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HEART RATE RESPONSE DURING A MOUNTAIN-BIKE EVENT: A CASE REPORT

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ABSTRACT

Carpes FP, Mota CB, Faria IE. Heart rate response during a mountain-bike event: a case report. ***JEP****online* 2007;10(1):12-20. The purpose of this study was to describe the exercise intensity profile of a mountain bike (MTB) cross-country event during competition (3½ h) of an elite male highly trained cyclist in attempt to report the time of exercise spent in different zone of intensity during a prolonged exercise. An experienced elite cross-country cyclist (age of 21 years, VO_2max of 75.42ml/kg/min and HR maximal of 200bpm, power/mass ratio of 6.59 W/kg) was monitored with a hear rate (HR) monitor during a cross-country competition. The cyclist was evaluated in our laboratory two weeks before the competition. The duration of the competition was 211min and the cyclist's mean exercise intensity was 86%HRmax. The athlete was able to maintain 67 minutes (32% of the total time) of the race at an intensity >90%HRmax that was relative to exercise intensity above his individual anaerobic threshold. The intensity range of 80% to 90%HRmax was supported during 58% of the race time (122 minutes). Finally, the intensity below 80%HRmax was observed only during 10% of the race time. The HR during competition presented the larger values at the start of race and the cyclist was able to sustain an intensity superior to that observed in professional road cycling. Other studies using larger sample sizes are required to confirm the present results.

Key Words: Cycling, Exercise physiology, Endurance, Cross-country, Training.

INTRODUCTION

The monitoring of exercise performance during competition presents several limitations. In this regard, field data collection requires special technology for the evaluation and storage of the information with accuracy for a long duration, and occasionally, under adverse situations. The most accessible and primary variable monitored parameter is the heart rate (HR). It is used to establish the competitive event intensity profile (1,2,3), to analyze competitive stress and training responses (4), and to detect early overtraining, especially when used in combination with lactate curves and questionnaires (5).

The use of hear rate (HR) monitors is recognized by scientists, coaches and sports participants as a powerful tool to monitor HR during physical activity. Although there are data showing that HR measured with monitor's are accurate during numerous physical activities (6), to better explain and interpretate HR data requires that such information be related to maximal oxygen uptake (VO_2max).

Oxygen uptake (VO_2) is difficult to obtain when compared to the HR. Moreover, the VO_2 recordings during a competition often interfere with the athlete's performance. For example, when the athlete that is competing while using a portable gas analyzer the weight of the device and its discomfort can stress the athlete. To avoid this problem, a substantial number of scientific papers have been published to describe the exercise intensity based on the HR data during road cycling (7,8,9,10,11,12,13), but there are few scientific papers focusing the off-road cycling (3,14,15,16). The road cycling research shows that a high exercise intensity, related to percent of the maximal oxygen uptake (%VO_2max), is sustained for periods in excess of one hour of exercise. These data indicate that the road cyclist must possess high aerobic power as well as anaerobic capacity. Little, however, is known regarding the physiological demands of mountain-bike competition.

The mountain-bike cross-country cycling (MTB) competition is an endurance event of mass-start stage characterized by off-road circuits with continuous climbs and descents on gravel roads and field tracks. It has been an official Olympic sport since 1996 Atlanta Summer Games (3). The International Cycling Union (UCI) suggests an optimal competition winning time of 105 to 135 minutes. UCI calendar of competition includes up to 260 international cross-country competitions every year forcing the off-road cyclists to usually compete at least once a week for nine months a year, reaching a total of 30-40 competitions. Part of this competition is in the form of short stages races.

Based on the premises that the exercise intensity during field competition is of great importance for coaches and athletes as well because this information can be used for designing training plans and to monitor the performance along a season of competition, the aim of this study was to describe the exercise intensity profile of a highly trained elite cyclist during a MTB cross-country event, with a time duration of 3½ h, using HR to show the exercise intensity of a long duration competitive event. The results from an elite well-trained athlete can be useful to comparison with other athletes from same discipline and physical characteristics, as well as aggregate information about the characteristics of MTB competitive events.

METHODS

Case report

The athlete monitored is a male elite MTB cyclist with 12 years of cycling experience and seven years of competitive events. He presented no symptoms of overtraining based on previous reports from athlete like sleep characteristics, diet, effort perception, and was included among the top national rankings (4th position). Recently, he was winner of the 2006 PowerBar Reebok International Cup in the under-23 category.

