Investigation of the effect of pasture and stable management on large intestinal motility in the horse, measured using transcutaneous ultrasonography

S. WILLIAMS, C. A. TUCKER, M. J. GREEN and S. L. FREEMAN*

School of Veterinary Medicine and Science, University of Nottingham, UK.

Keywords: horse; intestinal motility; management; ultrasonography

Summary

Reason for performing study: Management regimes have been identified as risk factors for equine intestinal motility disorders. However, it is not known how management factors affect gastrointestinal motility.

Hypothesis: Large intestinal motility was similar in horses on a stabled and a pastured management regime.

Objective: To investigate the effect of 2 different management regimes on large intestinal motility assessed with ultrasonography.

Methods: A within-subjects crossover design was used to compare large intestinal motility between a stabled and a pastured regime in 16 working horses. Group A was managed under a standardised stabled regime throughout the study. Group B was maintained at pasture for the first monitoring phase and then transferred to the stabled regime for the second monitoring phase. Motility of the caecum, sternal flexure and aboral left ventral colon (contractions/min) was measured twice daily for 2 consecutive days using transcutaneous ultrasonography. Mean values for each management regime were pooled for analysis using multilevel statistical modelling.

Results: Significant variables identified by the model included: time of day, region of intestine, management regime, and combination of region of intestine and management regime. Motility assessed by ultrasound was significantly lower in stabled horses compared to pasture-kept horses. Intestinal motility for caecum was 1.7 ± 0.3 contractions/min (pastured = 2.0, stabled = 1.4), sternal flexure was 1.6 ± 0.2 contractions/min (mean (pastured = 1.7, stabled = 1.5), and left ventral colon was 0.8 ± 0.3 contractions/min (pastured = 1.0, stabled = 0.7).

Conclusions: The null hypothesis was disproven. Large intestinal motility assessed by ultrasound was significantly reduced in stabled horses compared to pastured horses. This effect was most marked in the aboral left ventral colon.

Potential relevance: This study has demonstrated a possible mechanism for the increased risk of large intestinal impactions in stabled horses.

Introduction

The horse has a highly specialised large intestine, which has evolved to cope with the ingestion of large quantities of grass. Domestication and stabling have dramatically changed the natural feeding patterns and diet of the horse.

Colic is a significant cause of morbidity and mortality in the horse (Tinker et al. 1997) and large intestinal conditions are amongst the most common causes of colic (Reeves et al. 1989; Proudman 1991; Dabareiner and White 1995).

Management regimes have been identified in epidemiological studies as a significant risk factor for equine colic. Stabling has been associated with a significant increase in colic compared to horses that are not stabled (Cohen et al. 1995; Hudson et al. 2001). Other components of a stabled regime, such as feeding concentrates, are also significantly associated with colic (Tinker et al. 1997; Hudson et al. 2001; Abutarbush et al. 2005).

Epidemiology has identified risk factors for colic, but further study is required to elucidate how these factors alter gastrointestinal function.

The aim of this study was to determine the effect of management regimes on large intestinal motility, assessed by ultrasound. The null hypothesis was that horses on a stabled regime would have similar large intestinal motility compared to those on a pastured regime.

The objectives of the study were to determine the effect of region of the large intestine, time of day and type of management regime on large intestinal motility assessed by transcutaneous ultrasonography.

Materials and methods

The study was approved by the Ethics Committee at the School of Veterinary Medicine and Science, University of Nottingham.

Subjects

The study was performed in horses permanently based at the Defence Animal Centre, Melton Mowbray and used for equitation training. Horses were initially allocated into 2 groups of 8 animals.

*Corresponding author email: sarah.freeman@nottingham.ac.uk

[Paper received for publication 15.01.11; Accepted 14.03.11]
Group A acted as a control group and was selected from a population that were maintained on a stabled regime throughout the study. Group B was selected from horses turned out to pasture, which were then transferred to the same stabled regime as Group A.

Selection criteria for the study were: no history of gastrointestinal disease within the previous 12 months, participation in an established anthelmintic programme, clinically normal at the start of the study and subject to the specified management regime for a minimum 2 week period prior to recruitment to the study.

Fifteen geldings and one mare, aged between 7–16 years old and ranging in height from 163–180 cm were recruited. Breed types were Irish Draught, Dutch Warmblood or crossbreds.

