Effectiveness of a heavy, lined rug for maintain body temperature in a horse on a cool, rainy day

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Introduction

Horses are found across a variety of environments: hot/cold deserts; tropical; and subarctic conditions. This suggests that they have a wide thermo-neutral zone (TNZ); the range of ambient temperature which allows an animal to maintain core temperature without raising metabolic rate (Christopherson and Young, 1986 as cited in Morgan 1998). The TNZ in the horse has been reported to be between 5-25°C (Morgan, 1998), and horses that are acclimatised to colder temperatures can have a TNZ that drops to -15°C (McBride, Christopherson, & Sauer, 1985). The low TNZ range is correlated with the thermoregulation mechanisms and large size of the horse (Morgan, 1998). Insulation in cold weather captures body heat and is achieved through piloerection of the coat, and vasoconstriction of peripheral vessels (Blaxter, 1989 as cited in Cymbaluk 1994). Body heat is dissipated through the skin and via evaporative ventilation (respiratory system), and thus respiratory rate (RR) and heart rate (HR) may increase to increase heat loss (Morgan, 1997a).

Studies have shown that rugging horses after exercise in cold (<10°C) temperatures may prevent heat dissipation (Hartmann, Connysson, & Dahlborn, 2014; Wallsten, Olsson, & Dahlborn, 2012). Domestic horses are commonly rugged in cool (<20°C) or rainy weather in Australia. The aim of this experiment was to determine if a waterproof rug aids in maintaining body temperature of a stabled horse on a cool, rainy day. Specifically, the study determined whether there was a difference in heart rate (HR), respiratory rate (RR) or rectal temperature (RT) in rugged horses compared with unrugged horses.

Materials and Methods

Ten mature mares were placed in stables and randomly assigned a treatment group: rugged (n=5) or unrugged (n=5). Waterproof rugs (synthetic or canvas) were used. HR was measured using a stethoscope (Kindcare® Professional Stethoscope) on the ribcage behind the elbow; beats were counted for 15 seconds then multiplied by four to determine beats per minute (bpm). RR was measured by either observing expansion of the ribcage or feeling expansion with the hand placed on the flank of the horse. Breaths were counted for 15 seconds and multiplied by four to determine breaths/minute. RT was measured using a lubricated digital thermometer (Liberty DT-K01A) inserted approximately 2cm into the rectum and held at an angle touching the rectal wall. Measurements were taken in the same order (HR; RR; RT) each time. Ambient temperature and humidity was also recorded. All measurements were taken at baseline (0 minutes, before treatment, i.e. rugs were put on immediately after baseline measurements), and then every 15 minutes for a total of 120 minutes.

After examining the data for outliers, an unpaired, 2-tailed, equal variance t-test (Excel) was performed to compare results obtained from rugged and unrugged horses. Results were considered significant where $p<0.05$.

Results

On examination of the individual horse data, one horse in the rugged group had an excessively high HR and was determined to be an outlier. This data point was omitted from further analysis.

Three horses in the rugged group were observed to be overtly sweating, whilst none of the unrugged horses showed signs of sweat. Rectal temperature was significantly increased ($p=0.00987$) in rugged horses compared to unrugged horses (Figure 1). Table 1 shows environmental conditions during the study; ambient temperature fluctuated during the experiment, however temperature was the same at the beginning and end of the time period. Relative humidity increased during the experiment.

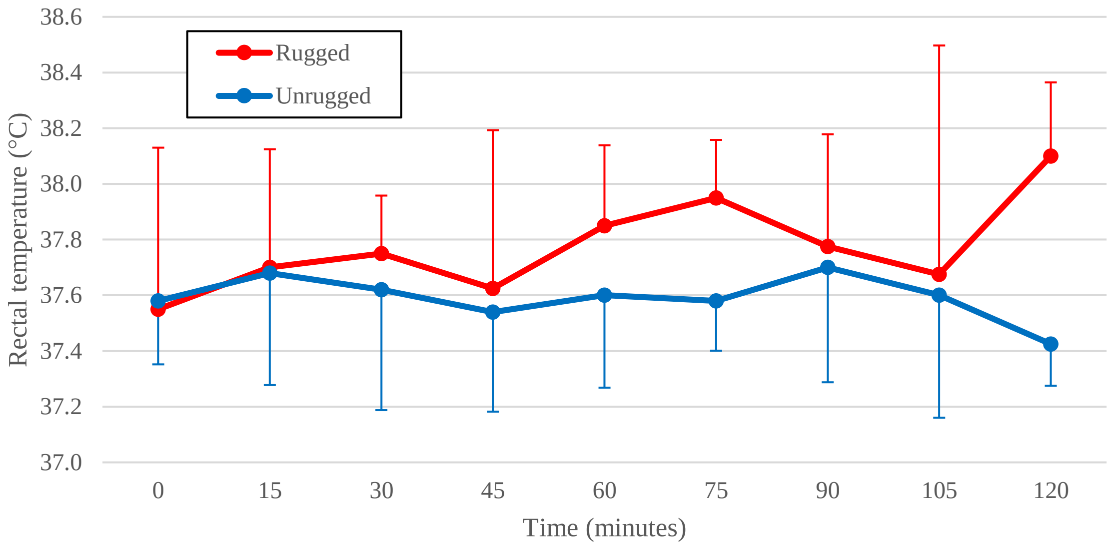

Figure 1: Average rectal temperature (°C) in rugged (n=4, red) and unrugged (n=5, blue) horses over 120 minutes. Time=0 baseline measurement (no treatment in either group). Standard deviation shown by error bars.

