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CONTRIBUTION OF RESPIRATORY HEAT LOSS TO HEAT BALANCE IN THOROUGHBRED HORSES PERFORMING NEAR MAXIMAL EXERCISE UNDER THERMONEUTRAL AND HOT-HUMID CONDITIONS

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BY

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DEDICATION

To all those who encouraged me to complete this thesis,

Particularly my wife, Bernice,

And parents, Howard and Jessie

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DECLARATION

I, *Raymond John Lund*, do hereby declare that the experiments presented in this thesis were conceived and executed by myself and, apart from the normal guidance from my supervisor, I have received no assistance.

Neither the substance nor any part of this thesis has been submitted in the past, or is being, or is to be submitted for a degree in the University or any other university.

This thesis is presented in fulfilment of the requirements for the degree of PhD.

Signed:..

Date:....20 AUGUST 2000....

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ABSTRACT

The purpose of the studies presented in this thesis was to develop a greater understanding of the contribution of respiratory heat loss to the thermal balance of exercising horses.

In the first experiment the effect of three different warm-up regimens on the thermal balance of Thoroughbred horses was investigated. The experiments showed that a low intensity warm-up was most beneficial aiding heat dissipation during subsequent exercise. The study also showed the heat loss by sweating is not restricted by the rate of sweat production, but by the evaporation rate of the sweat.

In the second experiment, horses were exercised to fatigue in thermoneutral and hot-humid environments. The evaporative heat dissipation from sweating and from the respiratory tract was severely impaired during the hot humid exercise protocol. There was a significant increase in the heart rate and the metabolic rate during the hot humid protocol, thus indicating the additional work done by the horse in an effort to dissipate the rapidly accumulating heat. The significantly shorter time to fatigue may be a mechanism to protect the horse from circulatory collapse as the circulatory demands for cardiac output exceed its capacity.

In the third experiment adaptations that the horse is able to make to alleviate the compromised evaporative heat loss were identified. These experiments showed that the horse is able to shorten its stride, increase minute ventilation and the velocity of the air in the conducting airways. The results presented also indicate that the horse is able to modify the evaporative area of the airways to enhance evaporative heat loss from the respiratory tract. The experiments also showed that during exercise in hot-humid environments, small changes in the evaporating surface vapour pressure have a significant effect on the vapour pressure gradient thus having a significant effect on the evaporating heat loss.

Finally, the lessons gained during the experiments presented in this thesis were used to revise and refine a mathematical model of the thermal balance of exercising horses. The resulting model is more accurate and easier to apply to use in the field.

SAMEVATTING

Die doel van die studie was om 'n beter begrip te verkry van die bydrae van asemhalings-hitte-verlies tot die termiese balans van die volbloed renperd.

In die eerste eksperiment is die effek van drie verskillende opwarmings oefening roetines op die termiese balans van volbloed perde ondersoek. Die eksperimente het getoon dat `n lae intensiteit opwarming die mees voordeligste is en hitte verspriding gedurende die daaropvolgende oefenng fase fasilteer. Die studie het verder getoon dat hitte-verlies deur sweet nie beperk is deur die produksie van sweet nie, maar deur die tempo van die verdamping van sweet.

In due tweede eksperiment is die perde geoefen tot moegheid in `n termo-neutraal en `n warm hoë humiede klimaat. Die verdampingshitte vermorsig van sweet en van die asemhaling streek was baie benadeel gedurende die warm humiede oefening protokol. Daar was `n merkende toename in die hatklop sowel as die metaboliese spoed tydens die warm hoë humiede omstandihede, wat daaropdui dat die perd addisionele werk moet doen in `n poging om die vinnig opbouende hitte te verminder. Die heelwat korter tyd tot moegheid kan dalk 'n meganisme wees om die perd te beskerm teen

sirkulerende ineenstorting wanneer die sirkulêre vereistes van die vraag vir kardio uitset die kapasiteit daarvan oorsky.

In die derde eksperiment is die aanpasing wat deur die perd gemaak kan word, aangaande verdampingshitte-verlies geïdentifiseer. Hiedie eksperiment het getoon dat die perd oor die vermoë beskik on die spoed van lug in die lugweg te vertraag sowel as die spoed van die lug in die geleidingslugweg. Die resultate toon ook dat die perd oor die vermoë beskik om die asemhalingsarea te bevorder. Die eksperiment het ook getoon dat gedurende oefening in `n warm humiede klimaat, minimale veranderinge in die verdampsarea `n merkwaardige impak het op die verdampingshitte-verlies.

Ten slotte is die resultate van die studie gebruik on die wiskundige model van termiese balans van renperde aan te pas. Die aangepaste model is meer akuraat en is ook maklike om in die pratyk te gebruik.

PUBLICATIONS EMANATING FROM THIS THESIS

1. Guthrie, A.J., Lund, R.J., (1997) Thermoregulation - Base Mechanisms and Hyperthermia. Veterinary Clinics of North America: K Hinchcliff – Extracted from the literature review presented in Chapters 2 and 3 :Appendix B.
2. Lund, R.J., Guthrie, A.J., Mostert, H.J., Travers, C.W., Nurton, J.P. and Adamson, D.J. (1996) Effect of three different warm-up regimens on heat balance and oxygen consumption of Thoroughbred horses. J. Appl. Physiol. 80: 2190-2197
3. Mostert, H.J., Lund, R.J., Guthrie, A.J., Cilliers, P.J. (1996) An Integrative Model for Predicting Thermal Balance in the Exercising Horses. Equine Veterinary Journal 22:7-15: Appendix A
4. Lund, R.J., Guthrie, A.J., Nurton, J.P., Mostert, H.J., Travers, C.W. and Hodgson, D.R. (XXXX) Respiratory Heat Loss from Horses in Extreme Hot-Humid and Thermoneutral Environments :Chapter 5
5. Lund, R.J., Guthrie, A.J. and Lyon, Q (XXXX) Design of a simplified Ultrasonic Air Flowmeter : Chapter 6
6. Lund, R.J., Guthrie, A.J., Nurton, J.P. and Meyer, C (XXXX) Respiratory Adjustments During Exercise in Hot-Humid Environments to Aid Heat Loss in Thoroughbred Horses: Chapter 7

7. Lund, R.J. and Guthrie, A.J. (XXXX) Refinements to a Mathematical Model of the Thermal Balance of Exercising Horses: Chapter 8

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