Effect of Three Kinds of Severe Repeated Exercises on Blood Lactate Concentrations in Thoroughbred Horses on a Treadmill

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The purpose of this study is to examine the effects of various rest periods during intermittent exercise with respect to blood lactate concentrations in Thoroughbred horses. Four Thoroughbred horses each underwent three types of intermittent exercise program and blood lactate concentrations during the exercise, which was carried out on a 7% inclined treadmill, were measured. The intensity of each bout was set at 116% HRmax for 50 sec. Each program comprised three bouts separated by rest periods set at either 2, 5 or 15 min. Blood lactate concentrations during the second and third bouts increased approximately 6 mmol/l in the 15-min intermittent exercise program, but almost no changes were observed during all bouts in the 5-min intermittent exercise program. By contrast, blood lactate concentrations decreased during bouts in the 2-min intermittent exercise program. It is considered that this suggests more lactate in muscles was oxidized to supply energy in the 2-min intermittent exercise program than in the other two exercise programs. It is therefore suggested that a 2-min intermittent exercise program more effectively stimulates the lactate oxidation system in Thoroughbred horses than do programs with longer rest periods.

Key words: intermittent exercise, lactate, rest period, Thoroughbred

Blood lactate concentration has been widely used in field training as an indicator of training intensity and performance [3, 12]. It is important to consider the accumulation of lactate in muscles in order to improve the performance of Thoroughbred racehorses. Lactate is produced in the process of glycolysis with high intensity exercise. However, lactate is more important as an indicator of aerobic capacity, such as VLa4 (velocity at a lactate concentration of 4 mmol/l) and LT (lactate threshold), than as an indicator of anaerobic capacity. It is thought that energy in Thoroughbred horses during races is primarily produced in the aerobic metabolism. Eaton et al. [4] states that approximately 70% of the energy that is required to run 1,000 m is provided through the aerobic metabolism.

It had been thought that most lactate passed the cell membranes by diffusion and was metabolized in the liver after exercise. But recently, it becomes clear that dissociated lactate needs a transporter at a physiological pH to pass thorough the cell membranes, and is the substrate, which is metabolized to produce aerobic energy during exercise in muscles with a high aerobic capacity like Type I fibers [2, 7]. Therefore, it is important for horses to have many oxidative fibers that can readily metabolize lactate in order to alleviate the accumulation of lactate and maintain running speed for extended periods. In order to achieve this, it is thought to be important to provide training that increases the ability of the muscles to oxidize lactate.

Interval training, in the broad sense (including intermittent training), is recommended for humans for the purpose of increasing both speed and endurance [1]. In a sense, a type of interval training is used in conventional training for racehorses. But few detailed study for rest periods of interval training has been in
Thoroughbred horses. The report by Harkins et al. [5] is one of the few studies that have assessed the effects of interval training in terms of blood lactate clearance. In their study, there was a significant decrease in lactate levels at 1,000 m running after the interval training, but not conventional training.

In this study we have measured blood lactate concentrations in Thoroughbred horses during intermittent exercise in order to investigate the effects of the rest periods on lactate metabolism.

**Materials and Methods**

**Horses**

One 6-year old and three 5-year old male Thoroughbred horses were used in this study (body weight; 460.3 ± 15.3 kg). They had been previously acclimated to high speed treadmill exercise and had been in training for two months. Training was underwent 5 days/week on a treadmill inclined at 7%. The maximum heart rate (HRmax) of each horse was measured 1–2 weeks prior to the study. To measure HRmax, each horse underwent an incremental test in a treadmill with a 7% slope until the point of maximum exertion was reached. The intensity of each intermittent exercise bout was set at 116% HRmax and was determined on the basis of the HRmax test result. Immediately prior to the commencement of the intermittent exercise, a catheter was inserted into the right jugular vein for continuous blood sampling during exercises.

**Exercise**

The horses performed warm-up exercises on the treadmill (Kagra, Mustang 2200). The exercises comprised walking at 1.7 m/s for 1 min (0% inclined), trotting at 3.5 m/s for 5 min (0% inclined) and walking at 1.5 m/s for 5 min (7% inclined). The speed of the treadmill was then rapidly increased to obtain 116% HRmax (approximately 14 m/s). The horses galloped at this speed for 50 sec (bout). After the bout, the speed was immediately decreased to 1.5 m/s to allow the horses to walk (rest). Three exercise bouts were done in each test. All horses performed three intermittent exercise programs, each program having a different rest period: 2-, 5-, and 15-min intervals. Each horse undertook the three programs in a random order. After the third bout in each program, the horses walked on the treadmill for 15 min at 1.7 m/s (0% inclined) (Fig. 1).