His training at the time of this report covered approximately 400 km/week in track and road courses with a mean training intensity approximately 75-90% of the HRmax recorded in the laboratory. His physical and performance characteristics were above that reported for competitive mountain-bike cyclists (3,15,17) thereby endorsing his physical characteristics as highly trained (18, 19). He signed an Informed Consent Term, in agreement with the Committee of Ethics in Research with Humans of the Institution where this study was conducted.

Procedures

Prior to the competition (two weeks before), the cyclist was evaluated in the laboratory, to obtain the physiological and physical information. Body mass and height were measured using anthropometrical devices (Welmy Corp., Brazil). The body fat was measured by means of skinfolds technique (20, 21) using a skinfold caliper (Cescorf Corp., Brazil)

The athlete was asked for not training over the last 24 prior to testing. To determine the maximal oxygen uptake (VO_2max) and maximal power output, the cyclist performed a maximal cycling test on a SRM® Training Systems cycle ergometer (scientific model, SRM Science, Welldorf, Germany). During the test, the cyclist pedaled with a self-preferred cadence between 90 and 105 rpm (8,15). This choice for high cadences during the evaluation is based on previous experiences with the cyclist. He preferred a cadence of 103 rpm during a laboratory simulated 40 km cycling time-trial which is in agreement with the results of Takaishi et al (22), who showed that well-trained cyclists prefer higher pedaling rates which minimize the neuromuscular fatigue.

The VO_2max test began with an initial workload of 100W and was increased 50W each three minutes. Exhaustion was defined as the point when the athlete was no longer capable of maintaining the appropriate pedaling rate between 90-100 rpm. The highest VO_2 value obtained from the last minute of exercise was considered the VO_2max (23). The oxygen uptake during the maximal cycling test was measured breath-by-breath with a gas analyzer Vmax 229 Series (Sensor Medics, Yorba Linda, CA) that was calibrated before the session according to the manufacture recommendations. Maximal power output was determined as the highest workload a cyclist could maintain for a complete 3-min period.

Capillary blood samples to determine the lactate concentration were collected from right ear lobe before the exercise, while the cyclist remained at rest, and during the maximal test at 3 minute intervals. The blood samples were subsequently analyzed with a Biosen 5030-L (EKF, Barleben, Germany). Blood lactate data was used to determine the lactate concentration at rest and during exercise and used to determine the individual anaerobic threshold (IAT) (24) when an abrupt increase in the lactate concentration was observed during the incremental exercise. The HR was monitored every 5 s during the maximal test with a HR monitor Polar Accurex Plus (Polar Electro, Oy, Finland). The physical and performance characteristics of the athlete are listed on the Table 1.

Field data collection

The field data collection was conducted through the monitoring of HR response during the 2005 Brazilian Mountain Bike Cup (this competition had occurred in Brazil at November, 2005). The evaluated athlete was the winner in the under-23 category and had the third best time in the general classification. The course of race had one lap only, with 80 km, including three climbs with a flat and slight descendent course at the third final section. The course constituted a green grass area, mud road with hard road narrows and single-track trials. The athlete suffered no spills and does not walking or running during the race.

Table 1. Physiological and physical characteristics of the elite cyclist evaluated.

Variable	*Result*
Age (years)	21
Height (m)	1.85
Body mass (kg)	72.1
Body fat (%body mass)	6.63
VO_2max (l/min)	5.43
VO_2max (ml/kg/min)	75.42
$IAT_{\%VO2max}$(%VO_2max)	89
HR_{IAT} (bpm)	177
HRrest (bpm)	51
HRmax lab (bpm)	200
HRmax field (bpm)	188
Maximal power output (W)	475
Power/mass ratio (W/kg)	6.59
Lactate at rest (mmol/l)	1.3
Lactate max (mmol/l)	11.6

Abbreviations: VO_2max; maximal oxygen uptake; $IAT_{\%VO2max}$; %VO_2max observed at the individual anaerobic threshold; HRrest, HR measured during night sleep; HRmax field, maximal HR observed during competition; HRmax lab, maximal HR observed in laboratory.

During 20 minutes before the race, the athlete warmed-up with the bicycle mounted on a simple stationary roll. Throughout the race, the position adopted by the cyclist was characterized by a trunk inclination of ~ 75º and grasping the handlebars with elbows slightly bent, minimizing the effects of the body posture on the HR response (5). During the race the subject had adopted a similar posture.

