



ELSEVIER

RESEARCH

Preliminary investigations of horses' (*Equus caballus*) responses to different bridles during foundation training

Jessica S. Quick,^a Amanda K. Warren-Smith^b

^aFaculty of Rural Management, University of Sydney, PO Box 883, Orange, NSW, 2800, Australia; and

^bSchool of Agricultural and Wine Sciences, Faculty of Science, Charles Sturt University, P.O. Box 883, Orange, NSW, 2800, Australia.

KEYWORDS:

behavior;
bit;
bitless;
bridle;
heart rate;
horse;
training

Abstract Throughout equitation history, bitted bridles have been the primary method of controlling the ridden horse. In response to health and behavioral concerns arising from the use of bitted bridles, bitless bridles offer new methods of steering and control. However, the effectiveness of bitless bridles on horses had not been previously examined scientifically. Therefore, the current study measured behavioral and cardiac responses of horses undergoing foundation training (bridling, long reining, and riding) wearing either a bitted or a bitless bridle.

The horses wearing the bitted bridle exhibited more chewing, opening of the mouth, pawing the ground, and tail swishing than those in the bitless bridle. The horses wearing the bitless bridle exhibited more head lowering during long reining compared to those in the bitted bridle. The frequency of chewing, opening the mouth, and head raising decreased as training progressed. The number of steps taken after the application of the halt stimulus was greatest for the horses in the bitted bridle during long reining compared with those in the bitless bridle. During long reining, the heart rate and heart rate variability of the horses were higher for those in a bitted bridle compared with those in a bitless bridle.

The results of this study suggest that horses wearing bitless bridles performed at least as well as, if not better than, those in bitted bridles. If the use of bitted bridles does cause discomfort to horses, as suggested by some, then the use of bitless bridles could be beneficial and certainly warrants further investigation.

Crown Copyright © 2009 Elsevier Inc. All rights reserved.

Introduction

From the time when horses were first tamed as a source of milk and meat 5000 years ago (Waran et al., 2002) to modern day when horses have become companions used for pleasure and sport, a variety of methods designed to control

the horse have existed. One such device is the bit, introduced in 2300 BC with the original design consisting of a straight bar mouthpiece carved from hardwood (Edwards, 2000) and now more commonly made of metal (Britton, 1995).

Bits are fitted within the mouth (Vernon, 1998), and depending on the design of the bit, they are intended to apply pressure to a number of different points on the horse's head including the lips, diastema, hard palate, summit of nuchal crest, lower mandible, and tongue (Waran et al., 2002). As safety is of paramount importance in the equine industry (Macbeth, 2003), humans desire the comfort of knowing

Address for reprint requests and correspondence: A.K. Warren-Smith, Faculty of Science, School of Agricultural and Wine Sciences, Charles Sturt University, P.O. Box 883, Orange, NSW, Australia, 2800; Phone: +61 2 6365 7852; Fax: +61 2 6365 7590.

E-mail: awarrensmith@csu.edu.au

that the horse can be controlled when riding and driving. However, bits are a potential source of enormous discomfort to the horse, as the mouth is a highly sensitive site (McLean and McGreevy, 2005).

Despite the universal use and acceptance of bitted bridles by riders, a substantial number of problems caused by the bit are now hypothesized. These problems are said to range from mild to acute conflict behaviors such as bucking, rearing and bolting, as well as training concerns such as a lack of flexibility, energy, or forward motion, and leaning on or being above the bit (Cook and Strasser, 2003). Expressions of horses' attempts to take flight from a situation that is causing them stress, known as hyper-reactive responses, have been recognized in horse behavior (McLean, 2003). For example, the extension of the neck by raising the head is seen as a hyper-reactive response to bit pressure (McLean and McGreevy, 2005).

Consequently, there are new concepts of horse control emerging that focus on bitless methods. One such design is a bitless bridle, which is based on a method of steering and control not previously used in any other bitted or bitless bridle. Cook's (1999) design is meant to be a "pain-free" rein aid, based on pressure mainly across the nasal plane, less along the cheeks, and least across the nuchal crest. The pressures employed with this bitless bridle are spread over a larger surface area than with a traditional bitted bridle and are essentially used to effectively and gently "push" the horse in the desired direction. A bitted bridle, on the other hand, would tend to focus greater pressure on the smaller and highly sensitive region of the horse's mouth (Cook, 1999).

