Nutrition, Thermoregulation and Training of the Equine Athlete and the Application of Biotechnology to Athletic Injuries

Convenors: W. L. Bryden and R. J. Rose
Departments of Animal Science and Veterinary Clinical Sciences
Faculty of Veterinary Science, University of Sydney, NSW 2006, Australia

ABSTRACT: Successful athletic performance of the horse is dependent on many factors. In this contract aspects of feeding and of exercise physiology, especially in relation to thermoregulation and overtraining, are discussed. Musculoskeletal injury is a constant threat to equine athletes and possible use of equine somatotropin to reduce the impact of injury is reviewed.

Key Words: Horse, Nutrition, Feeding Practices, Exercise Physiology, Thermoregulation, VO₂ max, Overtraining, Growth Hormone, Equine Somatotropin.

INTRODUCTION

During the last century, the role of the horse in society has changed from a “beast of burden” to an animal that is used largely for sport and recreation. Unlike most other large animals that are used for meat, milk and fibre, the horse is used for its athletic ability. The work output or athletic achievements of the horse revolve around its genetics and training, the way it is fed and its ability to cope with the environment (see Hodgson and Rose, 1994). Training and aspects of feeding and nutrition of the performance horse and the special adaptation of the horse to cope with a high thermal load are addressed in this contract.

The provision of sufficient nutrients to meet dietary requirements is a problem in the athletic animal. The difficulty is to supply sufficient amounts of energy and to maintain normal gut function through provision of roughage. Over the last ten to fifteen years there has been increased research into the nutrition and dietetic problems associated with athletic performance in the horse. Most studies have involved racing, whether it be flat racing, harness racing or endurance competition (see Lawrence, 1994). A major area of elite performance involves three day event horses and the nutritional aspects of this area of athletic performance have been relatively neglected. In this contract this area is examined.

Physiological limits to athletic performance, especially as they relate to thermoregulation, have only recently been studied in the horse. The problems associated with the combined effects of exercise, heat stress and humidity on the horse became apparent leading up to the 1996 Olympic Games in Atlanta. During that period and subsequently, research has been directed at gaining a greater understanding of thermoregulatory aspects of equine exercise and these are reviewed. Thermoregulation is only one aspect of exercise physiology in which significant advances have been made in the last 20 years. Much effort has been devoted to applying the knowledge gained to the improvement of training programs for horses and the avoidance of overtraining.

A major restriction on the athletic life of the performance horse is lameness associated with injuries to tendons and ligaments. There has been much interest in applying the new techniques in biotechnology to aiding the recovery from athletic injuries. One area that is showing promise is the application of recombinant equine somatotrophin or growth hormone to the treatment of athletic injuries and this is discussed in the final segment of the contract.

ASPECTS OF THE NUTRITION OF EVENTING HORSES

E. A. Owens
Ridley AgriProducts, Pakenham, Victoria 3810

During the 2000 Olympics, Australia will attempt to win its third consecutive gold medal in three-day eventing. It is important that Australia’s equine athletes are not limited in their performance by sub-optimum nutrition. To attain this goal, there is a need for a better understanding of “acceptable” variation in standard nutritional parameters of eventing horses. To this end a detailed study was sponsored by the Australian Sports Commission and conducted during 1997 and 1998. As part of the project, the daily workloads, body weights and feed intakes were measured for each of 11 elite eventing horses, over a continuous 5-day period. The diets fed were sampled and analysed. The following paper summarizes some of the outcomes from that study and provides some insight into current feeding practices of eventing horses across Australia.
Table 1. Average body weight (kg), average daily feed intake (kg DM) and average daily digestible energy intake (MJ/kg diet) for eventing horses over 5 days