For the duration of the race, energy replacement included 26g of carbohydrates of a commercial gel every 30 min of race and the athlete consumed about 2.5 liters of water. The total time of the race was 3h 31min, on a sunny day with temperature near 28°C. No banned substances were detected in the subject before the start of the race and the athlete was familiarized with the use of the HR monitor. The crank length used by the cyclist was 172.5 mm on a conventional crank system using Shimano clipless pedals on a Bianchi mountain-bike bicycle.

The HR was monitored every 5 s with a monitor Polar S725 (Polar Electro, Oy, Finland) throughout the race, and after the race the data were downloaded by infra-red transmission to a portable computer using the specific software (Polar Precision Performance SW, version 4.01.029, Polar Electro Oy, Finland).

Statistical Analyses

To verify the relationship between the HR and VO_2 during the maximal cycling test the Person r correlation test was applied. For the analysis of the HR storage during the race, the data were grouped and the mean of each minute presented relative to the total race duration. Based on the relationship found between the HR and VO_2 during the maximal cycling test ($r = 0.96$; $P<0.05$), the HR values were used to express four exercise intensity zones expressed as %HRmax (2,13). The four exercise intensity zones were >90%, 80-90%, 70-80%, and <70%HRmax. The time spent for each intensity zone was calculated, and the time spent above the IAT was also determined.

RESULTS

The HR recording was started by the athlete on the race start, and it was stopped at the finish line. The athlete monitored showed a HRmax of 188 bpm and a HRaverage of 173 bpm. The HRaverage was equal to 86%HRmax, corresponding to 98% of the HR at IAT, and corresponding to 85% of the maximal oxygen uptake (%VO_2max) observed at laboratory. When the time spent was analyzed related to intensity corresponding to IAT, the flowing results were found: for intensity from 50% to 75% of IAT, the time spent was 2 minutes, while for intensity from 76% to 100% of IAT the time spent was 109 minutes. Therefore, the total time with exercise intensity supported above the IAT was 100 minutes.

The analysis of the HR relative to the time at different exercise intensities based on the maximal HR at laboratory shows that the cyclist spent a long time at a HR intensity >90 %HRmax. However, throughout most of the race the intensity was between 80% and 90% HRmax, as illustrated on the figure 2.

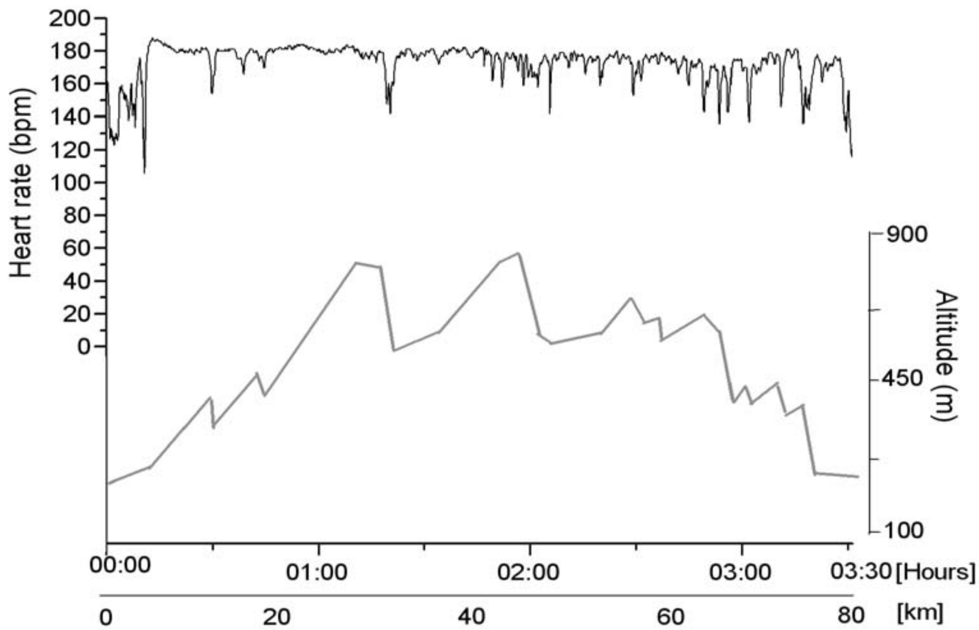

Figure 1. Subject's heart rate response in relationship to course profile.

