Journal of Equine Veterinary Science 33 (2013) 586-589

Journal of Equine Veterinary Science

journal homepage: www.j-evs.com

Original Research

Heart Rate, Net Cost of Transport, and Metabolic Power in Horse Subjected to Different Physical Exercises

Giuseppe Piccione DVM, Vanessa Messina DVM, PhD, Marilena Bazzano DVM, Claudia Giannetto DVM, PhD, Francesco Fazio DVM, PhD

Department of Experimental Science and Applied Biotechnology, Laboratory of Veterinary Chronophysiology, Faculty of Veterinary Medicine, University of Messina, Polo universitario dell'Annunziata, Messina, Italy

ARTICLE INFO

Article history:
Received 4 April 2012
Received in revised form
10 September 2012
Accepted 19 September 2012
Available online 13 November 2012

Keywords:
Horse
Physical exercise
Heart rate
Cost of transport

ABSTRACT

Considering that workload can also be expressed in terms of estimated net transport cost (COT), the metabolic energy needed to transport unit mass of animal unit distance, the aim of our study was to describe the heart rate (HR), COT, and the total metabolic power requirement per kilogram (P) during different exercises (aerobic, anaerobic, and aerobic—anaerobic exercises). On the basis of their attitude, 25 horses, divided into five equal groups, traveled a distance of 6,000 m, walking at 100 m/min in a horse walker (group A); performed 20-minute treadmill walk at 130 m/min, average speed up gradient of 5% (group B); performed a 700-m-long show jumping course with 13 fences (group C); traveled a distance of 2,100 m galloping at a speed of 700 m/min (group D); and traveled a distance of 2,000 m trotting at a speed of 660 m/min (group E). On each horse, HR was continuously recorded by means of an equine HR monitor. COT was calculated with the following formula: (HR − 35) kg^{-1} m^{-1} 10^3; P was calculated applying the formula: (HR − 35) min^{-1} kg^{-1}. COT and *P* values, estimated from the mean HR, measured continuously during each experimental condition showed no linear relationship with HR and speed. The use of combined weight of horse and tack (group C and D) and horse, tack, and sulky (group E) statistically changed the results of formula application. COT and P change in different exercises and provide additional information about performance in athletic horses.

1. Introduction

The horse is an extraordinary athlete that has an ability to perform physical activities, both running and jumping, at a level that exceeds that of most other animals of similar body size. This superior athletic ability is attributable to their high maximal aerobic capacity, large intramuscular store of energy substrates, ability to increase oxygen-carrying capacity of blood, efficiency of gait, and thermoregulation [1]. Exercise creates a need for efficient use of all the physiological systems of the horse's body [2]; in fact, complex and integrated responses occur to allow muscular contraction while maintaining organism homeostasis. These responses include a large increase in flux of substrate, the oxidation of which depends on a nearly constant supply of oxygen. Increased oxygen delivery to muscle is achieved through increases in minute ventilation, alveolar ventilation [1], and rate of blood flow to tissues, which is largely regulated by heart rate (HR, heart beats per minute). HR in turn is driven by oxygen and carbon dioxide levels in the blood [2]. Increases in values of these variables with exercise are roughly dependent on the relative intensity of exercise itself [1]. Different studies on mammals, including horses, have shown that the total

Corresponding author at: Giuseppe Piccione, DVM, Department of Experimental Science and Applied Biotechnology, Laboratory of Veterinary Chronophysiology, Faculty of Veterinary Medicine, University of Messina, Polo universitario dell'Annunziata, 98168 Messina, Italy.
E-mail address: giuseppe.piccione@unime.it (G. Piccione).

