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An investigation into the daily level of voluntary activity of stabled riding school horses.

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Abstract

The importance of correct feeding practice has been highlighted by the increase of prevalence of obesity in horses. Human research has suggested that voluntary activity (VA) levels may have the ability to influence digestive energy (DE) requirements, accounting for 15 – 50% of human daily energy expenditure. Therefore, the aim of this study was to investigate whether levels of non-structured exercise differ between stabled horses with similar bodyweight (BW) and similar structured workloads, but with different estimated DE intakes to maintain their BW. Twelve mature horses were selected based on their estimated DE intake and BW, and were paired according to their BW, breed, estimated DE intake, and structured exercise. Within each pair, one horse (L) had a relatively lower estimated DE intake than the other horse (H) to maintain a similar, constant BW. Estimated DE intake was significantly ($P<0.01$) different between Group L and Group H. Each pair was observed for 72 hours during which structured exercise and non-structured exercise were measured. HR was used as a measure of workload during the structured exercise. Two RT3 accelerometers, located on a roller (RT3-R) and head collar (RT3-H), were used to measure VA levels when stabled in addition to visual observations using focal sampling between 07:00h and 18:00h. RT3-R and RT3-H activity levels were not significantly ($P>0.05$) different between individual horses. Median activity counts were significantly ($P\leq0.001$) higher during the day time (06:30h – 18:29h) compared to the night time (18:30h – 06:29h). Both RT3-R and RT3-H were significantly ($P\leq0.001$) higher around feeding time. Activity measured using RT3 accelerometers suggested higher activity levels for horses in Group H over the 24 hour periods, although this was not significant ($P>0.05$). It was therefore concluded, that differences in VA levels during stabling could not explain the difference in estimated DE requirements between horses with a similar BW and workload.

Keywords

Activity, equine, estimated energy requirement, accelerometer

1.0 Introduction

The prevalence of obesity in horses used for leisure has been increasing, potentially as a direct result of domestication and current management practices (Argo, 2009; Sillence *et al.,* 2002; Wyse *et al.*, 2008). Weight gain is likely to occur when there is an imbalance between energy intake via the diet and energy requirement (Geor & Harris, 2005; Harris and Kronfeld, 2003). Various intrinsic and extrinsic factors have the potential to affect the digestible energy (DE) requirements of an individual horse being exercised including the horse's body weight (BW) and age plus any individual absorptive and metabolic factors, stage of training and workload, ability and weight of the rider, as well as environment and terrain (Anon, 2007; Harris, 1997; Hintz and Cymbaluk, 1994). However, it has been suggested that the small individual differences in workload between individuals of a similar bodyweight , age and fitness undertaking similar types of structured exercise under the same environmental conditions cannot always explain the variability in estimated DE intake required to maintain a constant BW (Dekker *et al.,* 2007; Dekker, 2009). Individual differences in absorptive capacity or metabolic efficiency are a possible explanation (Anon, 2007), but other less obvious differences may exist between individuals including the amount of non-structured exercise they undertake.

Within current management systems, horses are often housed in individual stables with limited or no turn-out into a paddock or field, which limits their ability to undertake free movement or non-structured exercise (Brehme and Rose, 2007; Harris, 1999; Petersen *et al.*, 2005). In fact very few studies have focussed on the levels of non-structured activity or voluntary activity (VA: any movement within the stable or during turn-out that is not a result of human encouragement) of horses during stabling or turn-out (Rose-Meierhofer *et al.*, 2010; Werhahn *et al.,* 2012) and the potential influence of this on individual DE requirements. Human studies have suggested that VA may play an important role in the regulation of energy balance, where VA is associated with posture maintenance, fidgeting and all other daily activities which are not classified as exercise (Levine *et al.,* 1999; Levine *et al.,* 2000). Reported data in humans has suggested that VA can account for ~15% of the daily exercise expenditure in sedentary individuals to more than 50% of the daily energy expenditure in extremely active individuals (Deriaz *et al.*, 1992; Levine, 2003; Livingstone *et al.*, 1991; Ravussin *et al.*, 1986), and may contribute to the inter-individual variation in susceptibility to weight gain as a response to overfeeding (Levine *et al*, 1999).