The bitless bridle should not be confused with existing bitless bridles such as the hackamore or bosal, as the construction and function of the styles differ greatly. For instance, when used correctly, the hackamore provides communication using anterior pressure, which is effective to restrain forward movement, halt, and encourage the horse to lower its head (Britton, 1995). However, lateral communication for turning and steering is limited in hackamore and bosal bridles (Cook and Strasser, 2003) without supplemental training to teach the horse to respond to an indirect or neck rein. It is often thought that since such pre-existing bitless bridles do not incorporate a bit in their design, they are not capable of inflicting pain to the horse. However, they still hold the potential to cause injury if used by a rider with unyielding hands. This is of particular importance when combined with the leverage offered by devices with longer curb shanks, as the pressure applied by the rider that is already concentrated over relatively small areas of the nose and poll is intensified (Britton, 1995). In conjunction with the potentially painful materials used to construct some bitless bridles, such as chain in the noseband, it can take very little physical effort on the part of the rider to injure a horse's nose or jaw.

In training and behavioral studies, cardiac measures such as heart rate and heart rate variability have been regarded as

measures of stress in horses (Mohr et al., 2000; Visser et al., 2002). Likewise, certain behavioral responses such as ear movements (Heffner and Heffner, 1983; Wolski, 1984), head position (Feist and McCullough, 1976; Kesel and Neil, 1998; Waring, 2003), licking of the lips and chewing (Parelli, 1993; Roberts, 1996), and pawing and sniffing the ground (McDonnell and Poulin, 2002) have also been regarded as measures of the arousal state of horses.

Accordingly, the following study examined the cardiac and behavioral responses of horses undergoing foundation training wearing either a bitless bridle or a bitted bridle.

Materials and methods

Horses

Six horses (aged 2 years) of thoroughbred ($n = 2$), warmblood ($n = 2$) or Australian stock horse ($n = 2$) breeding that had previously had only basic training with a head collar and lead rope (i.e., had not previously had a bridle or saddle on, or been mounted) were originally recruited into the program. Three of the horses were geldings and three were fillies. None of the fillies was observed to be showing signs of estrus during the study. Unfortunately, owing to circumstances beyond the control of the experimenters (one horse was injured and one student withdrew from the program), only 4 horses completed the study. The horses were housed in yards (9 m x 6 m) that included rubber-lined shelters with a pine shavings bed at the Orange Campus Equine Centre of Charles Sturt University. The horses were maintained on hay (Lucerne and oaten) and supplemented with a concentrate feed (CopRice Cool Conditioner, CopRice, PO Box 561, Leeton, NSW, 2705, Australia) to meet National Research Council (1989) equine nutritional guidelines.

Procedure

Both bridles were full sized. The bit used in the bitted bridle was a standard, full-sized Fulmer (FM) (full-cheek) snaffle. The bitless bridle used was the BitlessBridle (BitlessBridle, Inc., Wrightsville, PA, USA), which makes use of an under the chin crossover strap (Figure 1). The horses were paired for breed and sex such that half the horses wore a bitted bridle and the other half a bitless bridle (Table 1). Prior to the commencement of the trial, all horses were familiarized with wearing a firmly secured lunge roller. They were initially introduced to the test arena during the first 2 days of foundation training and free-lunged at walk and trot until they appeared to be in a calm state. This was assessed by observation of the horses not showing any behavioral signs of tension such as alertness, raised head carriage (Feist and McCullough, 1976; Kesel and Neil, 1998; Waring, 2003), and increased frequency of ear movements (Heffner and Heffner, 1983; Wolski, 1984).