<table>
<thead>
<tr>
<th>Horse</th>
<th>Bodyweight</th>
<th>Daily intake</th>
<th>DM intake*</th>
<th>DE intake*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>588</td>
<td>11.89</td>
<td>2.02 ± 0.116</td>
<td>133.9 ± 6.61</td>
</tr>
<tr>
<td>2</td>
<td>558</td>
<td>9.84</td>
<td>1.76 ± 0.083</td>
<td>126.2 ± 4.49</td>
</tr>
<tr>
<td>3</td>
<td>539</td>
<td>9.45</td>
<td>1.75 ± 0.617</td>
<td>113.1 ± 43.28</td>
</tr>
<tr>
<td>4</td>
<td>615</td>
<td>10.01</td>
<td>1.63 ± 0.235</td>
<td>116.8 ± 26.04</td>
</tr>
<tr>
<td>5</td>
<td>547</td>
<td>8.13</td>
<td>1.48 ± 0.522</td>
<td>101.4 ± 36.18</td>
</tr>
<tr>
<td>6</td>
<td>529</td>
<td>12.95</td>
<td>2.45 ± 0.203</td>
<td>151.5 ± 18.33</td>
</tr>
<tr>
<td>7</td>
<td>582</td>
<td>10.26</td>
<td>1.76 ± 0.593</td>
<td>126.3 ± 41.57</td>
</tr>
<tr>
<td>8</td>
<td>503</td>
<td>10.31</td>
<td>2.05 ± 0.173</td>
<td>116.6 ± 9.70</td>
</tr>
<tr>
<td>9</td>
<td>483</td>
<td>10.27</td>
<td>2.12 ± 0.161</td>
<td>105.6 ± 7.86</td>
</tr>
<tr>
<td>10</td>
<td>498</td>
<td>9.80</td>
<td>1.91 ± 0.178</td>
<td>105.4 ± 9.64</td>
</tr>
<tr>
<td>11</td>
<td>518</td>
<td>9.90</td>
<td>1.91 ± 0.167</td>
<td>111.5 ± 11.86</td>
</tr>
</tbody>
</table>

* mean ± SD (n=5)

Daily Feed Intake and Body Weight Variations

During the study, each horse was weighed at the same time each day using portable scales and each feed ingredient weighed for each meal over a 5 day period. Rejected feed was recorded and samples retained for analysis. Table 1 summarizes the average body weight and dry matter (DM) intake for each of the 11 eventers. The horses consumed an average of between 1.48 to 2.45% bodyweight. Recommendations by the NRC (1989) suggest daily feed intakes for working horses of 2 to 3 % bodyweight.

In an Australian study of 25 Thoroughbred (TB) and Standardbred (SB) racing stables, Southwood et al (1993a), found that the feed intake of TB’s and SB’s was similar to NRC published requirements. In this study, body weight was estimated using the formula from Carroll and Huntington (1988) and feed intake was recorded for only a single day. In contrast, the results in Table 1 with eventing horse, shows less agreement with NRC recommendations for feed intake and highlights the individuality of horses in their feed intakes and the importance of considering existing patterns of feed intake when recommending a diet change.

Generally, riders were not aware of the actual weight of their horses, nor the normal range of variation of that body weight in response to work intensity, climate or feed changes. The standard deviation for body weight change over the 5 day study period for the eventers was between 1.67 and 10.6 kg. A drop of 26 kg was noted in a horse that was accidentally denied water after a gallop day. Three horses that were on 4 meals a day feeding pattern were most closely supervised by their rider and showed the lowest daily variation in body weight.

Diet Adequacy and Raw Material Variability

Raw materials were analyzed at the University of New England and the DHI Forage Testing Laboratory in Ithaca New York. Digestible energy (DE) was estimated using the equation from Pagan and Hintz (1986a,b). Declared nutrient levels by the manufacturer were used for proprietary feeds and supplements. Data from the NRC (1989) were used for the balance of nutrient data for each of the ingredients to produce an estimate of nutrient intake for each day of the evaluation. This information was then compared against predicted requirement from data provided from Kentucky Equine Research’s Microsteed programme and the NRC (1989) for mature horses in work.