The aim of this study was therefore to investigate whether VA levels differed between stabled horses with similar BW, undertaking similar levels of structured exercise but requiring different estimated DE intakes to maintain their BW. It was hypothesised that VA levels would differ during a 24 hour period and that horses with a higher estimated DE intake would have higher levels of VA.

2.0 Material and Methods

Horses and diets

Twelve mature horses (8 geldings and 4 mares) with mean age of 10.9 ± 4.0 years (range: 5 – 18 years) of mixed breeds were selected from a large population of experienced riding school horses (Table 1). All horses were on a routine anthelmintic and dental care program and only animals in good health and dental status, which did not exhibit any stereotypic behaviour, were recruited. All horses had similar levels of structured exercise. This exercise consisted of on average ten student training sessions per week (range: 8 – 12 sessions per week), which included flat work and low level jumping. During the weekend, horses were hacked out or walked out. None of the horses were turned out during the study period. All horses received their standard commercially available diet during the study. The compound feeds were provided twice daily at 07:00h and 16:30h and the hay or haylage was provided three times per day at 07:30h, 12:30h, and 17:00h.

Table 1. Mean (± SD) age, height, bodyweight (BW), body condition score (BCS), estimated DE intake and relative workload (RW) for horses in group L (n = 6) and horses in group H (n = 6). Different letters (a, b, c etc.) indicate significant differences (P<0.05) between the two groups, i.e. ‘a’ is significantly different from ‘b’, etc.

Variable	**Group L (n = 6)**	**Group H (n = 6)**
Age (years)	10.3 ± 4.9 ^{a}	11.5 ± 3.3 ^{a}
Height (cm)	157.7 ± 1.0 ^{a}	162.0 ± 4.6 ^{a}
BW (kg)	518.8 ± 25.8 ^{a}	530.0 ± 30.7 ^{a}
BCS	4.32 ± 0.79 ^{a}	4.32 ± 0.81 ^{a}
DE intake (MJ/day)	102.3 ± 13.9 ^{a}	125.3 ± 8.8 ^{b}
RW (%HR_{max})	42.0 ± 4.2 ^{a}	41.6 ± 3.8 ^{a}

Horses were selected based on their estimated DE intake and their BW, which was monitored weekly (Eziweigh 2, Tru-Test Ltd, Aukland, New Zealand) for a five week period prior to the start to confirm that the chosen horses were maintaining their BW on their individual diets. A BW variation of 1% BW between weekly weighing sessions was considered insignificant and the result of daily variation due to last time of defecation or urination. In addition, body condition (BC) of the horses was determined using either Henneke *et al.* (1983) or Kienzle and Schramme (2004) dependent on the horse's breed. The individual DE intakes were estimated based on the DE values (MJ/kg) of commercially available feeds as provided by the feed manufacturers, and the DE values of hay or haylage as determined by an independent laboratory (Direct Laboratories, Wolverhampton, UK).

Horses were paired based on a number of variables, including BW, breed, structured exercise load, and estimated DE intake. A maximum difference of 6% BW between paired horses was allowed. Each pair consisted of one horse (L) which received a relatively lower amount of estimated DE (MJ/kg) (mean 18 ± 8% lower) than the other horse (H) in order to maintain a similar constant BW.

Data collection

Two RT3 accelerometers (StayHealthy Inc, California, USA), located on an anti-cast roller (RT3-R) and on an easy-snap head collar (RT3-H), were used to determine VA levels. Previous work (Dekker, 2009) had demonstrated that these positions provided the most reliable measurements. Both accelerometers were set to record activity over one-minute intervals.

Each pair of horses was observed over a period of 72 hours. During this period, horses were used for their normal riding sessions during which heart rate (HR) was monitored (Polar S610i, Polar, Kempele, Finland), but RT3 accelerometers were removed. Relative workload (RW) was calculated as the mean HR during work as a percentage of the horse's estimated maximum HR ((HR_{max}). HR_{max} was estimated using the equation: $HR_{max} = 224 - \text{age}$ (Vincent *et al.*, 2006).