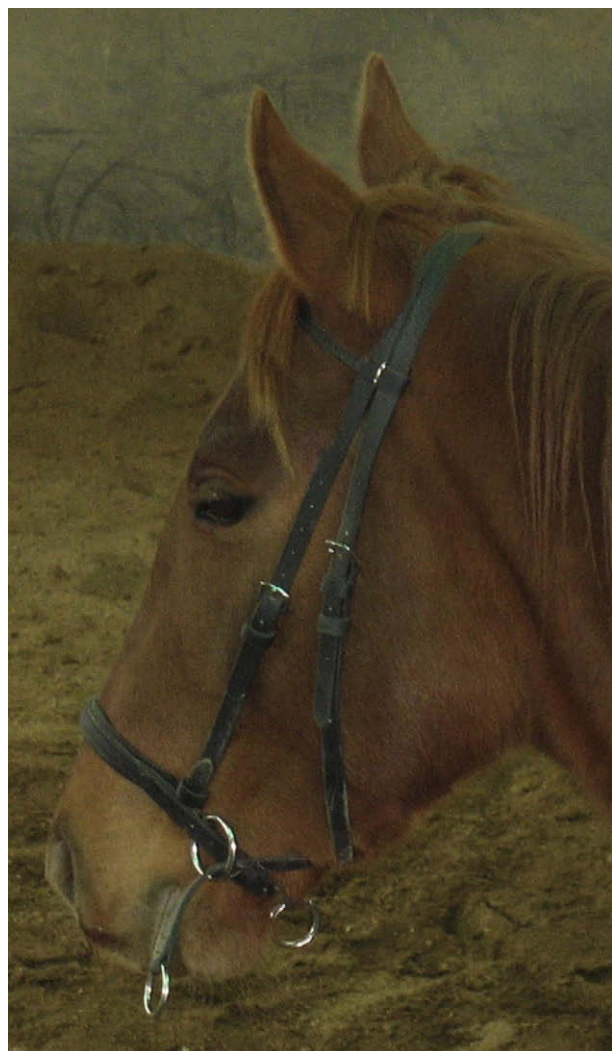


Figure 1 The bitless bridle on one of the horses used in testing.

On the test days, each horse was caught, had a webbing head collar and cotton lead rein applied, and led into the center of the test arena. Surcingles secured the heart rate monitor (Polar Accurex II, Baumann and Haldi, Switzerland) such that the lubricated electrodes were placed under the surcingle, 15 cm below the withers on the right side and behind the elbow on the left side. At the commencement of each session, each horse was held still while a pretest heart rate was recorded for 60 seconds. The day-to-day procedure for the foundation training was then followed as described

Table 1 The characteristics of the horses and the bridle group to which they were allocated

| Horse | Age (y) | Breed | Sex | Bridle |
|-------|---------|------------------------|---------|---------|
| 1 | 2 | Warmblood | Gelding | Bitted |
| 2 | 2 | Warmblood | Filly | Bitless |
| 3 | 2 | Thoroughbred | Gelding | Bitless |
| 4 | 2 | Australian stock horse | Filly | Bitted |

in Table 2. The sequence of testing of pairs alternated, but the same experienced handlers who were familiar to the horses were used throughout testing. The procedures used in these trials were normal handling procedures, and the experimental protocol was approved under Protocol Number 06/120 (Animal Care and Ethics Committee, Charles Sturt University, Australia).

Bridling

The heart rate monitor application was completed as described above. Each horse was fitted with a bridle according the group to which they were allocated (Table 1). The procedure for putting on the bridle was as follows. Beginning with the horse wearing a halter and lead rope, the handler would stand on the left side of the horse, at the neck, facing in the same direction as the horse. Then with the right hand holding the bridle and passing under and around to the front of the horse’s nose, the left hand then guided either the bit into the horse’s mouth for the bitted bridle or the crossover straps under the chin for the bitless bridle. Once the bit or crossover straps were in place, the bridle was placed over the ears to be positioned on the summit of the nuchal crest. The throatlatch of the bitted bridle was secured and fitted, allowing for approximately 5 cm between the throatlatch and the throat (Edwards and Thomas, 1998). The buckle on the chin strap of the bitless bridle was tightened so that one flat finger was able to fit between the chin strap and the ventral aspect of the mandible. Once the bridle was securely in place, the horse was held still beside the handler for 5 minutes. The bridle was