0737-0806/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jevs.2012.09.010

energetic cost of transport (COT) per unit distance is a constant that is independent of speed, but that falls with increasing body weight [3,4]. A curvilinear relationship between speed and energetic expenditure of locomotion has been previously showed by Hoyt and Taylor [5]. Afterward, Wickler et al. [6] demonstrated that when horse was free to choose the trotting speed, the selected speed produced the minimum cost of locomotion. Moreover, Roberts et al. [7] provided some evidence that metabolic cost of locomotion is closely correlated with the rate of force production and hence stance time [4,8]. For this reason, many studies have described horse physiological and energy responses to exercise on treadmill [4] or track [9]. However, few studies [3] dealt with how the COT per unit distance and total metabolic power requirement per kilogram (P) change when a horse is subjected to different workloads directly in the field. Different parameters have been used to measure the energy expenditure of locomotion. Among these, HR has been monitored to allude to energy cost in terms of rate of oxygen consumption (VO_2). In fact, VO_2 is an indirect measure of metabolic rate that can be converted to rate of energy expenditure, although this requires additional assumptions concerning the metabolic substrate being used [10]. In addition, the aerobic work capacity, or maximal oxygen consumption (VO_{2max}), which is the best indicator of cardiovascular fitness, has been shown to be a good predictor of equine athletic performance [11]. However, because this study was performed in the field, VO_2 was not directly measured. Therefore, even if HR has some limits, such as changes in the relationship between HR and VO_2 depending on horse emotional state and fitness level [10], it is well documented that HR has a linear relationship to workload [10,12] and it is a useful indicator of VO_2. According to this knowledge, in our study, we used HR inside two equations to estimate COT [3,4] and P [3]. The aim of this study was to describe COT and P in relation to HR in trained horses subjected to different exercises: aerobic (horse walker and treadmill), anaerobic (trot and gallop), and aerobic—anaerobic (show jumping).

2. Materials and Methods

For this study, 25 clinically healthy and regularly trained horses of different breeds (Table 1) were used after obtaining informed consent from the owners. The study was carried out in May in Sicily. All horses were kept in individual boxes under natural photoperiod and natural indoor temperature (18°C-20°C). The horses were fed a standard ration three times a day (07:00 AM, 12:00 AM, and 08:00 PM) in amounts calculated according to the increasing energy needs. The ration consisted of hay (first cut meadow hay, sun cured, late cut, 8 kg/horse/d, 6.9% crude protein on average) and a mixture of cereals (oats and barley, 50% each, approximately 3.5 kg/horse/d). Water was available *ad libitum*. Before the start of the study, the healthy status of the animals and their performance level were evaluated by means of cardiorespiratory system evaluation, as well as hematological and hematochemical profile assessment. After evaluation of these parameters, all subjects clinically healthy and in good performance conditions were used. Animals were divided into five equal groups on the basis of their attitude (Table 1). The first group (group A) walked a distance of 6,000 m, at 100 m/min average speed, in a horse walker (Pessa Studio, Italy). Group B trained for 20 minutes, at 130 m/min average speed, on 5% gradient treadmill (Horsegym 2000, GMBH). Group C performed a show jumping course of 700 m with 13 fences (six verticals of 1.20-1.30 m in height; three oxers of 1.25 m in height and 1 m in spread; 1 triple bar of 1.30 in height and 0.70 m in spread; 1 triple combination of verticals of 1.25 m in height and oxer of 1.20 m in height and 1 m in spread); all horses were ridden by the same rider. Group D covered a distance of 2,100 m, galloping at an average speed of 700 m/min; all horses were ridden by the same rider. Group E covered a distance of 2,000 m, trotting at an average speed of 660 m/min; all sulkies were driven by the same driver. Before starting the actual exercise, all horses were subjected to a suitable warm up according to their own exercise, and then they were equipped with equine HR monitors (Polar Horse Trainer, S 610, Polar Electro Europe BV, Fleurier Branch, Switzerland) to record HR. Two electrodes were placed against the horse's wet coat: the positive electrode was first placed under the saddlepad, the negative electrode was then fixed to the saddle girth on the left side of thorax, and finally the electrodes were connected to a transmitter (T51H), fixed to a breast strap, that transmitted data to a watch-type data logger (Polar S-610I), placed near the electrodes. Recorded data were then downloaded on a personal computer, by using the Polar Equine 4.0 software, to be analyzed. In particular, HR was logged every 5 seconds during the whole exercise. The mean HR values, obtained from each horse, were used in the application of 1-way analysis of variance (ANOVA) to determine a statistical significant effect of exercise on HR. In addition, the same mean HR values were used to estimate the net COT through the following formula, provided by Williams et al. [4]:

$$C_{OT} = (HR - 35)kg^{-1}m^{-1} \cdot 10^3$$

Table 1
Breed and mean values of body weight, combined weight (horse, rider, tack, and sulky), heart rate, duration, distance, and speed of group A (horse walker), B (treadmill), C (show jumping), D (gallop), and E (trot)

	A	B	C	D	E
Breed	Italian saddle	Italian saddle	Italian saddle	Standardbred	Thoroughbred
Body weight (kg)	496	520	500	444	546
Combined weight (kg)	—	—	575	519	641
Heart rate (beats/min)	58	77	140	187	203
Duration (minutes)	60	20	2	3	3
Distance (m)	6,000	2,500	700	2,100	2,000
Speed (m/s)	1.6	2.1	5.8	11.6	11.1