In addition to data collected by the RT3 accelerometers, horses were observed visually between 07:00h and 18:00h during the 72h study period. Focal sampling with continuous recording was used for 30 minutes, with one horse being the focus at any one time. Observation periods were allocated evenly between paired horses, enabling a representation of their activity pattern to be evaluated. Horses were observed before, during, and after concentrate meals as well as between meals and training sessions. The observer was situated outside the stable with a clear view of the horse. Different stable activities and behaviours were recorded during one minute time periods, which coincided with the RT3 accelerometers' intervals. These activities were further categorised as leg movement, head movement, and total movement per minute during data analysis.

Statistical analysis

Data were analysed using SPSS version 15.0 for Windows. Using the Shapiro-Wilk W test it was determined that raw data was not normally distributed ($P>0.05$). Therefore, the median of the data was used when aggregating the rough data to one hour intervals (n = 288), time periods (day: 06:30h – 18:29h and night: 18:30h – 06:29h, n = 24), day level (n = 36) and horse level (n = 12). Spearman's correlation coefficient (r_s) with a significance level of $P\leq0.05$ was used to determine correlations between monitored activity and observed activity using the raw data.

Aggregated data for hourly intervals, day periods, day level, and horse level showed a normal distribution established using the Shapiro-Wilk W test with a significance level of $P \leq 0.05$, allowing for the use of further parametric tests. Pearson's correlation coefficient (r) was used to determine correlations between horse characteristics and aggregated data at horse level. Secondly, a one-way ANOVA with a Bonferroni post-hoc test with a significance level of $P \leq 0.05$ was used to determine whether VA levels were consistent during 72h observation period using aggregated data at day level, as well as whether the mean daily activity measured by RT3-R and RT3-H were significantly different between horses. Thirdly, an independent t-test with significance level of $P \leq 0.05$ was used to determine significant differences for RT3-R and RT3-H between day time and night time using the aggregated data for time periods. Finally, aggregated data at hour level was used to determine patterns of daily activity in addition to observed activity through visual observations.

3.0 Results

Throughout the study the horses maintained a consistent BW (mean variation 2.2 ± 2.3 kg BW) and BCS and remained clinically healthy. All horses remained sound and maintained their normal weekly workload. Within pairs the average difference in BW was 3.3 ± 1.7 %BW.

Observed activity

On average each individual horse was observed for 515.6 ± 94.4 minutes (range: 451 – 627 minutes) between 07:00h and 18:00h over the three consecutive days. The number of observed minutes was not significantly different ($P > 0.05$) between horses in Group L and Group H (506.8 ± 93.5 minutes and 524.3 ± 103.3 minutes, respectively). The main observed activities included standing (52.4 ± 10.1%), eating hay (41.7 ± 9.6%) and eating concentrate feed (5.8% ± 2.6%). Observed activity showed weak, but significant ($P < 0.05$) correlation with monitored activity. Activity measured by RT3-R showed a weak correlation ($r = 0.22$) with the amount of time spent walking and moving around the stable. The activity recorded by the RT3-H showed a moderate correlation with eating ($r = 0.40$) and vertical head movement ($r = 0.24$).

Monitored daily activity

Data from RT3-R (median counts = 6.5, range: 0 – 144) was significantly (P<0.0001) lower compared to data from RT3-H (median counts = 144, range: 0 – 2073.5). There was no significant difference between individual horses for median daily activity as measured by the RT3-R (P>0.05) and RT3-H (P>0.05). No significant correlations (P>0.05) were found between median activity counts of the individual horses and the horses' characteristics, including age, BW, BCS, DE intake, and RW.