Study design

A within-subjects crossover design was used; horses in Group A were maintained under the stabled regime throughout the study, while horses in Group B were subjected to both stabled and pastured management regimes. This study design aimed to ensure that differences in motility were a result of the management regime and not confounding unknown external factors. This was ensured by having a group that was stabled throughout to compare with the horses transferred to the stabling regime.

Horses in Group A were stabled on shavings, with continuous access to fresh water. Hay and concentrates were fed twice daily according to the establishment’s feeding regime. The average daily haynet weighed 7.6 kg. The concentrate ration was pasture cubes (Pasture Cubes) and chaff (Fibergy Chaff), fed according to bodyweight and body condition score, plus 30 ml of cod liver oil. Concentrate feed was divided into 2 equal meals, given at 07.00 h and 16.30 h. All horses received 60–90 min of light exercise/day between 10.30 h and 12.30 h.

Horses in Group B were kept at pasture 24 h a day, with continuous access to fresh water. They received no controlled exercise and no supplemental feed. During the study, horses in Group B were transferred to the stabled regime described for Group A. They had a 2 week acclimatisation period of gradually increasing concentrates and exercise (according to the normal Defence Animal Centre protocol), before the second monitoring phase during the stabling regime. Monitoring phases were therefore at least 2 weeks following a change in management.

The management regimes were part of the routine management implemented by the Defence Animal Centre - no alterations were made for the purpose of this study.

One horse in Group B was excluded from the study as its diet was supplemented with concentrate meals whilst at pasture. Two horses in Group B remained at pasture for the full duration of the study and therefore all measurements from these 2 horses were grouped with the pastured data. In summary, data from the stabled regime consisted of measurements pooled from 13 horses, while data from the pastured regime consisted of measurements pooled from 7 horses.

Ultrasonographic assessment

Transcutaneous ultrasonography was used to assess motility of the caecum, sternal flexure and left ventral colon, using methods as described by Freeman et al. (2001).

Each horse was prepared, without clipping, by cleansing with antiseptic solution (Hibiscrub) and alcohol (Surgical Spirit), followed by application of a coupling gel (BCF Technology Ltd). Real time B mode ultrasonography was performed in the same order of each region, using a MyLab 30 with a 5–7.5 MHz curvilinear transducer (Esaote).

The caecum was imaged in the caudal right flank in the paralumbar fossa region with the probe oriented dorsoventrally. Sternal flexure was imaged in the midline cranioventral abdomen, caudal to the sternum, with the probe oriented lateromedially. Aboral left ventral colon was imaged in the caudal ventral abdomen close to the inguinal region, with the probe oriented craniocaudally. Regions of the intestine were identified by their position in the abdomen and ultrasonographic features (Freeman and England 2001; Williams et al. 2011).

Motility was assessed twice daily for 2 consecutive days in each monitoring period. First measurements were made in the morning between 08.00 h and 10.00 h, and the second measurements were made in the afternoon between 13.00 h and 15.00 h. All examinations were performed in a stable with minimal restraint of the horse. Two horses from each study group were examined on each day (4 horses/day).

The frequency of contractions was measured for 4 one minute periods, for each region of the intestine, repeated at each measurement time (AM or PM). Contractions were recognised as the movements of the intestinal wall and luminal contents. Contractions were not categorised by type/orientation. The number of contractions/min was evaluated by 2 observers at each measurement time.

Data analysis

The data were initially evaluated in Microsoft Excel 2007, and the distributions of contractions/min for region of intestine, management regime and time of day (AM or PM) were assessed graphically.

Statistical analysis was performed using a ‘random effects’ generalised linear mixed model in MLwiN (version 2.10, Rasbash et al. 2009). This type of model was used because it allowed the correlations within the data (in this case the repeated measurements within each horse), to be dealt with appropriately. The response variable of interest was the number of contractions/min for each region of intestine. Therefore, individual horses were classified as level 2 units and the ‘within-horse’ measurements (contractions/ min) as level 1 units. Therefore, in the final model, the coefficients provided an estimate of the difference in contractions/min, between each category of the predictor variables. The predictor variables (fixed effects) tested in the model were ‘time of day’ (AM or PM), ‘management regime’ (stabled or pastured), ‘region of the large intestine’ (caecum, sternal flexure, left ventral colon). Predictor variables were deemed significant and remained in the model when $P<0.05$. Interactions were tested between significant predictor variables and also remained in the model when $P<0.05$. Model fit was evaluated using conventional methods based on graphical assessments of residuals.