Table 2 The day-to-day procedure for the foundation training that was followed

| Day | Procedure |
|-----|--|
| 1 | All horses were introduced to the test arena. |
| 2 | All horses were introduced to the test arena. |
| 3 | All horses were bridled for the first time in the test arena. |
| 4 | All horses were bridled for the second time in the test arena. |
| 5 | All horses were bridled for the third time in the test arena. |
| 6 | All horses were long reined for the first time in the test arena. |
| 7 | All horses were long reined for the second time in the test arena. |
| 8 | All horses were long reined for the third time in the test arena. |
| 9 | All horses were ridden for the first time in the test arena. |
| 10 | All horses were ridden for the second time in the test arena. |
| 11 | All horses were ridden for the third time in the test arena. |

then removed by undoing the throatlatch and noseband or chin strap, then sliding the headpiece forward over the horse's ears and allowing the bridle to fall gently off the head. The horse was then held still beside the handler for a further 60 seconds to determine the horse's response after the bridle was removed.

Long reining

The heart rate monitor application and bridling procedure were completed as described above. Once bridled according to their allocated group, cotton lunge reins were attached to the bit rings on the bitted bridle or to the rings of the crossover straps on the bitless bridle. The inside rein passed through the D-ring on the same side of the surcingle and then to the trainer's hand, and the outside rein passed through the D-ring on the outside of the surcingle, around the horse's hindquarters, and then to the trainer's hand. From the center of the arena, the handler guided the horse around the arena using verbal commands and pressure on one or both of the long reins for a period of 10 minutes.

Riding

The bridling procedures were completed as described above. Then, a standard thick cotton saddlecloth and an Australian stock saddle were fitted to each horse and the long reining procedure conducted as previously described. When long reining with the horse saddled, the lunge reins were placed through the corresponding stirrup irons rather than the D-rings of the surcingle. The stirrup irons were tied in the "down" position in place under the horse's girth to reduce free swinging. The heart rate monitor electrodes were securely placed underneath the girth behind the elbow on the left side, and underneath the saddlecloth 15 cm below the withers on the right side. The girth and surcingle were then secured firmly. For safety reasons, given that this was the first time the horses had been mounted, an additional handler (who was familiar to the horses) assisted the rider from the ground. As the handler held the horse from the near (left) side, the rider mounted the horse from the same side. The handler then left the test arena, and the rider proceeded to work the horse in various gaits (walk, trot, and canter) for a total period of 10 minutes.

Measurements and data analysis

All behavioral responses exhibited by the horses were recorded using a Swann Security Video Camera (Swann Communications Pty. Ltd., Richmond, Victoria, Australia) for subsequent analysis on a continuous observation basis. The behavioral responses observed and quantified included chewing, mouth opening, ear movements, pawing the ground, swishing the tail, head shaking, snorting, yawning,

bucking, and defecating and were defined according to [Waring \(2003\)](#). Cranial movements including head lowering, raising, or shaking/tossing. Other responses recorded were sniffing the ground, rubbing the muzzle on the ground or themselves, lifting and stamping a leg, and taking steps. In addition, the number of steps taken after the application of the halt stimulus was also noted. The frequency of each response was counted for each minute, and then the means for the testing time were used in the analysis. Heart rates were recorded continuously at 5 second intervals during testing, and the data were later downloaded using the Polar Equine Software (Version 4.0, Polar Electro Europe BV, Fleurier Branch, Switzerland). Heart rate variability was determined by the number of changes of heart rate during the test period.

The number of horses that completed the trial prevented any reliable statistical analyses, therefore only a descriptive analysis of the data is included. This analysis was performed using Microsoft Excel (2007).

Results

The horses wearing the bitted bridle exhibited more chewing and opening of the mouth than those wearing the bitless bridle throughout all stages of training, and the frequency of these responses decreased as training progressed ([Figures 2 and 3](#)). The horses wearing the bitless bridle exhibited more head lowering during long reining than those wearing the bitted bridle ([Figure 4](#)). All horses, regardless of bridle, showed head raising during training, although the frequency of head raising was least during bridling ([Table 3](#)). The horses wearing the bitted bridle did more head shaking during bridling and long reining than those wearing the bitless bridle ([Table 3](#)). During riding, it was the horses wearing the bitless bridle that seemed to be doing more head shaking than those wearing the bitted bridle ([Table 3](#)). Pawing the ground occurred most during the bridling phase of training by the horses in the bitted bridle ([Table 3](#)). The horses wearing the bitted bridle exhibited the most tail swishing throughout training compared to those in the bitless bridle ([Table 3](#)). The number of steps taken after the application of the halt stimulus (measured only during long reining and riding) was greatest for the horses in the bitted bridle during long reining compared with those in the bitless bridle ([Figure 5](#)). During long reining, the heart rate and heart rate variability of the horses were higher for those in a bitted bridle compared with those wearing a bitless bridle ([Figure 6](#)).