DISCUSSION

To the best of our knowledge, this study is the first to report the exercise intensity profile of a mountain-bike race longer than 3 hours. This study profiles the exercise intensity, based on HR responses during a competitive MTB cross-country event, with special regard to an event winning time of 200 minutes. The main finding of this study was the observation of high exercise intensity maintained during prolonged time during the race. The evaluated athlete was able to maintain 100 minutes of exercise above the IAT, performing a total of 189 minutes (89%) of the race accomplished above or 10% below the IAT. For road cycling (26), during competition time trial of different categories (prologue time trial - PTT, short time trial - STT, long time trial - LTT, uphill time trial - UTT and tem time trial - TTT) exercise intensities above the IAT have been found as predominant (about 90% of total time for PTT, 70% for STT, 50% for LTT, 45% for UTT and 55% for TTT).

The method applied to study exercise intensity during cycling has been used by several researchers to describe the physiological demands during competitive road cycling (7,10,11,12,20) and off-road cycling (3). In this regard, Lucía et al (10) have reported the capacity of road cyclists to tolerate high exercise intensities close to their ventilatory threshold for approximately 60 minutes. This finding is supported by Impellizzeri et al*.* (3) who showed that most of the road race is performed at moderate to high exercise intensity.

The cyclist monitored in the present study was able to maintain exercise intensity between 80 to 90%HRmax and a significant percent of total race time (32%) at intensity above his IAT. This finding confirmed that reported by Impellizzeri et al. (3), which indicate the importance of a high aerobic power for an elite MTB cyclist.

The average %HRmax observed during the race by the athlete evaluated was 86%HRmax. It was lower than that reported for a MTB race with time close to 120 minutes (3), however, it was higher when considered that the race studied had a duration of 211 minutes. Compared with that reported by

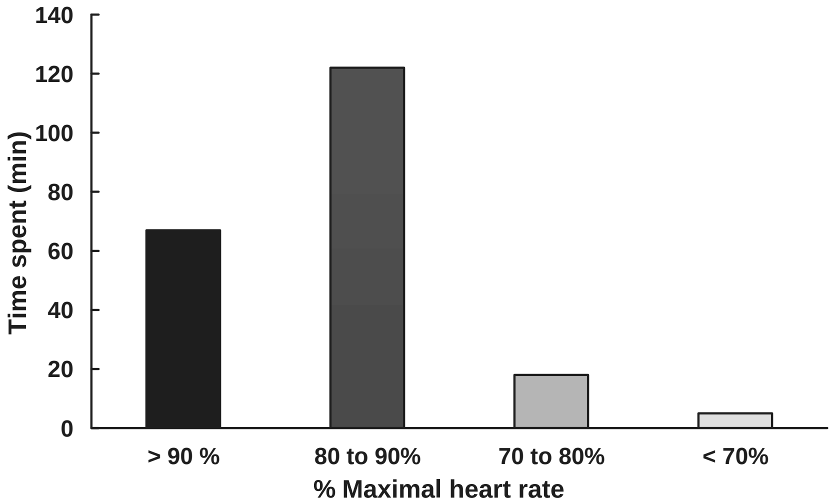

Figure 2. Percent time of race relative to intensity based upon % of maximal heart rates of >90%, 80 to 90%, 70 to 80% and

Padilla et al. (13) for long stages of road cycling of professional cyclists, the %HRmax attained was higher than that reported by this author. Padilla et al. (13) comment about an inverse relationship between exercise intensity estimated using average HR and %HRmax values and the duration of a road time-trial. The cyclist monitored in the present study was capable of maintaining exercise intensity near that expected during a short time-trial of 20 km (12). To explain this observation, the fact that the cyclist is younger and started competitive cycling at 14 years old, it is not unreasonable to assume that could be a reason for a higher muscle efficiency or adaptation to training.

Exercise intensity was not fairly reflected by the average race speed in competitive road cycling time trial (26). These authors refers that markers as %HRmax or the time distribution in relation to the different metabolic zones described using the heart rate at lactate threshold or on-set of blood lactate accumulation seemed to me more accurate indicators of the physiological demands of this cycling competition. The registered values of heart rate from time trial competition are related to time of race, with the short races presenting highest heart rate (26). Regarding MTB events, it was observed (3) that well-trained athletes present heart rate of 192 ± 5 bpm (89 ± 3%HRmax, 84 ± 3%VO_2max) for competition with 33 km (133 ± 10 min), 191 ± 6 bpm (88 ± 2%HRmax, 82 ± 3%VO_2max) for 40 km competition (165 ± 11 min), 192 ± 8 bpm (91 ± 2%HRmax, 86 ± 2%VO_2max) for 31.2 km competition (142 ± 4 min),, and 189 ± 7 bpm (90 ± 3%HRmax, 84 ± 3%VO_2max) for 33.1 km competition (148 ± 14 min). In comparison to the athlete evaluated in the present case report, it is observed an exercise intensity of 86%HRmax during competition with 80 km (211 min).

