Identification of the Lactate Threshold and the Heart Rate Deflection Point by the Perceived Exertion Curve

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ABSTRACT

Conde JHS, Rubio TBG, Ferreira GA, Luz Coelho R, De Oliveira FR, Osiecki R. Identification of the Lactate Threshold and the Heart Rate Deflection Point by the Perceived Exertion Curve. JEPonline 2014;17(3):32-38. The purpose of this study was to identify the lactate threshold (LT) and the heart rate deflection point (HRDP) by the perceived exertion curve (DmaxRPE). Nine physically active male subjects (weight, 77.3 ± 8.9 kg; height, 177.5 ± 3.2 cm; age, 22.2 ± 2.7 yrs, and body fat, 11.3 ± 5.5%) underwent a progressive treadmill test starting at 6 km·h⁻¹ with 1 km·h⁻¹ increments every 2 min. No significant differences for heart rate (HR), values of perceived exertion (RPE), and intensity of the occurrence of HRDP, DmaxRPE, and LT were found (P≥0.05). Significant correlations of HR, RPE, and intensity of occurrence of HRDP when compared to LT were found (HR, r = 0.90; RPE, r = 0.91; and HRDP, r = 0.91; all P≤0.05). Significant correlations of HR, RPE, and intensity of occurrence of HRDP when compared to LT were found (HR, r = 0.90; RPE, r = 0.91; and HRDP, r = 0.91; all P≤0.05). DmaxRPE had low correlations with FC, RPE, and intensity of occurrence of HRDP (HR, r = 0.14; RPE, r = -0.02; HRDP, r = -0.065; all P≥0.05), and also with the LT (HR, r = 0.35; PSE, r = 0.19; LT, r = 0.036; all P≥0.05). The results indicate that DmaxRPE has only reasonable predictive power to determine the LT.

Key Words: Physiologic Transition Thresholds, RPE (Ratings of Perceived Exertion), HRDP (Heart Rate Deflection Point)
INTRODUCTION

The lactate threshold (LT) is an important method to improve high intensity performance in endurance sports, and it is widely used as an indicator of aerobic fitness in athletes. One of the most traditional and accepted methods for determining LT is the fixed blood lactate of 4 mmol·L⁻¹ (25). However, this method requires trained personnel and has a relatively high cost. Recently, alternative methods for identification of LT have been proposed, including the heart rate deflection point (HRDP) (9) and the ratings of perceived exertion scales (RPE) (10,12).

The HRDP can be identified by a visual inspection of a heart rate (HR) vs. intensity plot. However, in some individuals, it is not possible to determine the HRDP by this method alone (21). Kara et al. (13), proposed the Dmax method to identify the HRDP. They showed that the HRDP is generally found at the point of maximum distance between a linear fit – using the first and last points of this plot – and the 3rd degree polynomial fit for all the points of the same plot. Several studies have shown that HRDP can be used to estimate the LT (9,13), regardless of sex, age, and level of training (1).

Borg’s RPE is (2) a widely used psycho-physical method to identify the LT. Some studies indicate that fixed RPE values have high correlations with LT. In the Borg category-ratio scale (CR-10 scale), the suggested fixed score is 5 (27). In the 15 points scale, the values are somewhere between 9 and 12 (22). However, the use of fixed scores does not take into account individual biological variability. Fabre et al. (10) proposed to identify a RPE threshold by the Dmax method (DmaxRPE). These authors identified the DmaxRPE in similar intensities of LT and showed strong associations between HR and intensity occurrence of thresholds (10). However, their studies were conducted on a bicycle ergometer. In addition, HR and intensity of occurrence of DmaxRPE were not compared to HR and intensity of occurrence of the HRDP. To our knowledge only two studies have assessed the DmaxRPE (10,12), which used a bicycle ergometer. Thus, it appears that there are no data in the literature concerning the identification of LT by DmaxRPE and HRDP in a treadmill. The aim of our study was to find evidence of the validity of DmaxRPE to identify the HRDP and LT while using a gradual treadmill exercise protocol.

METHODS

Subjects

This study included 9 physically active males (weight = 77.3 ± 8.9 kg, height = 177.5 ± 3.2 cm, age = 22.2 ± 2.7 yrs and body fat = 11.3 ± 5.5%). All subjects were informed about the methodological aspects as well as the risks and benefits of the study. An informed signed consent was obtained from each subject. The research procedures were approved by the local Ethics Committee.