**Measuring lactate and heart rate**

Blood samples were taken at before study, the end of each bout, and at 1, 2, 5, 10 and 15 min following the commencement of each rest period (or until the end of the rest period). Each sampling procedure was carried out in less than 10 sec. The blood samples were immediately cooled with ice, and the whole blood lactate was measured (YSI 1500 sport) within 6 hr of collection. Heart rates were measured during exercise by a HR monitor (POLAR Accurex plus).

**Statistic Analysis**

An analysis of variance was performed using the model: lactate level=individuals/type of intermittent exercise. When significant differences were observed, a Scheffe’s multiple comparison test was performed. Significance was set at p<0.05. The statistical software was Statistical Analysis Systems.

**Results**

In all tests, the peak heart rates of the third bout were higher than those of the first and second bouts. However, the peak heart rates were not different in all tests (Fig. 2). Blood lactate concentrations increased in the second and third bouts of the 15-min intermittent exercise program (from 3.76 to 6.02 mmol/l, from 3.84 to 6.38 mmol/l, respectively: Fig. 3). They did not change in the second or third bouts of the 5-min
intermittent exercise program (from 9.46 to 9.70mmol/l, from 11.94 to 11.36mmol/l, respectively; Fig. 4). By contrast, they decreased significantly in the third bout of the 2-min intermittent exercise program (from 13.39 to 10.43mmol/l: Fig. 5). In addition, peak blood lactate concentrations following each bout in the 2-min intermittent exercise program were higher than in those of the other two programs.

**Discussion**

Major result of this study was the difference of lactate concentration during second and third bouts between three tests. In this study the energy that was required for a single bout was the same for all three bouts in all tests, as they were all conducted at the same speed and over the same distance. However, the changing pattern of blood lactate concentration in the second and third bouts was different between tests. In other words, the amount of accumulated lactate during the third bout of the 2-min intermittent exercise program was lower than that in the third bout of the 15-min intermittent exercise program.

This can be explained as follows: If the aerobic system is activated by a workload, more of the aerobic system is recruited in the next bout. It was supported by the result that peak heart rate increased at third bouts.
in all tests. Therefore, energy production by means of the glycolytic system might decrease during the next bout. In the next and following bouts, aerobic exercise is performed using the lactate that has accumulated in muscle as a substrate [2, 7]. This further enhances lactate metabolism in the body. It is considerable that the decrease in blood lactate concentrations during the bouts in 2-min intermittent exercise is because the rate of lactate metabolism exceeds the rate of lactate production.

In the 2-min intermittent exercise program, blood lactate concentrations increased following the third bout. It is therefore possible to hypothesize that the blood lactate concentrations decrease because of the time it takes the lactate to move from the muscles to the blood. However, this hypothesis can be refuted because the increase of blood lactate concentration following the third bout is too small in comparison to the intensity of the exercise, and there are no factors particularly preventing lactate moving into the blood during the exercise. In humans, diffusion and carrier-mediated transport have been discussed as a means of lactate clearance from muscle to blood [8]. Today, carrier-mediated transport by means of monocarboxylic acid transporter in humans has become established theory. In horses, Koho et al. indicated that the horses had at least two kinds of monocarboxylate co-transporter isoforms. However the transport mechanism of lactate across the cell membrane is not yet fully understood [11]. In this study, we did not measure the direct evidences of the increase of lactate oxidation. The more experiment like a 14C-lactate tracer experiment will be needed to confirm this theory.

During exercise, lactate is metabolized primarily in muscles [6]. The lactate that is produced in muscle fibers with a high glycolytic capacity is metabolized in muscle fibers with a high oxidative capacity. Compared to other horse breeds, Thoroughbreds have many typeIIa muscle fibers, which are capable of high levels of contraction and oxidation [10]. This characteristic is advantageous for lactate production and metabolism. In addition, high lactate oxidation capabilities during exercise will naturally reduce the accumulation of lactate. Thus it is thought that an exercise pattern that stimulates the lactate oxidation process is an effective training method for energy production over a short time span, such as during a race.

Several reports state that peak lactate levels in horses decrease after adequate training [9]. However, Harkins et al. [5] states that horses trained by conventional methods have lower peak lactate levels than horses that undergo intermittent training. When applying interval training it is necessary to closely examine the horse’s capacity to buffer lactate, as well as its aerobic capacity. In Japan, time and facilities for racehorse training are limited. In addition, excessive overloading may cause illness or damage in the locomotor system. Therefore, interval training is suitable for Thoroughbreds as it allows for a low peak workload and a high overall workload.

This study examined how different rest periods influence blood lactate concentrations. It would be considered that the 2-min intermittent exercise program promotes lactate metabolism and stimulates the lactate oxidation system in Thoroughbreds more than the 15-min intermittent exercise program does.

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References


