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Comparative Biochemistry and Physiology, Part A 146 (2007) 375–380
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Determination of the anaerobic threshold and maximal lactate steady state speed in equines using the lactate minimum speed protocol

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Received 7 September 2006; received in revised form 13 November 2006; accepted 14 November 2006
Available online 22 November 2006

Abstract

Maximal blood lactate steady state concentration (MLSS) and anaerobic threshold (AT) have been shown to accurately predict long distance events performance and training loads, as well, in human athletes. Horse endurance races can take up to 160 km and, in practice, coaches use the 4 mM blood lactate concentration, a human based fixed concentration to establish AT, to predict training loads to horse athletes, what can lead to misleading training loads. The lactate minimum speed (LMS) protocol that consists in an initial elevation in blood lactate level by a high intensity bout of exercise and then establishes an individual equilibrium between lactate production and catabolism during progressive submaximal efforts, has been proposed as a nonfixed lactate concentration, to measure individual AT and at the same time predicts MLSS for human long distance runners and basketball players as well. The purpose of this study was to determine the reliability of the LMS protocol in endurance horse athletes. Five male horses that were engaged on endurance training, for at least 1 year of regular training and competition, were used in this study. Animals were submitted to a 500 m full gallop to determine each blood lactate time to peak (LP) after these determinations, animals were submitted to a progressive 1000 m exercise, starting at 15 km h^{-1} to determine LMS, and after LMS determination animals were also submitted to two 10,000 m running, first at LMS and then 10% above LMS to test MLSS accuracy. Mean LP was 8.2±0.7 mM at approximately 5.8±6.09 min, mean LMS was 20.75±2.06 km h^{-1} and mean heart rate at LMS was 124.8±4.7 BPM. Blood lactate remained at rest baseline levels during 10,000 m trial at LMS, but reached a six fold significantly raise during 10% above LMS trial after 4000 and 6000 m ($p<0.05$) and ($p<0.01$) after 8000 and 10,000 m. In conclusion, our adapted LMS protocol for horse athletes proposed here seems to be a reliable method to state endurance horse athletes LT and MLSS.

Keywords: Aerobic power; Athlete horse; Endurance race; Exercise

1. Introduction

Blood lactate based anaerobic threshold (AT) and maximal lactate steady state speed (MLSS), that are defined as the break point on the curve of blood lactate *vs.* workload during incremental exercise (Mader and Heck, 1986) and the maximal effort intensity that induce blood lactate concentration increases up to 1.0 mM (Heck et al., 1994) respectively, are said to be accurate parameters to modulate training loads as well as monitor the level of aerobic fitness resulting from training program (Dwyer and Bybee, 1983; Kohrt et al., 1989). MLSS has also been reported in literature as a good index of endurance events performance predictor in human athletes in a variety of modalities like running (Bacon and Kern, 1999), swimming (Ribeiro et al., 2003), cycling and rowing (Beneke and von Duvillard, 1996). There are several available protocols in literature to determine AT, based on blood lactate increase in response to progressive loads; however, all of them have been developed for human athletes (Farrell et al., 1979; Stegmann

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1095-6433/$ - see front matter © 2006 Elsevier Inc. All rights reserved.
doi:10.1016/j.cbpa.2006.11.002

et al., 1981; Heck et al., 1985; Weltman et al., 1990). Tegtbur et al. (1993) have proposed a protocol based on the individual lactate production and removal equilibrium, the so-called lactate minimum speed (LMS) that was defined as the velocity at which a curve fitted to the U-shaped blood lactate data derived from the incremental test that determines AT and MLSS at the same time.