Procedures

The subjects underwent a treadmill test (Greenmaster model x-fit7, São Paulo, Brazil) starting at 6 km·h⁻¹ with increments of 1 km·h⁻¹ every 2 min until voluntary exhaustion. Exhaustion was assumed when the subjects failed to maintain a certain speed or the HR reached values of ±10 beats·min⁻¹ of the maximum predicted HR (HRpredict) using the HRpredict = 220 - age (yrs) formula proposed by Cook (7). Peak velocity (PV) was determined by the rate achieved in the last full stage. When the last stage was not completed, the PV was considered the last stage corrected (15).

Measurements

The subjects’ HR response was monitored with a portable thoracic monitor (Polar Electro Oy, FI-90440, Kempele, Finland). Blood lactate was measured with a validated portable lactometer (Accutrend Plus, Roche Diagnostics GmbH, Germany) using 25 μL of a blood sample extracted from
the right forefinger (19). RPE was measured using the Borg's category-ratio scale (CR-10), with corresponding descriptors of “nothing at all” (0) and “maximal effort” (10). Each subject was: (a) familiarized with the RPE scale; (b) instructed to incorporate muscular and central cardiorespiratory feelings into an overall perception of effort; and (c) was asked to indicate how hard, heavy, and strenuous the exercise was in a given stage (3).

Heart Rate Deflection Point (HRDP) and Rating of Perceived Exertion Threshold (DmaxRPE)
The HRDF was identified in accordance with procedures proposed by Kara et al. (13). All HR equal to or greater than 140 beats·min$^{-1}$ was plotted at each stage versus intensity (i.e., the velocity of the treadmill). A 3rd degree polynomial fit of all these points was calculated as well as a linear fit of the first and last points of this same curve. The highest difference between these two lines was a point called Dmax. The intensity in which this Dmax occurs is defined as the HRDP. The RPE threshold was identified by the power output at which the largest difference between two lines occurred; that is, the 3rd-order polynomial fit of the RPE values and the 1st-degree linear fit between the two extreme values for the RPE curve (DmaxRPE) (10).

Lactate Threshold (LT)
The LT was defined as the intensity in which 4 mmol·L$^{-1}$ was achieved (i.e., Onset of Blood Lactate Accumulation - OBLA) (23).

Statistical Analysis
The normality of data was tested using the Saphiro-Wilk test. The only parameter not meeting normality was the velocity in which DmaxRPE was achieved. Friedman's ANOVA was applied on the difference between the velocities of occurrence of thresholds. A one-way ANOVA was used to determine differences between the velocities of occurrence of HRDP, LT, and DmaxRPE. The correlation of the intensity of occurrence of these thresholds was calculated with the Spearman rank test. Correlations between HR and RPE scores occurrence of thresholds were determined using a Pearson test. All significance was set at $P \leq 0.05$.

RESULTS
No significant differences ($P \geq 0.05$, refer to Table 1) were found between HR, RPE scores, and intensity of occurrence of the thresholds (HRDP, RPE, and LT) and the percentage of HR peak (%HRpeak) and percentage of maximum intensity (%Speedmax).

Table 1. Values for HR, Percentage of Maximum Predicted HR (%max HR), Intensity (Speed), and Percentage of Maximum Intensity (%Speedmax) at the Identification Point of HRDP, RPE, and LT.

<table>
<thead>
<tr>
<th>Methods</th>
<th>HR (beats·min$^{-1}$)</th>
<th>%HRpeak</th>
<th>Speed</th>
<th>%Speedmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRDP</td>
<td>179 ± 9</td>
<td>91.8 ± 3.9</td>
<td>11.2 ± 1.9</td>
<td>82.5 ± 5.7</td>
</tr>
<tr>
<td>DmaxRPE</td>
<td>175 ± 16</td>
<td>89.7 ± 7.6</td>
<td>10.7 ± 1.7</td>
<td>79.1 ± 11</td>
</tr>
<tr>
<td>LT</td>
<td>173 ± 7</td>
<td>88.6 ± 2.3</td>
<td>10.3 ± 1.4</td>
<td>76.1 ± 3</td>
</tr>
</tbody>
</table>
The PSE values identified in the HRDP, DmaxRPE, and LT were 5.9 ± 2.1, 5.4 ± 1.9, and 4.9 ± 1.3, respectively. The speed and HR values were significantly correlated between HRDP and LT (P≤0.05). The speed and HR values were not significantly correlated between DmaxRPE and LT and between DmaxRPE and HRDP (P≥0.05, see Table 2).

