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Transition Points of Heart Rate during a Progressive Maximal Intermittent Field Test in Young Soccer Players

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ABSTRACT

Ferreira-Junior AJ, Zanetti GG, Couto PG, Bastos LALG, Silva SF, Lima JRP, De-Oliveira FR. Transition Points of Heart Rate during a Progressive Maximal Intermittent Field Test in Young Soccer Players. **JEPonline** 2012;15(3):81-88. The purpose of this study was to identify the heart rate inflection point (HRIP) and the heart rate deflection point (HRDP) during a progressive maximal intermittent field test (TCar) in the 29 young soccer players. In order to identify the transition points, the differences of the heart rate (HR) values derived from linear and polynomial fits using all HR points were calculated. We were able to identify the HRIP in just three subjects (76 ± 1% of HR max and 77 ± 2% of Peak Velocity). The HRDP was identified in all the subjects (92% ± 2% of HR max and 84 ± 4% of Peak Velocity). The reduced number of identifications for HRIP was probably due the elevated values of HR in the first stage of TCar (149 ± 12 beats·min^{-1}). Thus, using the original TCar protocol, it is possible to identify the HRDP. However, for studies using HRIP, it should be used with a smaller initial load in the test.

Key Words Heart Rate, Transition Points, Soccer

INTRODUCTION

Given the specificity that is so important in sport assessment (3,19), there has been an increase in the use of a field intermittent graded test (TCar) to assess maximal aerobic power of soccer players (2,10,14). Carminatti et al. (5) and Da Silva et al. (9) reported the validity of a field IGT with short periods of pause (TCar) in the identification of peak velocity (PV). They also identified anaerobic threshold by the heart rate deflection point (HRDP) using visual inspection as proposed by Conconi and colleagues (7) and by second order polynomial fitting of the heart rate (HR) curve as recommended by Dmáx-Kara method (13).

Carminatti (6) showed that the HRDP during the TCar test, identified by the Dmáx-Kara method, is similar to the maximum lactate steady-state (MLSS). On the other hand, Lima (15) in a graded cycle-ergometer test, verified that it would be possible to determine a heart rate inflection point (HRIP) by a sigmoid fitting of HR curve. This point is correlated to the lactate threshold. Thus, it could be assumed that HR during a graded test shows two transition points (TP). Cambri et al. (4), using third order polynomial fit, proposed a modification in Dmáx-Kara method (13) where it then became possible to identify both HRIP and HRDP. The identification of both TP has been successfully applied in both treadmill (4) and cycle-ergometer tests (8,15).

Although the two TP have been successfully identified in different protocols in the laboratory, there are no data in the literature concerning the identification of these two TP in young soccer players using a specific IGT test. Therefore, the purpose of this study was to identify HRIP and HRDP in a progressive maximal intermittent field test (TCar) in young soccer players.

METHODS
Subjects
Twenty-nine young soccer players with at least 1 yr of regular training at the regional level were evaluated. The mean age and body fat of the subjects were 14.3 ± 1.4 yrs and 15.4 ± 6.3%, respectively. All subjects signed an informed consent, which was previously approved by the Ethics Committee of Itaúna University. The soccer players were instructed to avoid intense exercise during the 24 hrs prior to the test, and they were told not to eat solid food in the 2 hrs before the TCar.

Procedures
The assessments were divided into two steps. During the first step, the subjects' anthropometric were assessed. During the second step, the subjects were submitted to the TCar test in a grass field using soccer cleats. The assessment was done in the soccer field of the multisport Federal University of Lavras (UFLA). The temperature was 24.6 ± 2.6 °C and air relative humidity was 68.3 ± 13.1%.

Anthropometric Assessment
The subjects' body mass was determined using a digital scale Britânia®. Height was measured using a professional stadiometer Asimed®, and triceps and subscapular skinfolds were determined using the BodyCaliper®. The subjects' fat percentage was estimated using Lohman equation (16).

