
Twelve male physical education students participated in this study. All subjects were volunteers and gave their written consent to participate in these experiments. Their means standar devsiations (SD) for age, mass and height were 22.21 ± 2.48 years; 78.58±8.78 kg and 1.83±0.076cm, respectively.

Experimental protocol
All subjects performed four tests until exhaustion at the same time of the day to minimise the effects of diurnal biological variation, separated by at least 48 h, but all were completed within 4 weeks. For each test, subjects were verbally encouraged to continue for as long as possible. The subjects were considered as exhausted when they could not maintain the required speed associated with visible exhaustion. Before the tests the subjects are familiarised with the exercise procedure and with the analyses. The subjects were required to rest the day before the test and to have their last meal 2 hours before the test. These 4 tests were preceded by a standardised warm up wich consisted of 3 minutes of ergometer cycle. The test began immediatelly after this warm up All test were performed in a leg press machine where the individual must do the complete extention of knee and it was limited to 90° when it comes back. The first test was 80% of 1RM(RM, this was known from previous experience in the laboratory), the second one was 50% of 1RM, the third test was 20% of RM and the last one was the critical force. The subject might do the test until they couldn’t maintain it anymore. Heart rater(f) was determined by Polar 810i.

Determination of critical force
The critical force was determine by the exponential equation: betweenimal load intensity and reverse time until a exhaustion in the three pre-determined intensities.

Determination of lactate threshold:
Capillary blood samples were taken in rest and five minutes after the accomplishment of each test. The fingertip was cleaned with an alcohol swab,dried and then punctured with an manual lancet before 50 µl of blood was collected into a capillary tube. Blood samples were analysed for [la] in duplicate using an automated analyser (YSI 1500 Sport, Yellow Springs).

Determination of Statics:
Descriptive statistical results were expressed in terms of sample average and standar deviation (SD). Test Student was used for independent samples. In all cases, the significance level was p<0,05.

Results
The description of volunteers to variables; corporal mass, height and age, is represented in the below. The values are express for average and standard desviation. Table 1: Volunteers descriptions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Resultados</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(years)</td>
<td>22.21 ± 2.48</td>
</tr>
<tr>
<td>Height(m)</td>
<td>1.83 ± 0.07</td>
</tr>
<tr>
<td>Corporal mass (kg)</td>
<td>78.58 ± 8.78</td>
</tr>
</tbody>
</table>

The table 2 ilustrates the number of repetitions made until exhaustion in each one of four intensities tested. The values are express for average and standard desviation.

Table 2: Maximal repetitions for each exercise intensity
Like illustrated in the last table, the maximum number of repetitions until exhaustion were 14,78 5,78 to 80% 1RM; 39,44 11,63 to 50% 1RM; 206,11 136,63 to 20% 1RM and 406,27 339,51 to 18,11% 1RM. The last one is the critical force intensity.

The table 3 illustrates the lactate concentration prior and five minutes after the accomplishment of the maximum repetitions for each one of the four intensities tested. The values are express for average and standard deviation.

Table 3: Lactatemia Values

<table>
<thead>
<tr>
<th>Variables</th>
<th>80% 1RM</th>
<th>50% 1RM</th>
<th>20% 1RM</th>
<th>18,11% 1RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM</td>
<td>14,78</td>
<td>39,44</td>
<td>206,11</td>
<td>406,27</td>
</tr>
<tr>
<td>DP</td>
<td>5,78</td>
<td>11,63</td>
<td>136,63</td>
<td>339,51</td>
</tr>
</tbody>
</table>

Like illustrated in the table 3, the lactemia values were 7,48 2,78; 9,03 2,59; 6,22 2,32 e 2,65, respectively 80, 50, 20 and 18,11% (critical force) 1RM.

The graph below demonstrates the critical force for a volunteer. The value of Y represents the interception point between the intensity of the maximum force and the inverse of the time, which theoretically could be kept indefinitely without exhaustion.

Axle Y represents the intensity percentual of the maximum force, axle X represents the inverse of time for each one of the 3 intensities tested until the exhaustion.