Discussion

The horses wearing the bitted bridle exhibited more chewing and opening of the mouth during testing, an outcome that can most likely be attributed to the fact that they had a foreign object, i.e., a bit, in their mouth.

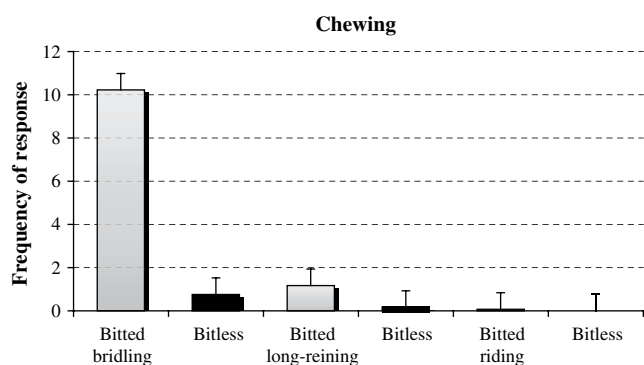


Figure 2 The frequency of chewing exhibited by the horses when undergoing foundation training (bridling, long-reining and riding) wearing either a bitted or bitless bridle.

According to the international body governing equestrian sports (*Fédération Equestre Internationale, 2005*), “satisfactory activity” of the mouth is permitted, although it should be noted that what exactly is meant by “satisfactory activity” was not explained. Nonetheless, opening the mouth is anecdotally considered to be an undesirable response in a performance horse, so for this reason the use of a bitless bridle would be preferred. Conversely, chewing has been regarded as an indicator of a horse being “relaxed in the bridle” (*Podhajsky, 1967; Anon, 1990*), and therefore a bitted bridle would be preferred to encourage this response. Evidently clarification is required to determine the difference between “satisfactory activity of the mouth” and “chewing the bit,” especially as in some equestrian disciplines, one is acceptable and one is not. In light of recent research (*de Cartier et al., 2005; Warren-Smith and McGreevy 2008; Warren-Smith et al., 2007*), it seems that it would be appropriate to revise the standards and criteria for judging of equestrian disciplines with a particular view to including objective measures.

Head lowering has been reported to improve horses’ performance in visual discrimination trials (*Hall et al., 2003*) and as one of the behavioral responses of horses undergoing massage (*McBride et al., 2004*), and it has been associated with behavioral states such as resting (*Caanitz*

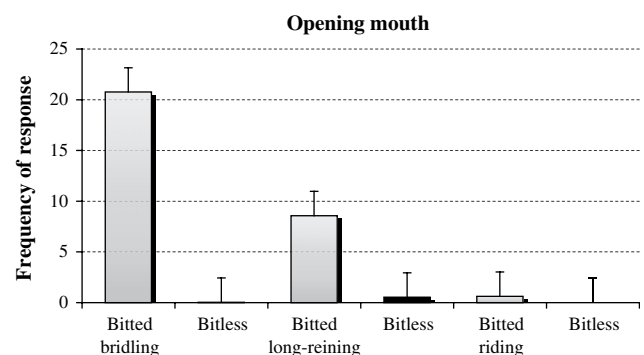


Figure 3 The frequency of opening of the mouth exhibited by the horses when undergoing foundation training (bridling, long-reining and riding) wearing either a bitted or bitless bridle.