TCar Protocol
Before the TCar test, the subjects were submitted to 10-min warm-up that consisted of a light run and 5 min of stretching. Then, the subjects performed the TCar test, which consisted of stages of 90 sec of shuttle-run with the initial distance of 15 m completed in 12 sec (9 km·h^{-1}). The pace was controlled by a sounding beep of the SpheraPortable Server software. A distance of 1 m (0.6 km·h^{-1}) was added to the subsequent stages. Between each stage, there was a 6-sec walking pause. At the end

of each stage, HR was recorded by a portable HR monitors (Polar® S810i). Figure 1 presents the protocol of the TCar test.
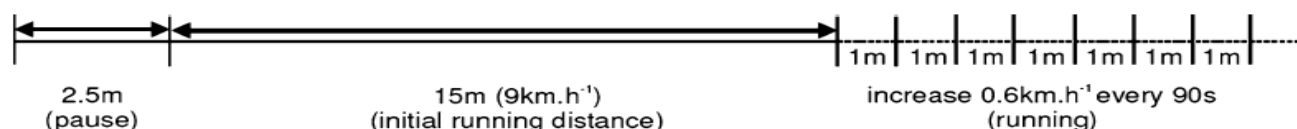

Figure 1. TCar Scheme.

Identification of the Heart Rate Transition Points

The values % of maximal HR recorded for each subject were plotted as a function of velocity (HR, beats·min^{-1} x Velocity, km·h^{-1}). The Dmáx-Cambri (4) method was used to identify the HRIP and HRDP. Briefly, the HR-velocity curve was fitted both by third-order polynomial and linear equations. The differences between the observed and fitted HR values were calculated for each stage velocity. After that, the differences were plotted as a function of velocity and the highest negative difference was considered as HRIP, and the highest positive difference was considered as HRDP (refer to Figures 2 and 3).
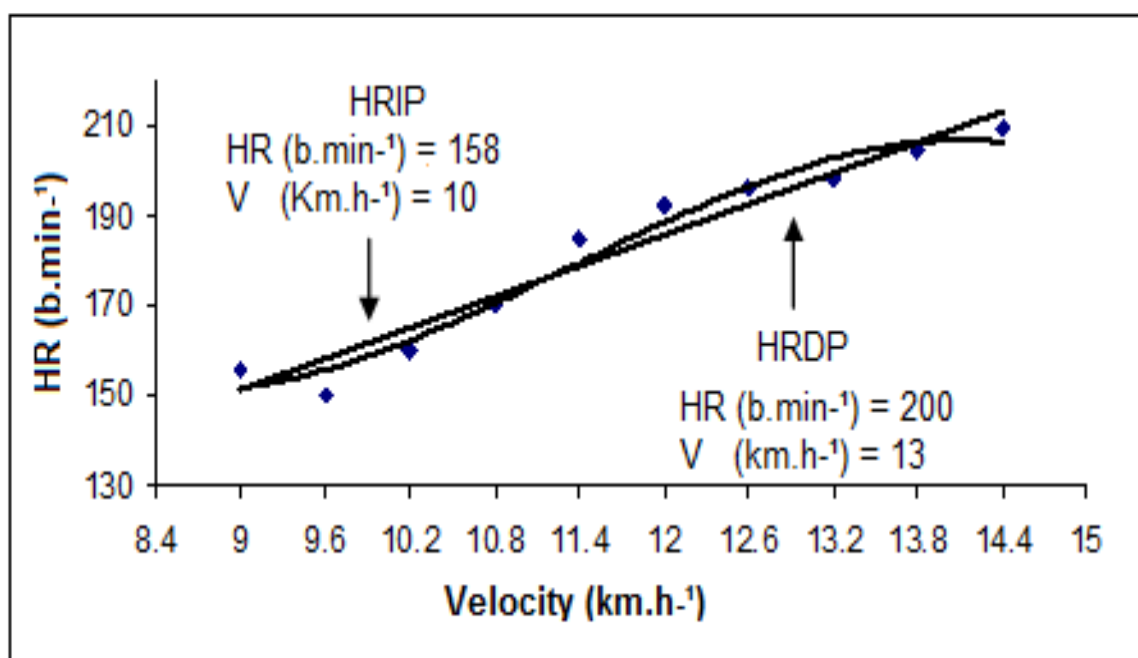