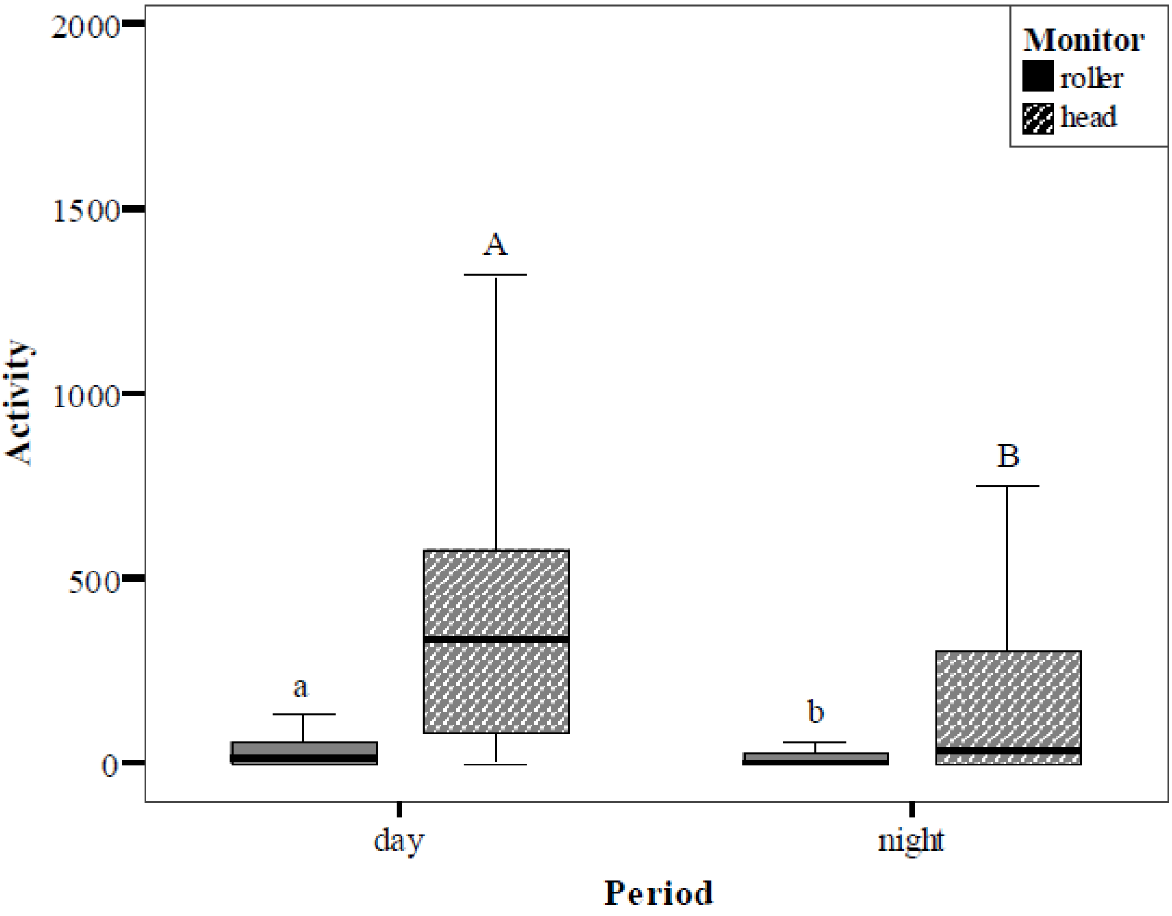

Figure 1. Median RT3 roller and median RT3 head activity during the day time (06:30h – 18:29h) and the night time (18:30h – 06:29h) (N = 12). N equals the number of horses. Bars with different letters are significantly different (P<0.05), i.e. 'a' is significantly different from 'b', etc.

Median activity counts of the horses was significantly (P≤0.001) higher during the day time (06:30h – 18:29h) for both RT3-R and RT3-H compared to night time (18:30h – 06:29h) (Figure 1). In addition, RT3-R and RT3-H differed significantly between individual hours (Figure 2), with increased activity being measured around 07:00h, 12:00h, and 16:30h. This was associated with the time of feeding. Both RT3-R and RT3-H were significantly (P≤0.001) higher during the eating of compound feeds compared to the eating of hay.