Results

There was no significant difference in contractions in Group A between both study phases (stabled consistently throughout the study), or in the stabled horses in Groups A and B. All measurements for each management regime were pooled for statistical analysis.
**Comparison of motility between different regions of the intestine**

The mean frequency of contractions for the caecum was 1.7 ± 0.3 contractions/min (pastured = 2.0, stabled = 1.4), sternal flexure was 1.6 ± 0.2 contractions/min (pastured = 1.7, stabled = 1.5), and for the aboral left ventral colon was 0.8 ± 0.3 contractions/min (pastured = 1.0, stabled = 0.7). The frequency of contractions in the aboral left ventral colon was significantly lower compared to the sternal flexure and caecum across both management regimes. For the pastured regime, the frequency of contractions was highest in the caecum and lowest in the aboral left ventral colon. With the stabled regime, the frequency of contractions was highest in the sternal flexure and lowest in the aboral left ventral colon region. The frequency of intestinal contractions in the aboral left ventral colon region was significantly lower compared to the sternal flexure and caecum in both management regimes (Table 1, Fig 1). There was no significant difference in contractions between the caecum and sternal flexure in horses on either management regime (Fig 1).

The final model is summarised in Table 1 and key findings are given below. Model residuals followed a normal distribution and were consistent with good model fit.

<table>
<thead>
<tr>
<th>Region of the large colon and management regime</th>
<th>Mean frequency of contractions (contractions/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caecum</td>
<td>Stabled</td>
</tr>
<tr>
<td>Sternal flexure</td>
<td>2.0</td>
</tr>
<tr>
<td>Aboral left ventral colon</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Standard errors that are <0.5 of each coefficient are significant at P<0.05.

**Effect of time of day on intestinal motility**

The frequency of intestinal contractions was significantly increased in the afternoon compared to the morning in both management regimes (Table 1, Fig 2).

**Effect of management regime on intestinal motility**

The frequency of contractions of all intestinal regions collectively was significantly lower when horses were stabled compared to the pasture regime (Table 1). Contractions were significantly less frequent in the sternal flexure and aboral left ventral colon region when horses were stabled compared to the pasture regime (Table 1).

The null hypothesis was disproven - there were significant differences in large intestinal motility assessed by ultrasound between the stabled and pastured regimes.

**Discussion**

The results of this study demonstrate that the stabled horses in this study have different large intestinal motility assessed by ultrasound compared to pastured horses. There are a number of factors that may predispose a horse to colic under stabled conditions, including differences in feed type, feeding patterns and intervals and exercise levels. It seems logical that these factors could mediate an effect by changing motility. This study investigated stabling management as a whole entity rather than isolating specific aspects, such as diet or exercise, thus including the effect of several factors. Subsequent studies will be required to identify the contribution of specific components (such as concentrate feeding, intermittent feeding and exercise) to motility changes.

Measuring intestinal motility in the horse is difficult. Ultrasound has been shown to be useful for assessment of motility (Freeman and England 2001; Mitchell et al. 2005; Sasaki et al. 2008). Transcutaneous ultrasound is a noninvasive procedure, that allows for the collection of real-time data. However, there are some limitations when used in the horse. Some regions of the gastrointestinal tract cannot be visualised, while others are highly mobile and can be difficult to repeatedly image. The regions...
of large intestine used in this study were selected as they are common sites of disease and can be repeatably identified using transcutaneous ultrasonography.

This study used transcutaneous ultrasonography as a noninvasive method in a normal working population of horses. This has advantages of evaluating an actual rather than an experimental environment. A small number of horses were lost from the study due to variation in the management. This problem was anticipated and power analysis of data from a previous study (Freeman et al. 2001) had showed that a minimum of 6 horses was required for each regime.

The use of a within-subjects crossover study design was important to control for unknown confounding factors. This was done by using a group that was continuously stabled. As there was no difference in data from this group collected during the first and second phase of measurements, the confounding factors were not significant and the data were pooled for analysis. Statistical multilevel modelling allowed for the analysis of several interlinking factors including both individual variables that were significant, significant interactions between different variables and the effect of repeated measures in the same animals.