Figure 2. Example of Individual Third-Order Polynomial and Linear Fitting of Heart Rate-Velocity Curve
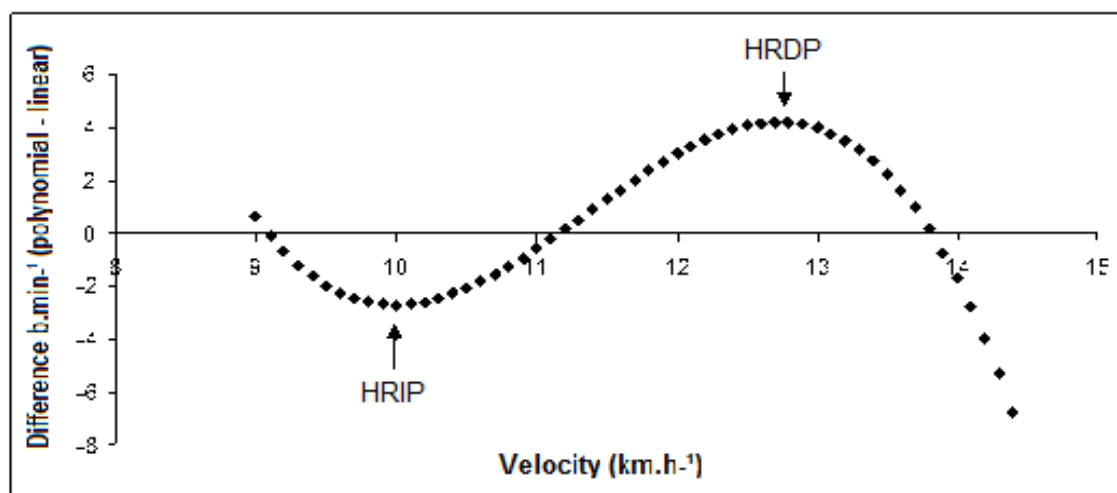
Figure 3. Example of Heart Rate Inflection Point and Heart Rate Deflection Point identification.

Statistical Analyses

The values are expressed as mean and standard deviation. The HRIP and HRDP are expressed in absolute and relative to maximum values.

RESULTS

All the subjects finished the TCar. They reached a PV of 14.1 ± 0.2 km·h^{-1} and a HR max of 200 ± 7 beats·min^{-1}, which corresponded to 97% of the maximal HR predicted for the subjects' age (220-age). The mean values of % HR max plotted as a function of the % PV and adjusted by third-order polynomial equation are presented in Figure 4. It was observed that the deflection of the curve (92%) in which PV HRDP was identified was not clearly evident with the curve inflection. Thus, the HRIP was found in only three participants (10.3%) that corresponded to $76 \pm 9\%$ of the PV and $76 \pm 2\%$ of the HR max. On the other hand, the HRDP was found in 100% of the subjects. The HRDP corresponded to $84 \pm 4\%$ of the PV and $92 \pm 2\%$ of the HR max (Table 1).

Table 1. Heart Rate and Velocity at Transition Points (Mean ± SD).

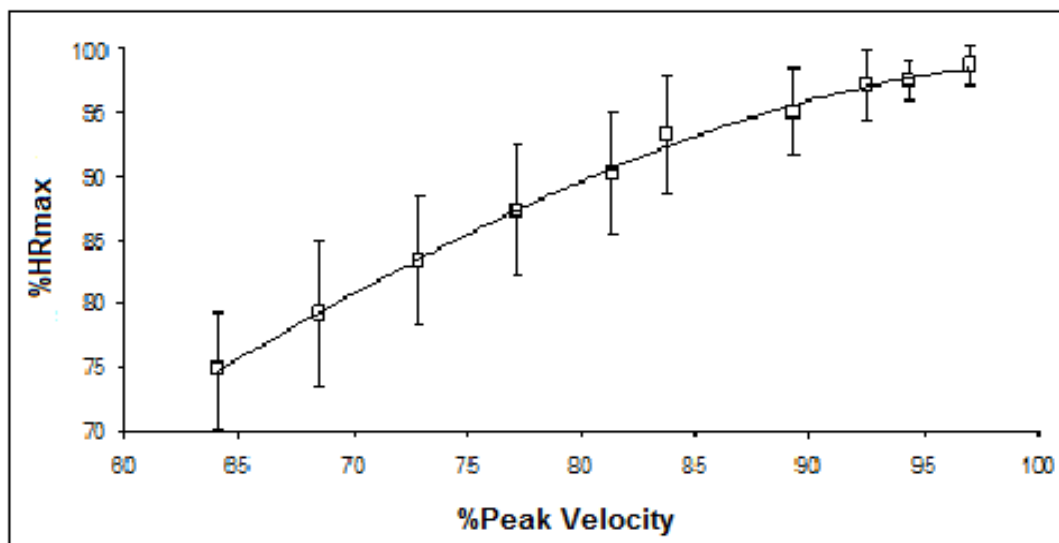|	HRIP (n=3)	HRDP (n=29)
HR (beats·min^{-1})	155 ± 8	185 ± 9
Percentage HR max (%)	76 ± 2	92 ± 2
V (km·h^{-1})	9.8 ± 1.0	11.3 ± 0.8
Percentage PV (%)	76 ± 9	84 ± 4

