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Contribution to our knowledge of the physiology and metabolism of endurance horses

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Abstract

The functional and metabolic processes of the endurance horse are discussed, based on personal experience and the scientific literature. Research on the energetic and physiological aspects of prolonged effort is reviewed, as regards the performance structure, described by Neumann, for human physiology.

Experimental data from our previous surveys on endurance horses, competing at different levels, are also presented and discussed.

The results on amino acid levels in blood, and related metabolic pathways, during endurance events, lead to speculation on the effects of the race distance on metabolic processes during long-lasting low-intensity exercise. In fact, the event distance has a significant influence on amino acid mobilization and their use as energy sources. In human athletes, the disappearance of some amino acids from blood circulation is linked to the onset of central fatigue. The effect could be similar in endurance horses; therefore, the correct intake of amino acids, and a proper feeding strategy, could improve performance.

Data are also provided on dehydration and oxidative stress associated with endurance work.

Keywords: Horse; Endurance; Exercise physiology; Nutrition

1. What "endurance" means in competition

Endurance horses compete in races that can be classified as low-intensity long-lasting trials. The first modern endurance ride was held in 1955 in California, from Lake Tahoe to Auburn (100 miles). Today, most endurance rides range from 30 to 160 km, or 100+100 km to be run over 2 days, or 500 km to be run over 5 days (Duren, 2000; Sosa Leon, 1998).

Most breeds have been tested and used for endurance races; the most competitive are Arabian or Arabian crosses due to their muscle fibre compo-

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sition, but other breeds, including Thoroughbred, Quarter Horses, Mustangs, Appaloosas, Morgans, Standardbred, and even Mules, have been used successfully (Duren, 2000). Arabian horses, compared to Thoroughbreds, are better adapted to endurance work because of their superior oxidative capacity (Prince et al., 2001). Arabians and Anglo-Arabians seem to have lower lactate concentrations, compared to Andalusians, at speeds up to 25 km/h (Castejon et al., 1994), thus, showing a better adaptation to long-distance, low-intensity work.

Endurance competitions are extremely difficult from a metabolic point of view, and for this reason, they are subjected to very strict veterinary controls to spare the horse's health. In a overview of 7117 starts in international (Eldric) races, only 50% of the subjects completed the ride, and 30% were eliminated: 63% because of lameness, 24% for metabolic reasons, and 13% for other causes (Burger and Dollinger, 1998). Metabolic problems, therefore, cause the elimination of 7.2% of horses starting international races, but some are retired for the same reasons between two veterinary gates during the race, while others have problems after the final veterinary examination.

For this reason, the correct metabolic management of the endurance horse is of the utmost importance, together with the correct prevention and treatment of osteo-articular pathologies.

2. Physiology overview of endurance effort

In sport, apart from the species involved, management is normally understood to mean the combination of actions aimed at obtaining maximum athletic performance, including economic, medical, as well as ordinary athletic factors (athletic evaluation, training regime, correct feeding).

From a physiology effort point of view, correct management is based on knowledge of the metabolic and functional processes involved in the particular athletic discipline.

In other words, it is of the utmost importance to understand which metabolic pathways are involved, and which physiological adaptations are induced by different type of exercise. In fact, different competitions can be classified according to criteria based on fuel utilization, work intensity, and work duration. This, in turn, allows the planning of an appropriate feeding regime. Indeed, these two aspects are closely related; in particular, for endurance work, which is very heavy from a metabolic point of view, as described here.

In sport exercise physiology, the word "endurance" defines the physical and mental capacity to withstand fatigue (Weineck, 1990).

The general concept of endurance can also be divided into different categories, as follows:

- General or local endurance, according to the proportion of muscle mass involved in the physical exercise (approximately 1/7–1/6 of the total voluntary muscle mass);
- Basic or specific endurance, according to either the general endurance capacity to perform exercises or the ability to compete in a particular sport discipline;
- Aerobic or anaerobic endurance, according to the fuel utilized and the energy metabolism involved;
- Static or dynamic endurance, according to the type of muscle contraction;
- Endurance to strength, explosive strength and velocity, according to the kind of muscle contraction activated.

It is also usual to divide the different sport competitions according to the duration of the effort: in this way, we can classify the endurance required as: short (from 35 s to 2 min), medium (over 2 min to under 10 min), and long-lasting (from 10 min to 6 h and more) (Neumann, 1990).

This classification is extremely useful, because it overcomes the problems raised by analytical classifications, and, more importantly, it permits the integration of the different adaptation processes, which took place in the whole organism, according to the duration of the required activation.

In endurance trials, therefore, it is extremely important that the principle metabolic processes reach a steady-state. We repeatedly measured the metabolic activity of horses competing in endurance trials, by recording the heart rate during the whole race. A sample of the measurements is given in Figs. 1 and 2, of a horse competing in a 72-km ride, completed successfully. The mean heart rate was, on this