All diets contained in excess of the NRC (1989) concentration for protein. Of the 11 horses studied, only one received no vitamin/trace mineral supplementation from either supplements or fortified feeds. Seven horses were receiving sub-optimum levels of Vitamin E, 6 were well below recommended intakes of sodium and 6 were deficient in minor vitamins. All horses appeared to receive adequate intakes of calcium, phosphorus, magnesium, potassium, iron, manganese and cobalt. There was a heavy reliance on roughage sources to provide the macro and micro minerals. Lucerne does provide a source of calcium but analysis of lucerne hays and chaffs used by participants in this evaluation, showed that the calcium level varied from 6.7 to 17.5 g/kg. The iron content in one sample was 65 mg compared with a stated level of 225 mg from the NRC. These results suggest that riders are naive to believe that roughage will provide an adequate source of all major minerals for their horses.

There is a need for an accurate and reproducible method for determining the DE content of feeds; both raw materials and compound feeds. It was found that the estimated DE for a commercial extruded feed was only 12.86 MJ/kg in contrast to a label claim of 16.9MJ/kg. This is a significant source of inaccuracy and misleading for those attempting to formulate balanced and appropriate rations for eventers.

Digestible Energy Intake

The average daily DE intake for each horse is summarized in Table 1. Some difference in digestible energy intake is not only inevitable but desirable, when work loads change from non-work to full work days. When applied to the eventing horses studied, the daily DE intakes exceeded (by 1 to 80 MJ/day) the level predicted by the NRC (1989) equation. Once again this illustrates the need to establish, as accurately as possible, the DE intake of a working horse in relation to body condition and work load, before making recommendations on diet.
change since existing formulas appear to underestimate the actual requirement.

**Feeding Practices**

Each horse studied was on full feed with little or no access to pasture. Each horse was stabled for at least 10 hr per day and more than 60% of horses studied were meal fed twice a day. To prevent digestive dysfunction (excessive gas production, colic, laminitis and impaired fibre digestion) resulting from starch overload, grain intake in horses fed 2-3 times daily should be limited to 0.5 kg of grain per 100 kg body weight (Clarke et al., 1990). Three of the eventers studied consumed a grain portion well in excess of this recommended maximum.

Hay was usually fed in conjunction with or immediately after the concentrate feed. No rider routinely weighed either the concentrate or fibre portion of their horses diet. Routhage contributed between 23 and 65% of the horses total feed intake (as fed), with the majority of horses receiving between 40 and 50% of their feed intake as roughage. The variation was largely a result of the hay being fed by volume rather than by weight.

This study also showed that while a few of the participants had a clear grasp of the principles of basic equine nutrition, a number were confused about feeding and viewed nutrition as a low priority in the performance of their horses. Many professional riders employ staff who supervise horse feeding. As a result, riders forfeit intimate knowledge of their horse’s feed intake and feeding behaviour. During the study, instances were discovered where riders were unaware of their horses level of feed intake and/or rejection, were unaware that certain ingredients were being excluded from the diet either due to lack of availability, or grooms who simply forgot to include that ingredient. Feeds prepared for one horse were mistakenly fed to another and in one case, a horse was accidentally denied access to water after a gallop day through staff negligence. These instances should not be viewed as the norm, but indicate that the nutritional adequacy of many horses is being compromised because their riders do not believe that nutrition is worthy of their personal interest or attention. This also highlights the need for closer interrogation of riders when a feeding related disorder is suspected.

**Formulation of Eventing Rations**

Eventing horses are mature, and those in open, adult competition, tend to be over 16 hh with a body weight between 480 and 600 kg. These horses are worked 6 days per week for more than an hour per day and have particular nutritional needs to meet the demands of long term work and intense competition. Considerable work needs to be done before we understand fully the nutritional requirements of these horses, moreover, the acceptable variation in nutritional parameters needs to be clarified.

In order to formulate a balanced ration for an eventing horse, we are faced with the dilemma of deciding what to measure, against which standards and using what resources? Consistent, reproducible laboratory tests for horse DE determination of feedstuffs and finished feeds need to be established and implemented by the major feed manufacturing companies. NRC values, last published in 1989, do not take into sufficient consideration variations in work loads, feeding practices or breed differences and address minimum, rather than optimum nutritional requirements for performance. Actual body weights and weights of individual feed ingredients are a minimum requirement in any nutritional evaluation. Riders rarely take the time to measure these parameters themselves and in some cases, cannot be relied upon to give an accurate record of the horses feed status. Professionals who cater to riders of eventing horses, need to be aware of the differences in both requirement and feeding practices of these horses versus Thoroughbreds and/or Standardbreds.