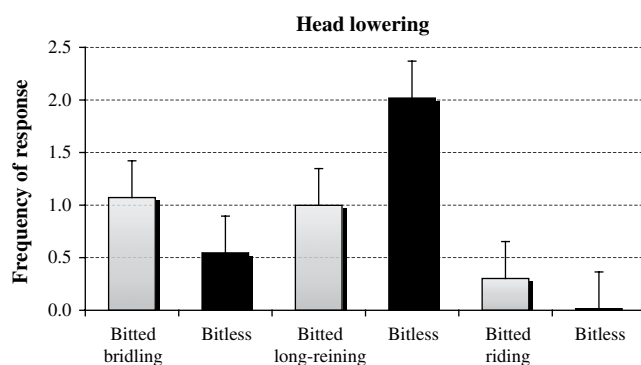


Figure 4 The frequency of head lowering exhibited by the horses when undergoing foundation training (bridling, long-reining and riding) wearing either a bitted or bitless bridle.

et al., 1991), relaxation (*Chamove et al., 2002*) and freedom to stretch (*Blignault, 1997*). Head lowering was shown more by the horses who wore the bitless bridle during long reining. From the results of the current study, it is difficult to determine if the head lowering performed by the horses was a result of relaxation or stretching. Regardless, both states represent a favorable outcome in horses undergoing foundation training.

A desirable characteristic of competition horses is a steady head carriage while performing (*Marshall, 1981; Anon, 1986; Anon, 1988; Fédération Equestre Internationale, 2005*). Movements such as shaking or raising of the head have been reported as responses to discomfort or pain (*MacDonald, 2003*) in locations of the body such as the mouth, limbs, and back (*Fraser, 1992*). Head movements (shaking/tossing) were exhibited mostly by the horses that wore the bitted bridle during the bridling days and by those wearing the bitless bridle on the riding days. This finding suggests that these horses were showing the most discomfort during these training sessions. It is encouraging that there was a decrease in the frequency of head shaking/tossing as training progressed, indicating that the horses were becoming accustomed to the bridles and the training.

A number of researchers have noted that pawing the ground is a behavioral response exhibited during a conflict situation (*Ödberg, 1973; Luescher et al., 1991; Redbo et al., 1998*), for example, either as an activity of distraction or in anticipation of the release from restraint or a stationary position. Pawing the ground was exhibited mostly during the bridling sessions by the horses in both groups. This outcome is most likely explained by the fact that it was during this stage of training that all horses first experienced having the bridles put on, thus some conflict could be expected. Given that the frequency of pawing was greatly decreased during the rest of the training sessions, it would appear that the horses became accustomed to the bridling process relatively quickly, that is, after the initial bridling session.

One of the aims of long reining is to introduce horses to the rein stimuli that they will encounter during other

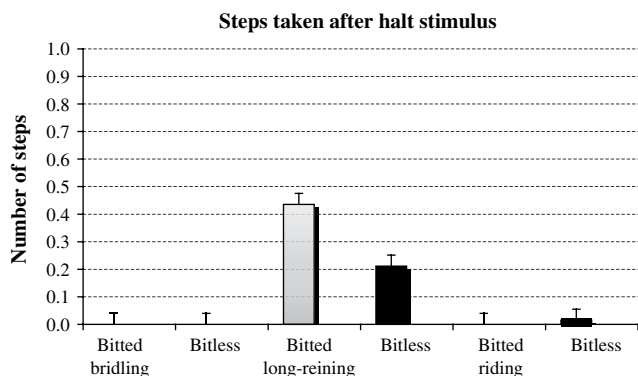
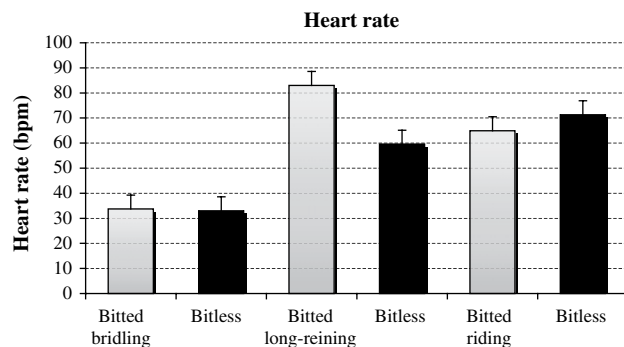
Table 3 The mean of responses exhibited by horses during foundation training (bridling, long reining and riding) wearing either a bitted or bitless bridle