Discussion

The purpose of this study was to determine the number of repetition made until exhaustion in the critical power intensity and, the concentration of lactate relate to each load intensity. Like demonstrated in the results, there is a reverse relation between intensity of exercise and maximal number of repetition, indicating that fatigue is accelerated when the load is increasing. However, when the lactate concentration is analysed to each percentual of maximal load, the values of lactate concentration to 50% 1RM were significantly better than the 80 and 20% of maximal force. Even if fatigue causes don’t be the purpose of this study, we know that various factors can decide the appear of fatigue during the exercise, like a acidosis. The decrease of creatine phosphatases(CP) and accumulate of inorganic phosphofosfato(Pi) appears like a main causes of acidosis during the high intensity exercise. In intensity under the threshold lactate, factors like hypertermic, dehidratisation, decrease of glycogen stores and decrease of excitability of central nervous system decide a interruption of exercise above the exhaustion.

Studies of AGOSTINI E BALDISSEIRA (2000), determined the existence of lactate threshold in load next 30% 1RM, the intensities of 80 and 50% 1RM were supra thersold, it means big possibility of acid fatigue(7,48 e 9,03 mM of lactate concentration, respectively. Lactate concentration in 50% 1RM is bigger than 80% 1RM because the longer time of glycolitic utilization. The degradation of CP in this intensity is smaller for each repetition. Westerblad et al. (2002), the speed up rhythm of CP use, increases the concentration of Pi, which speeds up the fatigue for inhibiting diverse places of the contractil process.

The lactatemia values (6,22 mM) 20% of the 1RM had been considered raised, since the intensity is placed below of the lactate threshold in resisted exercise. However the acidosis is not necessarily the agent causing of fatigue in this intensity, because in resisted contractions, more intense (80 70% 1RM) until the exhaustion, the values of lactate had placed around 9 the 12 mM (OF AGOSTINI and BALDISSEIRA, 2000).

According to HOLLMANN & HETTINGER (1989), the resisted performance in sub- threshold intensities depends to delivery intracellular oxygen, the capacity of mitocondrial metabolism and the nutrients stored in the glycogen form, as well as, the quality of the metabolic processes. Any one of these factors can have influenced the appearance of fatigue.

Another purpose of this study was to determine the critical force intensity and the number of repetitions made until the exhaustion of it. This value was 18,11% 1RM, with the number of repetitions 406,27 339,51. It is significantly bigger than 80 and 50% 1RM intensities. Differently of critical power and critical velocity, which had been supply lactate threshold (Martin and Whyte 2000), the critical force were placed below the lactate threshold, indicating that theoretically it could be kept indefinitely for a long time. However, the critical force express a mathematical equation and not a physiological phenomenon. That is why, factors related with exhaustion in intensities sub thresholds, also could be possible involved in the fatigue cause in the intensity of it.

Conclusion:

Through these results we can conclude that the critical force value is smaller than lactate threshold intensity in resistance exercise, promoting raised number of repetition until exhaustion. However for being a physiological phenomenon and not mathematician, the fatigue still is evident.

References
Moritani T, Nagata A, deVries HA, Muro M. Critical power as a measure of physical work capacity and anaerobic
Determinación del tiempo hasta la exaustión en la intensidad de la fuerza crítica

Introducción: La potencia y la velocidad críticas son conceptos fundamentales para el estudo de la fatiga e exaustión en ejercicios dinámicos no resistentes. En este estudio se analiza la relación entre la potencia y la velocidad críticas y el tiempo hasta la exaustión en la intensidad de la fuerza crítica.

Objetivo: El objetivo de este trabajo fue determinar la intensidad de la fuerza crítica y el número de repeticiones realizadas hasta la exaustión en la intensidad de la fuerza crítica. Método: Doce voluntarios de género masculino con edad media de 22 años fueron seleccionados, con una edad media de 22 ± 4.45 y un peso promedio de 78 ± 5.86 kg.

Resultados: Los valores de velocidad crítica fueron de 4.78 ± 2.78, 9.03 ± 2.59, 6.22 ± 2.92 y 2.65 ± 2.14 respectivamente para 60, 50, 20 y 11.11% (fuerza crítica) de 1RM. Conclusión: Los resultados obtenidos se pueden concluir que el valor de la velocidad crítica es menor que la intensidad del límite de la fuerza crítica, lo que indica que el número de repeticiones realizadas hasta la exaustión es menor que la intensidad del límite de la fuerza crítica.

Palabras claves: Fuerza crítica, límite de la fuerza crítica.