**THERMOREGULATION IN THE HORSE DURING EXERCISE**

**D.R. Hodgson**

Department of Veterinary Clinical Sciences, University of Sydney, Camden NSW 2570, Australia

Following the onset of exercise there is a marked increase in the metabolic rate to provide energy for muscular contraction. A ten to twenty-fold increase above resting metabolic rate occurs in response to endurance exercise, whereas in horses undertaking high intensity exercise, for example flat racing, the increase is normally more than 60-fold and may be up to 90-fold in elite animals (Rose et al., 1990; Seeherman and Morris, 1990). The metabolic efficiency of the processes which convert stored energy into mechanical energy (locomotion) is low (~20%), with much of the energy produced during exercise being liberated as heat. The effect of this heat load can be expressed according to the formula: M = H + S, where M is the metabolic rate; H the rate of heat loss; and S the rate of change in stored heat reflected as an increase in core temperature. As M increases, thermoregulatory mechanisms are activated in an attempt to maintain core body temperature in a tight range, normally within a few degrees of that at rest. In comparison to other sweating mammals, for example man, the horse possesses a large metabolic capacity. When expressed on a mass specific basis horses have metabolic capacities 50-100% greater than elite human athletes. However, unlike man, the horse has a low surface area:body mass ratio (1:35-40 for humans - 1:90-100 for horses) (Hodgson et al., 1993). As a result of these discrepancies enormous demands are placed on the thermoregulatory system of the horse during exercise.

Fortunately, despite these apparent disadvantages for an exercising mammal, the potentially devastating effects of thermal stress are avoided in this species under most circumstances. This attests to the efficacy of the mechanisms responsible for dissipation of metabolic heat in response to exercise. Of these mechanisms, evaporative cooling, in particular evaporation of sweat from the skin, provides a primary means for heat loss during exercise (Carlson, 1983; Hodgson et al., 1993). Evaporative cooling from the respiratory tract also provides a notable route for heat loss during exercise (Heileman et al., 1990; Hodgson et al., 1993). The combined effects of heat storage during exercise, evaporative cooling at the skin
and across the respiratory tract and lesser contributions from other means of heat dissipation lead to a remarkably efficient capacity for heat dispersal in this species.

The horse also possesses the capacity to selectively cool the brain (McConaghy et al. 1995) a process that is believed to protect the brain from the deleterious effects of overheating during exercise. In addition this thermoregulatory adaptation is also thought to allow the brain to operate in a zone of optimal thermal efficiency thereby being able to rapidly invoke thermoprotective processes elsewhere in the body. The presence of selective brain cooling in the horse occurs despite there being no carotid rete at the base of the brain. Many other species, for example the camel, possess this rete which allows cooling in influent arterial blood by a complex rete containing venous blood cooled by evaporative mechanisms in the nose and upper airway. Although not possessing a rete as such, the horse appears to be able to tightly regulate the flow of venous blood cooled in the nasal passages to the cavernous sinus which is anatomically adjacent the hypothalamus, thereby allowing this organ to be cooled by 1-2°C below the temperature of the core (McConaghy et al. 1995).

However, despite the presence of effective heat dissipation mechanisms the potential for the development of heat stress increases when: i) the horse is inadequately conditioned for the athletic endeavour being undertaken; ii) exercise is performed under adverse ambient conditions, particularly if the temperature and humidity are high, factors which dramatically limit the efficiency of evaporative cooling mechanisms; and, iii) when thermoregulatory mechanisms within the horse are impaired, for example anhidrosis.