Despite traditional horse races that took place at jockey clubs for a long time, endurance horse events have become in the last decades a popular event all around the world, with its own world championship. Through this point of view, the exact determination of AT and MLSS is extremely important for endurance athletic horses, which may be submitted involuntarily to extenuating efforts of up to 160 km, with average speeds that can reach 15 km h^{-1} in international competition, sometimes leading to exhaustion levels of fatal consequences. In order to be useful to trainers the protocols for AT and MLSS determinations have to satisfy some opposing conditions. The methodology and the measurements used have to be simple, easy to use, and inexpensive, and at the same time able to generate reliable information about the dominant energy metabolism during physical exercises at different intensity levels. The Heck protocol (1985) has been used with horses for some time already. This protocol determines the onset of blood lactate accumulation (OBLA) based on a fixed lactate level of 4.0 mM. On the other hand the reference level for lactate in LMS protocol, which has been previously applied in humans and rats (Tegtbur et al., 1993; Voltarelli et al., 2002), but not in horses yet, does not state a fixed blood concentration. In opposite, LMS protocol states a dynamic equilibrium between lactate production and removal, and in humans it is thought to reach more individual and accurate results. The purpose of this paper was to standardize the LMS protocol for horse athletes and evaluate its effectiveness in AT and MLSS determination in endurance horses, in order to better state an individual metabolic parameter for training and performance effectiveness. Our hypothesis is that the LMS protocol proposed for humans could be adapted to endurance horse use to determine their individual MLSS. We gave high priority to individual treatment both in the methodology and interpretation of results when adapting this originally human protocol to horses.

2. Material and methods

2.1. Subjects

Five male horses (Table 1) with endurance training and competition history ranging from 1.5 to 7 years, were ridden by their owners on a 1200 m long, field track (grass surface), marked every 200 m. We used the owners, who were also the habitual riders of these horses, to eliminate those extrinsic variables related to the psychology and the biodynamic of horse/rider pairs, which can cause considerable variation in the results. In this manner these parameters can be applied to real competition conditions. This study was approved by the Biology Institute of the Campinas State University ethical committee and all horse riders signed a written consent statement where they were fully informed about all the risks the procedures could imply.

Table 1
Horse characteristics, concentration and time to lactate peak (LP)

Horse	Breed	Age (years)	Sex (S–G*)	Weight (kg)	LP (mM)	Time to LP (min)
01	Arab	7	G	390	8.5	9
02	Arab	6	S	400	13.4	15
03	1/2 Q.H.	10	G	445	7.3	1
04	Anglo Arab	12	S	410	8.7	3
05	Anglo Arab	9	G	510	7.7	1
Mean±SD		8.8±2.3		431±48.7	8.2±0.7	5.8±6.09

(*S: stallion/G: gelding).
LP – lactate peak.

2.2. Exercise protocols and diet

All exercise trials were done with a rest interval period of 36 h, to avoid tests intercourses. Horses were fed *ad libitum* according to their normal meal schedule, which was composed by 1.5 kg specific Purina horse chow twice a day approximately and a bunch of hay mixed with green stuff three times per day.

2.3. Lactate time to peak (LP) determination

The first modification made in the original human protocol was the utilization of a 500 m full gallop run to induce blood lactate level increase which then allowed the determination of lactate accumulation and removal kinetics. This run was preceded by a warm up session, which consisted of a 10-minute walk, followed by a 5-minute trot and a 1-minute canter. After the warm up and the full gallop, lactate level was determined with disposable reactant strips using a portable Accutrend® lactate meter (Fell et al., 1998). Blood samples were collected from the jugular vein with a needle and syringe, without local anesthesia or shaving and immediately applied to the reactant strips. Animals were held by their own riders by the bridle, close to the bridoon during blood sample collection. These measurements were done using samples collected, at rest, immediately after the end of the 500 m gallop run and each 1-minute regular intervals until blood lactate concentration returned near baseline values, what was about 20 min after the effort ended, with the horse remaining at rest during this period, while the rider stood down the horse all the time, allowing LP determination. LP time was used to determine the time at which horses were going to start the incremental submaximal efforts.

2.4. Incremental exercise protocol

After another 500 m full gallop run was made, lactate level measurement was conducted at the LP instant previously determined for that horse. This was then called the pre-test (PT) lactate level. This was followed by a series of consecutive