Table 1: Environmental conditions during the experiment. *Time point not measured.

Time	**Ambient temperature (°C)**	**Relative humidity (%)**
0 min	19.0	89%
15 min	NA*	NA*
30 min	20.8	85%
45 min	20.7	85%
60 min	19.3	92%
75 min	18.5	90%
90 min	19.1	95%
105 min	19.1	95%
120 min	19.0	95%

There were no significant differences in the HR (p=0.517291) or RR (p=0.057507) of rugged and unrugged horses in this study (Figures 2 and 3).

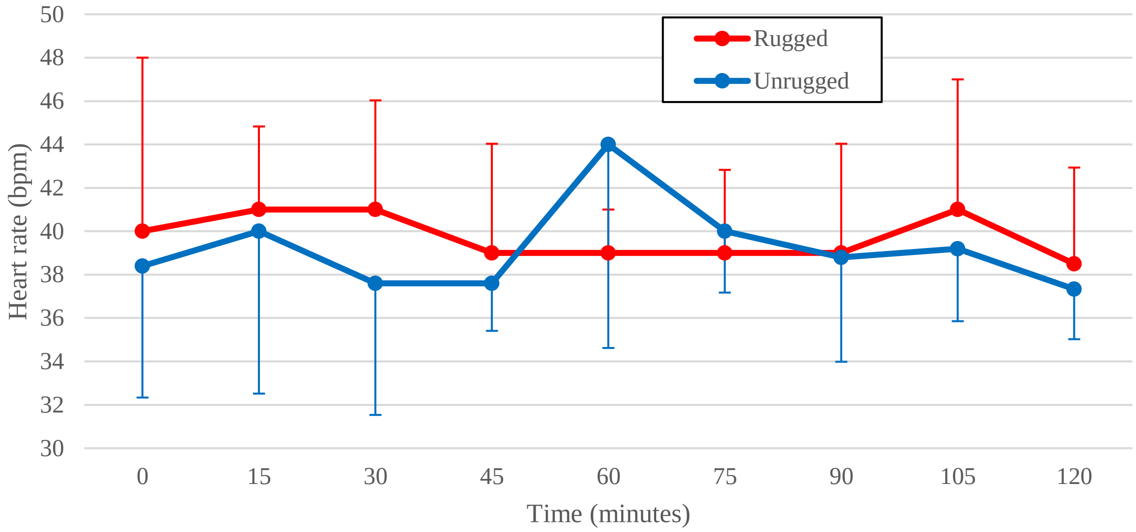

Figure 2: Average heart rate (beats per minute) in rugged (n=4, red) and unrugged (n=5, blue) horses over 120 minutes. Time=0 baseline measurement (no treatment in either group). Standard deviation shown by error bars.