ADAPTATIONS TO TRAINING AND OVERTRAINING IN THE RACEHORSE

D. L. Evans
Department of Animal Science, University of Sydney, NSW 2006, Australia

Briefly reviewed below are factors contributing to the comparatively high maximum oxygen uptake in racehorses, and its adaptation to exercise training. As well, the results of a recent longitudinal study of the effects of a period of highly intensive training are described, resulting in an overtraining syndrome.

Maximum oxygen uptake

Maximum oxygen uptake (VO\textsubscript{2 max}) expresses the maximum rate use of oxygen during exercise, and it defines the aerobic capacity of the horse. The VO\textsubscript{2 max} is the maximum amount of oxygen that the horse has the capacity to transport through the lungs, pump by the heart and use in muscles for the production of energy. It defines the upper limits to aerobic metabolic support for racing performance, especially in events lasting longer than approximately 50-60 seconds. VO\textsubscript{2 max} is typically measured during treadmill exercise tests that use increasing velocities until the point of fatigue of the horse.

Exercise responses and oxygen transport in humans and horses are qualitatively similar except for three main areas:
1. Splenic contraction in the horse approximately doubles haematocrit at maximal oxygen uptake compared to truly resting values, while in man there are virtually no changes in haematocrit;
2. Oxygen transport flow rates are about twice as great per kg in the horse as in man, and
3. Pulmonary function is compromised in the horse. This compromise is reflected in considerable hypoxaemia (low blood oxygen concentration) and haemoglobin desaturation; changes that are only seen in elite human athletes (Wagner, 1995).

Maximum oxygen uptake is usually limited by oxygen supply to the mitochondria rather than by intrinsic mitochondrial oxidative capacity (Wagner, 1995). The general consensus is that the rate of oxygen flow through the lungs and heart sets the upper limit of an animal’s maximum oxygen uptake. This implies that the capacity of the heart to pump blood to the muscles is the major limiting factor in determining an animal’s maximum oxygen uptake. The maximal cardiac output will depend on the horse’s maximal heart rate and the maximal stroke volume (volume of blood ejected from the left and right sides of the heart in each contraction). Maximal heart rates are usually in the range of 210-240 beats per minute. Stroke volume in the exercising horse ranges from approximately 0.9 – 1.3 litres, and is increased after training (Evans and Rose, 1988). The maximal rates of blood flow from the heart (cardiac output, or heart rate x stroke volume) can therefore range from approximately 200-350 litres per minute, depending on inherited heart capacity, maximal heart rate and state of training.

Typical maximal rates of oxygen uptake in untrained horses are 80-140 ml of oxygen per minute, per kg of body weight. These rates compare with values of approximately 30-50 ml/min/kg in untrained humans. The higher rates of maximal oxygen consumption in horses is mainly due to the much greater arterial oxygen content in horses during maximal exercise, secondary to splenic contraction and addition to the blood oxygen transporting capacity.

Maximal oxygen uptake increases by approximately 10-20% after training in horses. Elite middle distance and staying Thoroughbreds have values for VO\textsubscript{2 max} in the range 160-175 ml/min/kg. Good class Standardbred pacers have values in the range 150-160 ml/min/kg. Most of the increases in VO\textsubscript{2 max} occur in the first 6 weeks of training. However, in a study of prolonged training, there was a gradual further increase in VO\textsubscript{2 max} over a 7 month training period (Tyler et al., 1996).

A high VO\textsubscript{2 max} does not guarantee excellent racing performance, but, in general, Standardbred horses with a higher VO\textsubscript{2 max} have superior performance (Gavreau et al., 1995). Unfortunately there have been no studies of the associations between VO\textsubscript{2 max} and racing performance in Thoroughbreds, eventing or endurance horses. Performance of horses with a high VO\textsubscript{2 max} but low anaerobic capacity will probably be limited by poor sprinting ability.
Overtraining

For most horse trainers, there is delicate balance between attaining and maintaining peak fitness, and lameness or overtraining. Overtraining is defined as a loss of performance ability, despite the maintenance of or an increase in training effort. Athletic performance decreases, and horses must cease or reduce training for variable periods of time in order to recover.