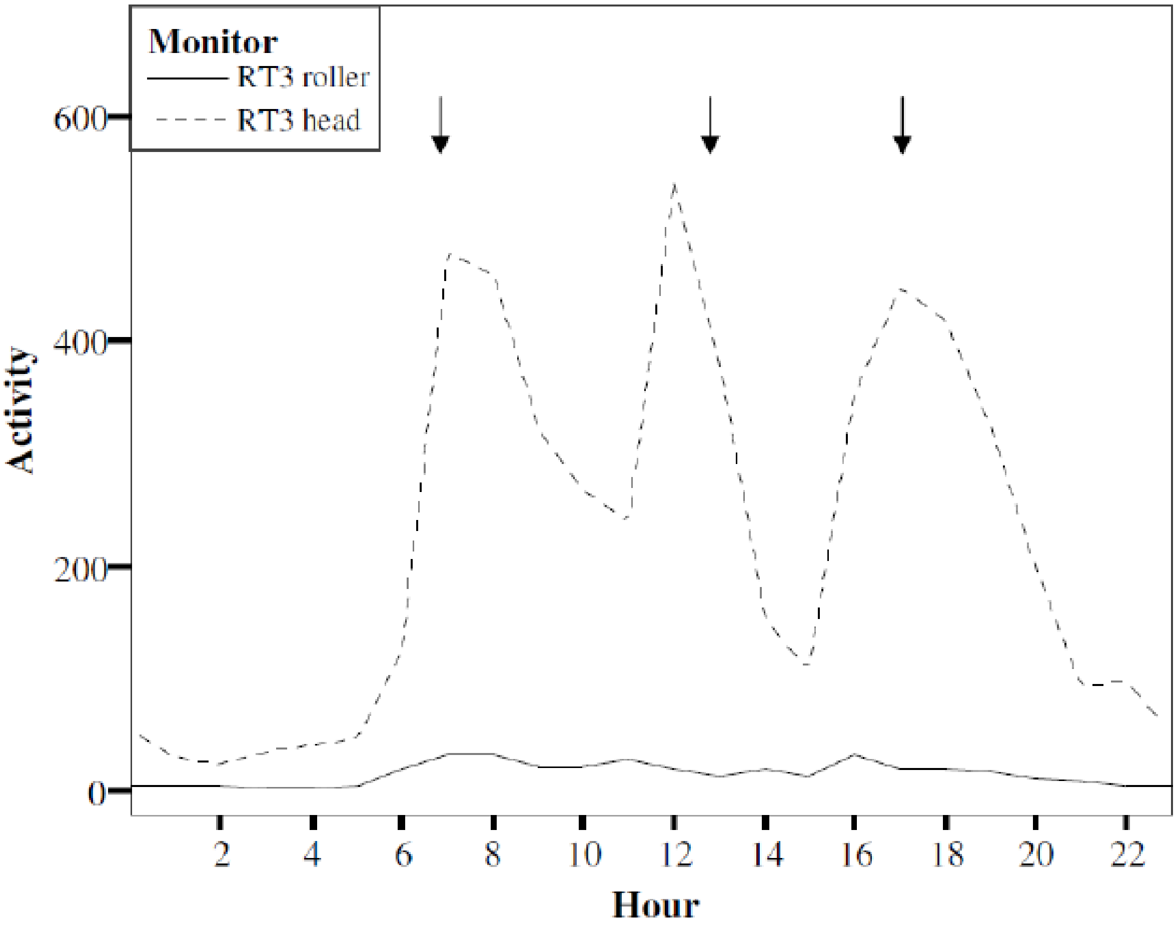

Figure 2. Activity pattern of mean RT3 roller activity and mean RT3 head activity over a 24h period (N = 12). N equals the number of horses. Arrows indicate occurrence of feeding

Activity within pairs

Group L and Group H did not differ significantly (P>0.05) in mean age, mean height, mean BW, mean BCS, and mean RW. Although the use of compound feeds did not differ between the two groups, the estimated DE intake (MJ/day) was significantly ($P<0.01$) different (see table 1) as expected. Horses in group L were visually observed to move significantly ($P<0.05$) more per minute than horses in group H (12.9 ± 7.8 movements per minute and 11.3 ± 7.2 movements per minute, respectively). However, activity measured using RT3-R and RT3-H indicated higher overall activity counts for horses in group H compared to group L during the daytime and night time periods as well as over 24 hour periods, although these differences were not significant ($P>0.05$) (Table 2).

Table 2. Mean (± SD) counts of the RT3 roller and RT3 head activity for horses in Group L (n = 6) and Group H (n = 6). Mean values for daytime (06:30h – 18:29h), night time (18:30 – 06:29h), and 24 hour period derived from data collected over a period of 72 hours. Different letter (a, b, c, etc) indicate significant differences ($P<0.05$) between the two groups, i.e. ‘a’ is significantly different from ‘b’, etc.

