Developments in the reduction of heat stress in the endurance horse

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Introduction

Heat stress is one of the major causes for concern for the welfare of endurance horses. Heat stress arises due to increasing heat storage within the horse resulting from inefficient dissipation, often accompanied by dehydration (Hodgson, Davis, and McConaghy, 1994). Studies examined in this paper investigate the reduction of heat production or systems that increase effective heat dissipation.

Horses have metabolisms capable of producing large amounts of heat due to the inefficient conversion of stored energy to mechanical energy (Hodgson et al, 1994). Dissipation of two-thirds of this heat is achieved via sweating with sweat losses of up to 10 L/hr reported (Hodgson et al, 1994) despite a small surface area relative to body mass when compared to other species. Heat not dissipated through sweating is stored (causing an increase in core body temperature) or dissipated via the respiratory tract and other machanisms.

Heat Storage

Geor, McCutcheon, Ecker and Lindinger's (2000) study had horses perform exercise tests in cool dry, hot dry, and hot humid conditions both during and after a 21 day heat acclimation period (moderate exercise in hot, humid conditions). This study compared the effects of heat acclimation on the horses' thermoregulatory response to both humid and dry exercise heat stress. One concern of the authors' was that improved aerobic fitness may cloud findings however there was no observed change in VO2 max .

Fluid balance

In a study by Lindinger, McCutcheon, Ecker and Geor (2000) horses were exposed to heat and humidity for 4hours/day during the acclimation period, performing standardized exercise tests in these conditions. This study compared the effects of heat acclimation on plasma volume and ion responses to hot humid conditions.

Heat acclimation

Benefits of heat acclimation include decreased heat storage before exercise in hot, humid conditions, and also before and during exercise in hot dry conditions. Benefits also include increased respiratory rate thus improved ability to dissipate heat, and increased exercise duration in hot dry conditions thus improved exercise performance (Goer et al, 2000).

Lindinger et al (2000) also found benefits of heat acclimation including the improved ability to regulate plasma volume during exercise in hot humid conditions accompanied by a faster return to normal plasma volume during recovery. This is due to an expansion of plasma volume associated with increases in Na+, Cl- and plasma protein levels. Increased plasma volume during exercise may account for improvements in skeletal muscle and skin perfusion which could increase heat transfer from core to body surface (Lindinger et al,2000).

Sweating responses

In a study by McCutcheon and Geor (2000) thoroughbred horses performed exercise tests in hot conditions while simultaneously training at moderate exercise in cool conditions. This study examined the sweating responses to hot dry exercise heat stress.

Adaption in the form of an altered sweating response produced larger fluid sweat losses during exercise and a decrease in rectal and pulmonary arterial temperatures after exercise. This was evident with an increase in sweating sensitivity and onset of sweating at a lower thermal set point. During recovery, ion losses through sweat and a decline in sweating rate were evident - thus overall sweat losses were consistent with the untrained state. McCutcheon and Geor (2000) concluded that training in cool conditions at moderate intensity is adequate to promote changes in sweating which are beneficial as they enhance thermoregulation and conserve sweat fluid and ions.

Fat adaptation

A study by Kronfeld, Custalow, Ferrante, Taylor, Moll, Meacham and Tiegs (2000) examined Arabian horses randomly assigned to one of two dietary groups - control and corn oil. The corn oil group received 10% corn oil and 3% soybean meal instead of 13% of the total (43%) cracked corn ration in the control diet. This study demonstrated a method for determining the lactate breakpoint (anaerobic threshold or lactate threshold) of horses and extended the results of other studies further illustrating the advantages of fat adaptation in equine athletes.

Fat adaptation is achieved by physical conditioning combined with a fat supplemented diet. Kronfeld et al (2000) found lactate breakpoint tended to be higher in fat adapted horses which is consistent with increased oxidative capacity during fat adaptation due to increased mitochondrial oxidative capacity especially for oxidation of fatty acids. A distinct advantage for fat adaptation in the endurance horse is the use of fat as an energy source produces less metabolic heat for the energy produced when compared to carbohydrate as the energy source - thus the horse has less heat to dissipate. Fat-adapted horses have enhanced regulation of glycolysis with decreased rate of glycolysis at low intensity exercise and increased rate of glycolysis at high intensity exercise (Kronfeld et al, 2000).

Comparison of studies

All conditioning-exercise protocols when used within the studies examined, with the exception of Kronfeld et al (2000), combined long duration / low intensity, medium duration / medium intensity, and short duration / high intensity exercise at the same speeds and for the same periods of time. Prior to the commencement of the study, McCutcheon and Goer (2000) had no conditioning period, instead using horses which had been rested for at least 16 weeks. A standardized exercise test was used in these studies.

The similarities are due to these studies being performed by the same group of researchers who have published many studies in the area of physiological adaptations associated with exercise in hot and/or humid conditions. Another of their studies found a reduction in sweating threshold and sodium ion concentration in sweat fluid, and an increase in peak sweating rate in response to heat acclimation (McCutcheon, Geor, Ecker, and Lindinger, 1999). This group of researchers consistently use about 6 Thoroughbred horses, aged 3-6 years, weighing 414-505 kg, with housing, feeding and experimental protocols as similar as possible within the limits of the study performed.

Kronfeld et al (2000) used a different conditioning regime consisting of low, medium and high intensity exercise - all for short periods of time. Two additional faster gallop components were added during the later stages of conditioning. Kronfeld et al (2000) used an incremental exercise test on horses not exercise-trained prior to the study, with a one week break in conditioning between two 5-week periods. (Lindinger et al (2000) and Goer et al (2000) used a 10-week period with no break, and trained horses.)

The horses were Arabian, of similar ages to those in other studies but substantially lighter (400-430kg), housed in stalls at night and dirt paddocks by day (other studies only used indoor housing). Diet was substantially different as it was the subject of this study.

Several studies have been published examining the effects of hydration - Geor and McCutcheon (1998) is one such example, with other studies such as that by Houpt, Eggleston, Kunkle, and Houpt (2000) examining the effect of water restriction on the behaviour and physiology of the horse. These studies have not been discussed here due to space constraints.

Horse welfare at the ride

At all endurance rides veterinarians are in attendance, who in association with the rider and race stewards are responsible for the welfare of competing horses. The AVA publishes *Guidelines for Veterinary Supervision of Endurance Rides* last published in 1991 with a new edition currently in the process of being written (Jan Eagleton, AEVA President, pers. comm.). These guidelines when combined with the knowledge, rules, and regulations of the international, national and state Endurance Rider Associations provide a scientific basis for assessments of the welfare of endurance horses.

Veterinary checks are performed on each horse prior to, at predetermined points throughout, and after completion of each ride to ensure horses meet minimum standards of mechanical and metabolic fitness (Frazier, 2000). Heat stress, consistent lameness, and failure to recover to an acceptable heart rate are the major areas for horses to be 'vetted out'. Heat stress is monitored by hydration factors such as capillary refill time, mucous membrane colour, skin tenting, and jugular refill time along with intestinal sounds.

Conclusions

Any advantage to the endurance horse which can be gained through scientifically proven training or dietary changes will improve the welfare of the horse competing in endurance rides. Heat acclimation has obvious benefits in increased heat dissipation via respiratory heat loss, lowered resting temperatures, and lowered stored temperature in hot dry conditions. Further study is required to determine the benefits of fat adaptation through the substitution of oils such as corn oil for carbohydrates in the diet.

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