The overtraining syndrome has also been described in human athletes subjected to rigorous training programs incorporating inadequate rest periods. Typically, an imbalance between exercise training and recovery periods leads to a situation where further adaptation to training does not occur. The syndrome is characterized by a decrease in performance capacity. In humans, signs of overtraining also include mood disturbances, persistent muscle fatigue and pain, weight loss, inappetence and increased susceptibility to injury and infection (Kuipers 1998, Stone et al., 1991). Similar signs, including poor appetite, body weight loss, behavioural changes and reluctance to exercise, typically accompany the reduction in performance observed in overtrained horses (Bruin et al., 1994, Persson et al., 1980). Despite considerable scientific investigation in human athletes, the physiological basis of the overtraining syndrome remains relatively poorly understood. Several mechanisms have been proposed, including decreased adrenal sensitivity to adrenocorticotropin (ACTH) (Lehmann et al., 1997) and failure of the hypothalamus to cope with the total amount of stress (Kuipers 1998).

In a cross-sectional study of overtraining in horses, plasma cortisol concentrations at rest and in response to ACTH administration were lowest in horses with red-cell hypervolaemia and a history of performing below expectation (Persson et al., 1980). The authors suggested that basal and ACTH-stimulated cortisol concentrations could be useful for detecting imminent overtraining prior to the occurrence of red cell hypervolaemia, a syndrome which was associated with a poor prognosis for return to athletic performance. However, plasma cortisol concentration two hours after ACTH administration was significantly higher in a longitudinal study of overtraining in horses (Bruin et al., 1994). In that study the horses may not have been truly overtrained because no decrement in performance capacity (assessed as total run time during a standardised exercise test) was reported. As well, a control group was not included, and it is possible that the result could have been due to prolonged training, rather than overtraining. Signs of overtraining of Standardbred horses were not related to changes in either maximal aerobic capacity (Tyler et al., 1996) or a difference in skeletal muscle adaptations (Tyler et al., 1998).

A longitudinal study of overtraining in Standardbred horses found that the syndrome was not associated with a decrease in adrenal gland sensitivity to stimulation by adrenocorticotropic hormone (Golland et al., 1999). Rather, overtraining was associated with a decrease in the cortisol response to intense treadmill exercise, suggesting that the dysfunction in overtrained horses occurs in the central nervous system.

The treadmill velocity at a heart rate of 200 bpm may be increased in overtrained horses (Persson et al., 1980). Regular measurement of heart rate during a standardised submaximal exercise test may assist the management of horses during periods of intense training.

Blood tests are frequently used to monitor horses in training. In a prolonged study of training and overtraining in Standardbred horses there were no significant changes attributable to the overtraining group (Tyler-McGowan et al., 1999). Measurements of red blood cell concentration, haemoglobin concentration, packed cell volume, white blood cell counts, and neutrophil to lymphocyte ratio changed with training, but there were no changes that indicated onset of the stress of overtraining. Regular red and white blood cell counts for monitoring stress of training in horses has no scientific basis.

Overtraining was associated with significant changes in a plasma biochemical marker; AST (aspartate aminotransferase). A gradual increase in plasma AST in blood samples collected before exercise at the same time of the day should be regarded as a warning sign for onset of overtraining (Tyler-McGowan et al., 1999). Concentrations of AST also increase for several days after exercise, and it is important that both the day and time of the week be standardised for blood collections. For example, there would be little point comparing the results from a sample collected on Monday morning, after a rest day, with results collected on the morning after a day of fast exercise. There was no significant effect of overtraining on plasma gamma glutamyl transferase (GGT) or creatine kinase (CK) activities in the same study.

Regular assessment of a horse’s ability to cope with intensive training, transport and racing schedules should not be based on regular measurement of plasma AST concentrations alone. Monitoring of appetite, body weight and the recovery of body weight after racing is also advisable.