Table 2. Correlation Coefficients between Two Thresholds in Each of Variables (HR, %HRpeak, RPE, Speed, and %Speedmax)

<table>
<thead>
<tr>
<th></th>
<th>HR</th>
<th>%HRpeak</th>
<th>RPE</th>
<th>Speed</th>
<th>%Speedmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRDP vs. LT</td>
<td>0.91*</td>
<td>0.87*</td>
<td>0.91*</td>
<td>0.90*</td>
<td>0.16</td>
</tr>
<tr>
<td>HRDP vs. DmaxRPE</td>
<td>0.14</td>
<td>-0.07</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.53</td>
</tr>
<tr>
<td>DmaxRPE vs. LT</td>
<td>0.35</td>
<td>0.15</td>
<td>0.19</td>
<td>0.04</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The main finding of this study was to demonstrate that the Ratings of Perceived Exertion Threshold (RPET) using the Dmax method (DmaxRPE) is found in similar intensities (speeds) of the Lactate Threshold (LT) and the Heart Rate Deflection Point (HRDP) when a treadmill incremental test is performed. To our understanding, this study is the first to use the identification of the DmaxRPE in a progressive treadmill test to compare it to HRDP.

The RPE is inexpensive and easily performed. This makes it an interesting tool for LT determination (11,17,24). Fabre and colleagues (10) proposed that the Dmax method could be applied to PSE. The method takes into account individual biological variations of the subjects, unlike the “fixed scores” method that is commonly used to determine LT (5 on CR-10 and 9 to 12 of the 15 points RPE scale) (22,27). In their work, Fabre et al. (10) reported no significant difference between the measured LT and DmaxRPE. On the other hand, they found the DmaxRPE at lower intensities of exercise compared to the LT identified by OBLA method (i.e., fixed concentration of 4 mmol·L⁻¹). The authors’ correlation coefficients were high, both between DmaxRPE and LT and DmaxRPE and fixed 4 mmol·L⁻¹ intensities (r = 0.97 and r = 0.93, respectively, P≤0.001). In our findings, the DmaxRPE was identified in similar intensities to the fixed lactate of 4 mmol·L⁻¹.

In Ferreira and colleagues’ work (12) conducted with carbohydrates, they looked at the manipulation of carbohydrates (CHO) on performance. They did not observe significant differences in the physiological variables and the scores between DmaxRPE versus LT. The correlation was significant only for the power output of occurrence in both thresholds in the control diet (r = 0.75, P≤0.05) while the low CHO diet had no association (r = 0.04, P≥0.05). This finding demonstrates that the amount of CHO in the diet has an influence on the LT.

In the studies of Ferreira et al. (12) and Fabre et al. (10), the RPE scores for LT were 3.4 ± 1.9 and 35.3 ± 11.8, respectively. However, in our study the RPE scores observed in LT were 5.44 ± 1.9. The values found for PSE scores are similar to those found in the study of Zamunér et al. (27). It is possible that this phenomenon is the related to the ergometer that was used in the different studies.
Ferreira and colleagues (12) and Fabre et al. (10) used the cycle ergometer in their studies to identify LT; whereas, the treadmill was used in the present study. Future studies with different ergometers should be performed to clarify this point.

The HRDP is a physiological variable often used in the literature. Mikulic et al. (18) found a strong association between physiological variables measured at the HRDP in rowers and LT ($r = 0.79 – 0.96$, $P \leq 0.001$). Although the method of finding HRDP intensity is still somewhat a controversial topic (5,13,15,25), it has been widely accepted as a good indicator of LT with HR and intensity at which HRDP is found being strongly related to physiological transitions (i.e., ventilatory and LT) (6). Perhaps, these discrepancies in intensities of HRDP are in part due to the diverse research protocols and the use of different ergometers. Additionally, there appears to be gender differences in the intensity of occurrence of HRDP (8). These genders difference may be associated with stroke volume due to differences in the size of the left ventricular cavity in men versus women (20).

CONCLUSION

Our results suggest that $D_{\text{maxRPE}}$ during a treadmill test has a reasonable power of identifying the Heart Rate Deflection Point and the Lactate Threshold.

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