Time	**RT3**	**Group L (n = 6)**	**Group H (n = 6)**	**All horses (n = 12)**
Day time	Roller	20.0 ± 12.8 ^{a}	20.5 ± 16.6 ^{a}	20.3 ± 14.2
(06:30h – 18:29h)	Head	376.0 ± 147.8 ^{a}	322.4 ± 109.4 ^{a}	349.2 ± 127.1
Night time	Roller	2.1 ± 3.1 ^{a}	5.8 ± 7.0 ^{a}	3.9 ± 5.5
(18:30h – 06:29h)	Head	36.8 ± 30.7 ^{a}	69.8 ± 47.7 ^{a}	53.3 ± 42.0
24 hour period	Roller	9.7 ± 6.3 ^{a}	11.3 ± 9.7 ^{a}	12.1 ± 13.4
	Head	117.4 ± 113.5 ^{a}	184.0 ± 88.9 ^{a}	201.3 ± 177.2

4.0 Discussion

The use of accelerometers to objectively measure activity in horses has been reported in various different contexts (Berger *et al.*, 1999; Burla *et al.*, 2014; Piccione *et al.*, 2008; Scheibe *et al.*, 1998), although to the authors’ knowledge no link has been made to energy expenditure and

DE requirements of the horse. With the knowledge that VA levels can account for more than 50% of the daily energy expenditure in extremely active human individuals (Deriaz *et al.*, 1992; Levine, 2003; Livingstone *et al.*, 1991; Ravussin *et al.*, 1986), it could be presumed that similar principles could be underlying to the anecdotal evidence that horses of similar BW and structured workload have significantly different DE requirements

Because of the various variables known to influence DE requirements in horses, the horses in this study had been paired according to a similar BW, age, breed, and estimated RW, but with significantly ($P<0.05$) different DE requirements (MJ/day) to maintain their BW and RW. Breed was considered an important factor, as previous results have indicated that reactivity, temperament, and VA levels tend to vary between different breeds (Hausberger and Muller, 2002; Lloyd *et al.*, 2008; Søndergaard and Ladewig, 2004). Although horses in Group L were visually observed to move significantly ($P<0.05$) more than horses in Group H, this was not mirrored in the recordings of the RT3-R and the RT3-H activity. Therefore, it can be presumed that other variables have a larger influence on the daily DE requirements of horses than VA levels in the stable.

Although VA levels were similar over the 72h observation periods, day time activity (06:30h – 18:29h) was found to be significantly higher ($P\leq0.001$) compared to night time activity (18:30h – 06:29h) for all horses. The higher activity levels recorded during the day time could be attributed especially to behaviour around feeding time (Figure 2). Increased activity levels have previously been recorded as anticipation behaviour (Cooper and Mason, 1998; Cooper *et al.*, 2000; Cooper *et al.*, 2005). However, in contrast to these studies, it is important to note that none of the horses in the current study performed any stereotypical behaviours. It can therefore be suggested that anticipation of feeding can result in an increase in activity in horses in general, not just those with stereotypies. Day time activity did not differ significantly between the two groups (Table 2), suggesting further that activity on the yard and the horses' exercise and feeding regimen strongly influenced day time VA levels. Indeed, horses have previously been shown to spend significantly less time resting after exercise and more time feeding and drinking (Caanitz *et al.*, 1991).

Although no visual observations were undertaken during the night time, it may be presumed that horses spent the majority of their time resting and ingesting hay, as reported by Greening *et al.* (2013). It is of interest to note that VA levels were slightly higher for horses in Group H, although the difference was not significant ($P>0.05$). Horses were all stabled on a combination of rubber matting and shavings, limiting the variable of bedding on behaviour and activity patterns during the night time period (Greening *et al.*, 2013). The difference between the two groups may potentially be the result of large individual differences within a relatively small sample size. Therefore, it is suggested that a larger sample size would be required to ascertain this. Although VA levels during turn-out were not evaluated during this study, this should also be considered as an influencing factor for differences in daily DE requirements between similar horses. It is suggested that further research is undertaken within this area.

5.0 Conclusion

The present study objectively measured the activity levels of stabled, general purpose horses with no stereotypical behaviours. Differences in VA levels could not explain the difference in estimated DE requirements between pairs of animals of a similar age with similar BW, workload, etc., although the trend for differences over night might suggest that it potentially could have a small role to play in stabled horses.

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