CONCLUSION

Racehorses have a superior oxygen transport system, reflected in comparatively high values for maximum oxygen uptake. Adaptations to training include increased VO\textsubscript{2 max}, and prolonged training results in continued adaptation of the oxygen transport pathways. However, highly intensive training over a short period of time can result in an overtraining syndrome in which body weight and exercise capacity decrease. This syndrome was not associated with changes in sensitivity of the adrenal cortex to exogenous adrenocorticotropic hormone. However, overtraining was associated with a decrease in the cortisol response to a standardised treadmill exercise test. Further studies are needed to further describe the central neuroendocrine responses to overtraining in racehorses.

SOMATOTROPIN IN THE EQUINE INDUSTRY


Department of Veterinary Clinical Sciences, University of Sydney, Camden NSW, 2570
The advent of recombinant DNA technology provided the ability to produce large quantities of highly purified somatotropin or growth hormone (GH) at justifiable costs. Recombinant human, bovine, porcine, and equine GHs are now commercially produced. These GHs are species specific although amino acid homology between bovine, porcine and equine GH is relatively close. Approximately 34% of amino acids are different between equine and human GH. Recombinant equine somatotropin (eST) was developed by BresaGen Limited, South Australia and introduced to the horse industry in 1993. Since then a number of international research groups have investigated the effects of eST on a diverse range of metabolic, physiological and physical variables in the horse. Studies have used the geriatric and young horse for longitudinal trials presumably because the greatest impact of eST can be expected to occur in both the immature and elderly horse. The development and commercial application of eST has trailed that of bovine and porcine somatotropin mostly because the incentive for improved productive efficiency is not of economic significance in the horse as it is in cattle and pigs.

Application of eST in the equine industry has potentially wide-reaching benefits. For the equine athlete there is considerable interest in determining what protective effect eST may have on the musculoskeletal system of horses in training and competition. In addition, effects on wound healing and body condition have been studied. Inevitably, there has been particular interest in the ability of eST to promote a stronger, faster horse and its potential as an ergogenic aid has also been investigated.

Recommended dosages for horses are 10-20 μg/kg by daily intramuscular injection over a period of 2 to 6 weeks. Six weeks is the more common treatment period. There is little information available on the need for subsequent treatments and if so at what point. The therapeutic margin of safety is considered excellent (Dart et al., 1998), and any adverse side effects have been limited to infrequent reports of transient lethargy and site of injection soreness.

Approved use of eST

Recombinant eST is marketed as EquiGen™ and is registered as an aid to improve the nitrogen balance of aged horses. Somatotropin levels decline with aging, and this physiological event is thought to contribute to a shift towards negative nitrogen balance, leading to a decline in body condition and muscle tone. The nitrogen-retention effect of eST has been equated to increased protein synthesis and/or decreased protein breakdown and this is manifested by improvement in muscle mass. In a report by Malinowski et al. (1997), mares 20 to 26 years old subjectively developed greater muscle definition than control mares, although their total body weight was not significantly increased. These same treated mares also demonstrated a significant increase in circulating leukocytes (granulocytes) and it was suggested that eST may have a role in stimulating immunity in aged mares. In a group of 2 year old Quarter horses, eST did not significantly effect body condition score or daily feed intake, but trends existed for increased body weight gain, and rump fat thickness was significantly decreased (Julen Day et al., 1998). Subjective analysis by veterinarians using eST in field trials suggests an improvement in body condition in the majority of horses treated.

Other uses of eST

Wound healing

Laboratory animals and humans have been the subject of many experimental and clinical trials to determine what beneficial effect GH may have on the process of wound healing. In general, wound bursting strengths have been improved and catabolic patients may benefit from GH administration to improve nitrogen retention. In the horse, healing of pectoral wounds was apparently not hastened by systemic treatment with eST in a group of geldings (Smith et al., 1999). In studies performed at the University of Sydney, systemic eST promoted increased granulation tissue formation in hindlimb dorsomedial metatarsal wounds but otherwise had no significant effect on rate of wound healing (Creis, 1999). Anecdotal evidence from field trials indicates eST may be of benefit in promoting healing of lacerations in horses.