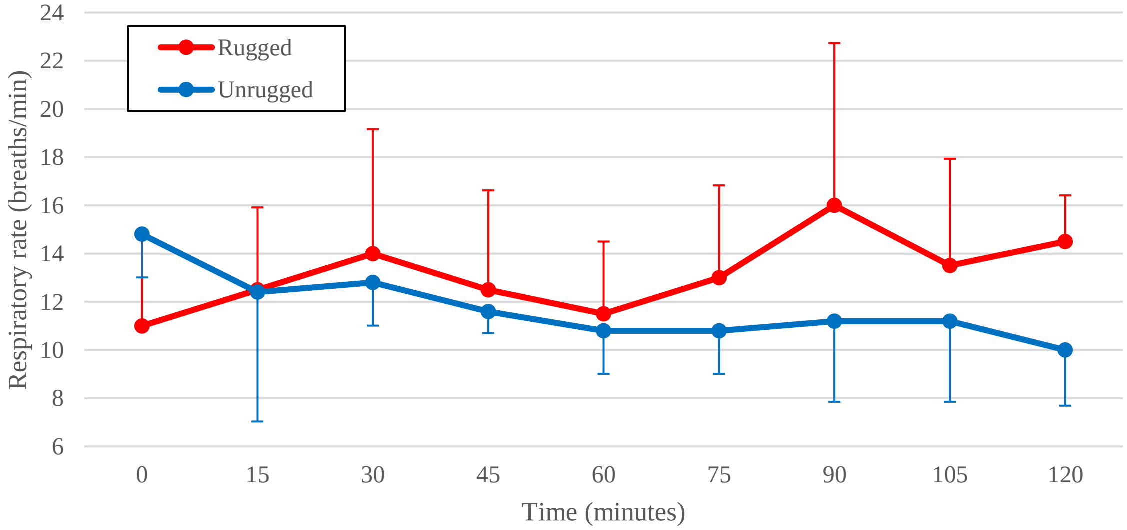

Figure 3: Average RR (breaths/min) in rugged (n=4, red) and unrugged (n=5, blue) horses over 120 minutes. Time=0 baseline measurement (no treatment in either group). Standard deviation shown by error bars.

Discussion

The ambient temperatures experienced during this experiment are well within the horse's ability to tolerate without changing metabolic rate (Morgan, 1998; McBride et al., 1985 as cited in Cymbaluk, 1994). The results of this study show that placing waterproof rugs on stabled horses increases RT above that of horses left unrugged. Average normal RT in horses is 37.0-38.5°C (Coumbe, 2012), and while the RT in both groups stayed within that range, the rugged group appeared to be approaching the upper range, while the unrugged group remained fairly stable over time. It is possible that the rugged horses were less able to dissipate body heat, resulting in an increase in core temperature (Hartmann et al., 2014; Wallsten et al., 2012). A similar effect has been shown in exercising horses, where the use of exercise blankets in colder (<0°C) conditions caused RT to increase to a similar degree as shown in this study; the authors considered this a sign of overheating (Wallsten et al., 2012).

While a transient overheating is usually effectively managed through evaporative cooling (via sweat and respiration) and other mechanisms, reducing this capacity (e.g. by preventing evaporation of sweat by rugging) for a prolonged period may cause unnecessary increases in metabolic rate and physiological stress, and in extreme situations may lead to heat stress (Hodgson, Davis, & McConaghy, 1994). The horse's natural winter coat has significant insulating properties (Morgan, 1997b) and has been shown to increase strain on the thermoregulatory systems and decrease efficiency in exercising trotters in cold weather (Morgan, Funkquist, & Nyman, 2002). It has been shown that the rate of evaporative heat loss in standing horses is constant in ambient temperatures up to 20°C, but that there is a substantial rate increase above this temperature (Morgan, Ehrlemark, & Sällvik, 1997). Ambient temperatures in the current study were just at this transition zone, suggesting that adding further insulation in the form of a rug may have caused the horses to begin overheating. Elevation of RT towards the end of the time period, evidence of sweat on some rugged horses, as well as an apparent trend for RR to be increasing over time (not significant at this n with the large amount of variation evident) support this idea. It is possible that the rugged horses may have started to use evaporative ventilation to maintain core temperature. Given a longer period the horses may have shown more conclusive signs of overheating; activating cooling mechanisms such as definite sweating and significantly increased RR and HR.

The horses used in this study were beginning to grow winter coats and were acclimated to being outside in cool weather. Acclimatisation is an important factor in thermoregulation; horses that are acclimated to colder conditions tend to have lower TNZ ranges which cause them both to be more comfortable at colder temperatures than non-acclimated animals (Mejdell & Bøe, 2005), and become overheated at lower temperatures (McBride et al., 1985). Even in very cold ambient temperatures, horses are unlikely to use provided shelters, unless there is wind or rain (Mejdell & Bøe, 2005). The horses used in this study were not only rugged, but were also placed inside stables in a barn, which would have reduced any chilling factors such as rain or wind, and increased heat retention. Further study could be directed at horses that are in summer coat and/or acclimated to warm temperatures or being indoors; it is possible that a rug at 20°C may have a different effect in this situation, as horses acclimated to hot conditions can have altered thermoregulation (Geor, McCutcheon, Ecker, & Lindinger, 2000; Guthrie & Lund, 1998). Alternatively, the current study could be modified to examine thermal responses to rugs in the same conditions with the horses outdoors in the weather, rather than sheltered.

A significant limitation of this study was that the horses were not allowed to acclimatise to being in the stables, as it caused differing levels of stress in individuals. One horse needed to be omitted from analysis due to this, and so the study could have been improved by allowing some time (e.g. one hour) for the horses to settle before the experiment was started. Controlling for age and breed/type could also have minimised variation within the study, as it has been suggested that different age groups (McKeever, Eaton, Geiser, Kearns, & Lehnhard, 2010) and breeds/types of horse (Langlois, 1994) may have differing thermoregulatory capacity. Human error could also have produced some extra variability as not all researchers were experienced in taking the measurements.

Conclusions

The findings of this study suggest that it is unnecessary, if not potentially deleterious over a longer time period, to put waterproof rugs on stabled horses on a rainy, cool (<20°C) day, as they are easily within their TNZ and may in fact become overheated.

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