When 14 male healthy recreational cyclists participating in a cycling-touring event the HR was measured (25). The monitoring was performed during the Ötztal Radmarathon 1999 with the distance of 230 km. The mean race time of 10 h 14 min was performed with HRmax of 188 bpm and the average valued of the measured HR was 145 bpm. Classifying the HR values according to metabolic zones of recovery (HR < 70% of HRmax), moderate aerobic (70-80% HRmax), intense aerobic (80-90% HRmax), and anaerobic (HR > 90% HRmax) was observed that the athletes spent 18.5% of total race time within recovery zone, 28% within moderate aerobic, 39.5% within intense aerobic, and 14% within anaerobic zone.

As reported by Impellizzeri et al. (13), the higher HR was observed at the start stage of the race. In cross-country events it is expected, because the start has a fundamental importance to the race strategy. Commonly it is observed that the athletes try to gain the front position to avoid slowing down when the road narrows and therefore enter in the single-track trails in a good position because on these tracks overtaking can be difficult. Physiologically, one of the reasons for the higher HR at the start of the race is related to the increase in the activity of sympathetic system. There is a raise in secretion of substances such as the adrenalin and corticoids, which induces the increase of the HR. (21). Also, this fact confirms the empirically supposition of coaches and MTB athletes about the cross-country as a intense activity for which an effort near of maximal is necessary at the start of the race, as shown by Impellizzeri et al. (3) and supported by the results present in the present paper.

The exercise intensity of cross-country lasting more than 2 hours is similar to time-trials lasting no more than 70 minutes, e.g., on the MTB races of long duration the cyclists are able to maintain exercise intensity similar to that sustained by a road cyclist during a race with less time. It suggests that factors other than duration of the event may influence exercise intensity during cross-country events (3), indicating that the cross-country cycling is a sport with a physiological demand higher than that required for the road cycling. This difference may be explained by the higher rolling resistance due the relative lower speed, larger tires, bad terrain conditions and continuous climbs and descents on the cross-country competitions (12). Moreover, intense and repeated isometric contractions of arm and leg muscles are needed to absorb shocks and vibrations due the terrain, and for bike handling and stabilization. The higher HR observed during exercise with isometric force may be one of the causes of the higher average HR in off-road compared to on-road cycling (28).

Heart rate monitoring remains as an important tool to training. It can be combined with the use of power output sensors to prescribe and describe the exercise intensity. Accordingly, the use of HR monitors remains the most accessible tool for athletes and coaches to provide information of field situations. As discussed by Boulay et al. (29) and Impellizzeri et al. (3), during a prolonged exercise, HR is linearly related to VO_2 whereas power output is not. This fact suggests that HR is a better indicator of exercise intensity during endurance training and competitions compared with the power output. Consequently it is also a useful tool for pace strategy (30). The HR information during competition and the power output during training is a good combination of tools to better explore the physiological responses of the athlete in preparation for competitive events. Jeukendrup and Van Diemen (5) suggest that during exercise the power output may be a better indicator of the former and HR may, under many conditions, be a better indicator of the latter.

The methodology applied on this study had limitations, as the environmental temperature, hydration status and the glycogen depletion were not monitored and controlled, however, it is expected that the error was small, since that experienced cyclists are generally adept at maintaining a proper nutritional profile level of hydration during a race (31) which minimizes increases on the body temperature and HR.

CONCLUSIONS

The exercise intensity related to %HRmax observed on this study on the MTB cross-country cycling present values above the observed on professional road cycling. This finding lends support to the belief that cross-country events present higher exercise intensity compared to available in the literature referring to road cycling. The athlete monitored, an elite MTB cyclist, presented physical and performance characteristics above the observed on elite road and MTB cyclists, being able to maintain near of 100 min of exercise above the IAT and a average intensity corresponding to 86%HRmax during 211 minutes, showing a notable physiological and physical capacity that may be related to the age which the athlete starts to participate on competitive events. Further studies, using larger sample sizes and different competition times, are needed to confirm the present results.

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