Tendon healing

There are limited scientific studies on the effects of eST on the equine tendon. In the most comprehensive study to date, Dowling (1999) concluded that systemic eST treatment did not significantly influence the biomechanical properties of normal tendons. In an associated biomechanical study, eST administration to horses with a collagenase-induced tendon injury did not result in a superior healing response and in fact the treated tendons were considered biomechanically inferior to the control group of healing tendons (Dowling, 1999). Once again, field trials have reported encouraging results with eST used for the treatment of tendonitis with apparently more rapid healing of lesions and less spelling time before return to training.

Bone and joint conditions

Initial studies on bone response to eST administration in 2 year old Quarter horses in race training did not reveal a significant positive influence, but a trend existed for a protective effect on bone mineral density (Julen Day et al., 1998). In eST treated horses there was no net loss in the total bone density in response to training as there was for the control group. Serum osteocalcin (a marker of osteoblastic activity) was also significantly elevated after 6 weeks of eST treatment (Julen Day et al., 1998). Further studies are being performed at the University of Sydney and Prince of Wales Hospital, Sydney, to examine the influence of eST administration on the response of metacarpal to training in yearling Standardbreds. If eST does improve the strength of bone and its ability to respond to the stress of training then there could be significant scope for its use in the prevention of training and racing related orthopaedic injuries in the horse. Such injuries are a considerable cause of economic wastage in the racing industry (Bailey et al., 1997). The effect of eST in promoting fracture healing in the horse is
unknown. In the dog, recombinant canine somatotropin enhanced the healing of an unstable ostectomy created in the mid radius (Wilkens et al., 1996) so it is reasonable to suggest that eST could promote healing of fractures in the horse. A protective effect of eST for joints, in particular articular cartilage, have yet to be established. However, IGF-1 is mitogenic for isolated equine chondrocytes (Henson et al., 1997) and has an important role in articular cartilage proteoglycan homeostasis (Trippel, 1992). A mechanism exists for a beneficial effect of eST on joints via IGF-1 production.

Exercise capacity

The effect that eST may have on a horse’s ability to perform (particularly racing) has attracted considerable attention given the concerns of racing officials over the unauthorised use of eST as an ergogenic aid. The aerobic capacity of unfit aged mares (20-26 years old) was not enhanced by the administration of eST although it is worth noting that these mares were not in a training program during the trial (McKeever et al., 1998). Recent studies at the University of Sydney examined the exercise capacity of 2 year old Standardbreds receiving eST while being trained and again there was no significant improvement in fitness (M.P. Gerard, pers. comm.). These results do not necessarily eliminate the potential for eST to be used as a ‘go fast’ drug and if administered to an even younger population of horses the consequences may be more attractive to trainers, for example, taller, more muscled horses.

CONCLUSION

There is still much to learn about the physiological consequences of eST administration in the horse. Controlled studies using young, rapidly growing horses (less than a year old) have yet to be published but it is possible that the effects of eST will be greatest in this age group. Rose (1998) suggests that the effect of eST in young horses is of considerable importance given buyer’s preference for mature yearlings. More research is required before the routine use of a course of eST can be recommended for treatment of musculoskeletal injuries, cutaneous wounds or a functional decrease in immunity. It is, however, accepted that the overall well-being of geriatric horses is improved by complementing their declining eST levels with exogenous ST and currently the use of recombinant eST is labelled for this purpose.

CONCLUDING COMMENTS

Investigations of areas such as nutrition, exercise physiology, thermoregulation, and biotechnology, as they relate to the horse, have increased substantially during the last decade, both in Australia and overseas. The result is that much new information, covering all aspects of horse management, have become available. The significant problem that this poses is collation and dissemination to all sections of the horse industry. The lack of nutritional understanding by horse professionals, demonstrated in this and other studies (Southwood et al., 1993b), is an example of the importance of education and technology transfer to the future success of the horse industry.

It is clear that there are significant areas of equine metabolism and physiology that are still only partially understood. There remains much to be discovered if we are to continue to improve the welfare and performance of the equine athlete.

REFERENCES


Emails: dean@vetsci.usyd.edu.au, wayneb@camden.usyd.edu.au