Figure 4. Percentage of the Maximum Heart Rate by Percentage of the Velocity Peak (Mean ± SD), Fitted by Third Order Polynomial Equation.

DISCUSSION

To the best of our knowledge, this is the first study that both HRIP and HRDP were identified in young soccer players during a graded field test. The TCar was chosen because: (a) it is a validated test for team sports; and (b) its use in assessment and prescription of aerobic soccer training. The main results are twofold. First, it was possible to identify the HRDP in all the subjects. Second, it was possible to identify the HRIP in only 10% of the subjects.

Heart Rate Inflection Point
The HRIP results in the present study are significantly different from that reported by Lima (15), De-Oliveira (10), and Costa et al. (8). They identified the HRIP in 72%, 74%, and 80% of the subjects, respectively. Lima (15) identified HRIP at 58%, De-Oliveira (10) at 74%, and Costa et al. (8) at 73% of the PV. It should be noted that the HRIP values were found in close intensities across these studies, regardless the protocol differences. It could be argued that during the initial loads of the progressive exercise there was a parasympathetic withdrawal due to the heart with a parallel increase in the sympathetic activation. This caused an alteration in the cardiac autonomic control (1) that resulted in an abrupt increase in HR (i.e., HRIP) (4).

The reason for the low number of subjects with HRIP in the present study is very likely related to the elevated metabolic demand on the first stage of the TCar test. At the end of the first stage, the subjects reached 65% of the PV and 74% of the HR max. At this intensity, most of the subjects may already have reached the HRIP. Thus, in retrospect, it is recommended that low initial velocities should be used to identify the HRIP. The problem is that there are no IGTs with low initial velocities (4).

Heart Rate Deflection Point
The HRDP was identified in 100% of the subjects at 84% ± 4% of the PV and 92 ± 2% of the HR max. These values are similar to the reported values by Carminatti (6) and Piasecki (18), using a similar protocol as applied in the present study. De-Oliveira (10) reported HRDP in 87% of the subjects. It appears that the existence of the HRDP is dependent on the action of the left ventricle as a function

of the level of catecholamines and circulating potassium. A possible explanation for the fact that we were able to find the HRDP in all subjects may be a function of their myocardial wall thickness, which may have resulted in a better cardiac efficiency in the progressive exercise test (17).

The intensity in which the HRDP was identified was similar to the values found by Carminatti (6) (78 ± 3% of the PV) and by Piasecki (18) (84 ± 5% of the PV). The %HR max of the HRDP found in the present study was 92 ± 2%, which is essentially in agreement with De-Oliveira (10) (91 ± 3% of the HR max) and Piasecki (18) (95 ± 2% of the HR max). Similarly, Carminatti (6) identified the HRDP at 88 ± 3% of the HR max. These findings support the notion that HRDP can be used as a useful tool for training prescription.

Limitation of the Study
One limitation of the present study was the lack of lactate measurement for the identification of lactate threshold (11). In future studies, lactate should be measured.

Practical Implications
It can be assumed that the HRDP is a simple index, easily identified during a progressive maximal intermittent field test. The results in this study further demonstrate the association between the HRDP and the MLSS (20), which should help stimulate the use of the HRDP by trainers and coaches as an additional tool for training control. On the other hand, the Dmáx–Cambri method (4) was not able to identify the HRIP, suggesting that the trainers and coaches should be careful when using the TCar to identify the HRIP.

CONCLUSIONS

It is concluded that it was not possible to identify HRIP during an intermittent graded test (TCar) in young soccer players, probably due the elevated cardiovascular effort during the first stage. On the other hand, the HRDP was identified in all the soccer players. Thus, using the original TCar protocol, it is possible to identify the HRDP. However, for studies using HRIP, it should be used with a smaller initial load in the test.

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