This study has produced baseline data on the normal motility of the large intestine in stabled and pastured horses. Frequency of caecal contractions were lower than those reported in other studies (Freeman and England 2001; Sasaki et al. 2008). These may be explained by differences in the size of the horses, the specific ultrasonographic technique, as well as possible effects of the time of day when measurements were made and the timing of measurements relative to feeding times.

Overall, this study clearly demonstrates that large intestinal motility assessed by ultrasound was lower in stabled horses compared to pasture-kept horses. There are a number of different management factors that could contribute to this; dietary factors are likely to play a major role. Concentrate feeding reduces rates of passage of ingesta compared to diets with a higher forage content (Pagan et al. 1998; Drogoul et al. 2001). Concentrates are usually fed as ‘meal boluses’, and studies have shown reduced spike burst activity in the equine pelvic flexure region in fasted compared to fed horses (Merritt et al. 1995). Volume of feed also affects rate of passage, with lower feed intakes associated with higher mean retention times (Pearson and Merritt 1991; Drogoul et al. 2001). Pastured horses will have a more continuous and higher volume of intake of forage, reflective of the natural feeding behaviour of horses.

Activity levels could also contribute to the reduced motility in the stabled regime. Exercise affects gastrointestinal function by decreasing the dry matter digestibility of feed and mean retention time (Orton et al. 1985; Pagan et al. 1998). Prolonged periods of inactivity due to stable confinement could therefore also contribute to the lower intestinal motility in the stabled horses. Activity levels may also contribute to the differences in motility between the morning and afternoon sessions (higher frequency of intestinal contractions in the afternoon); lower motility in the morning could be explained by low levels of activity overnight, although these speculations are not proven since activity was not measured in this study.

Ultrasonography does not provide an analysis of overall digestive transit, but the regional differences in motility identified in this study are interesting and may provide baseline data relating to the aetiology of large intestinal impactions. Pastured horses had the highest frequency of contractions in the caecum, whereas with the stabled regime it was highest in the sternal flexure. The aboral left ventral colon region had the lowest frequency with both regimes. In general, motility decreases in an aboral direction along the gastrointestinal tract to enhance retention of digesta in the large intestine for microbial fermentation and water absorption (Ross et al. 1990). The pastured regime followed this expected pattern in motility across the different regions of large intestine. It might therefore be proposed that the ‘normal’ pattern of motility was altered with the stabled regime. Disruption of normal motility patterns between different regions of the large intestine could potentially lead to an increased risk of gastrointestinal disease, specifically impaction.

The aboral left ventral colon had a significantly lower frequency of contractions in both management regimes. Despite its lower motility, the aboral left ventral colon was identified as the main region that was affected by the stabling regime; this corresponds with the clinical situation, where the pelvic flexure region is the most common site of impactions. Although motility data from clinical cases are not available, impactions are thought to be associated with a reduction in intestinal motility that compromises the flow of ingesta and dehydrates ingesta ( Sellers and Lowe 1986).

There are 2 key findings of this study: firstly large intestinal motility assessed by ultrasound is reduced in stabled compared to pastured horses, particularly in the pelvic flexure region. Secondly the pattern of motility across different regions of the intestine was altered in stabled horses. These results suggest a possible mechanism for the increased risk of impaction in stabled horses. These findings may be of significance in the development of effective management practices to prevent/reduce the risk of colic. Further studies are required to determine which aspects of a stabling regime are the key factors influencing intestinal motility in the horse.

Conflicts of interest

S. Freeman has received a grant from Waltham Foundation in 2009 for a molecular study ‘Effects of diet on fluid balance in the equine gastrointestinal system’.

Sources of funding

S. Williams was funded by the University of Nottingham Interdisciplinary Doctoral Training Centre.

Acknowledgements

The authors would like to thank the staff of the Defence Animal Centre, Melton Mowbray for their collaboration with this project.

Manufacturers’ addresses

1Dodson and Horrell Ltd, Kettering, Northamptonshire, UK.
2Regent Medical Ltd, Dunstable, Bedfordshire, UK.
3Batlle, Hayward and Bower Limited, Lincoln, UK.
4BCF Technology Ltd, Livingstone, West Lothian, UK.
5Esaote Group, Reading, Berkshire, UK.

References