| | Bridling | | Long Reining | | Riding | | Average SE |
|---------------------------|----------|---------|--------------|---------|--------|---------|------------|
| | Bitted | Bitless | Bitted | Bitless | Bitted | Bitless | |
| Buck | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 | 0.02 | 0.01 |
| Chew | 10.22 | 0.76 | 1.17 | 0.17 | 0.08 | 0.00 | 0.76 |
| Defecate | 0.00 | 0.02 | 0.08 | 0.05 | 0.03 | 0.06 | 0.02 |
| Ear movement | 12.88 | 10.47 | 10.92 | 9.43 | 12.13 | 10.58 | 2.07 |
| Head lower | 1.07 | 0.55 | 1.00 | 2.02 | 0.30 | 0.02 | 0.35 |
| Head raise | 0.67 | 0.82 | 0.57 | 0.69 | 0.22 | 0.23 | 0.17 |
| Head shake | 2.23 | 0.46 | 2.40 | 1.96 | 0.61 | 1.67 | 0.85 |
| Heart rate | 33.71 | 33.01 | 83.00 | 59.59 | 64.92 | 71.33 | 5.56 |
| Heart rate variability | 51.67 | 45.67 | 95.00 | 80.50 | 80.00 | 82.50 | 7.25 |
| Lift foreleg | 0.11 | 0.22 | 0.02 | 0.00 | 0.00 | 0.00 | 0.03 |
| Open mouth | 20.76 | 0.04 | 8.57 | 0.53 | 0.62 | 0.00 | 2.40 |
| Paw ground | 0.73 | 0.06 | 0.00 | 0.07 | 0.00 | 0.00 | 0.08 |
| Rub foreleg | 0.04 | 0.02 | 0.07 | 0.04 | 0.00 | 0.00 | 0.02 |
| Rub handler | 0.62 | 1.68 | 0.00 | 0.39 | 0.00 | 0.00 | 0.16 |
| Rubbing nose on ground | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.05 |
| Sniff ground | 0.11 | 0.00 | 0.24 | 0.35 | 0.00 | 0.02 | 0.07 |
| Stamp hind leg | 0.02 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 |
| Steps after halt stimulus | 0.00 | 0.00 | 0.44 | 0.21 | 0.00 | 0.02 | 0.04 |
| Steps backward | 1.44 | 1.25 | 0.10 | 0.50 | 0.05 | 0.21 | 0.19 |
| Steps forward | 2.23 | 3.74 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 |
| Tail swish | 1.73 | 1.20 | 1.53 | 0.30 | 0.15 | 0.55 | 0.66 |
| Turn head and touch side | 0.05 | 0.04 | 0.07 | 0.00 | 0.00 | 0.00 | 0.03 |
| Yawn | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |

activities, such as when ridden (Kusunose and Yamanobe, 2002). Consequently it is during long reining that horses usually first encounter the various stimuli that are applied to the reins for steering, slowing, and stopping. During long reining, the horses wearing the bitted bridle took more steps than those in the bitless bridle after the application of the halt stimulus before achieving the halt. This finding indicates that the horses in the bitless bridle were more likely than those in the bitted bridle to be able to perform the correct response to the halt stimulus when learning this stimulus–response relationship. In addition, the horses

wearing the bitless bridle had the lowest heart rates and heart rate variability during long reining, implying that the horses wearing the bitted bridle were experiencing the most stress when first encountering rein stimuli. Given that the rein tensions required to elicit the same responses are greater for long reining than riding (Warren-Smith et al., 2007), this outcome seems logical, and handlers should take care when long reining to try to use the lightest possible stimuli to preserve the sensitivity of horses' mouths.

It has been suggested that the use of a foreign metal object in an area as sensitive as the oral cavity causes pain

**Figure 5** The steps taken after the application of the halt stimulus by horses when undergoing foundation training (long-reining and riding) wearing either a bitted or bitless bridle.**Figure 6** The heart rate of the horses when undergoing foundation training (bridling, long-reining and riding) wearing either a bitted or bitless bridle.

to the horse, whether or not the rider or handler is aware of its infliction (Cook, 1999). The finding that the horses' heart rates were not different during bridling is significant, as it was the horses' first experience of bridling, and no locomotion was involved which could have influenced the heart rate of the horses. Cook and Strasser (2003) indicated that the use of a bit in a horse's mouth can also lead to other problems such as in the respiratory system, where the interference caused by a bit can impede breathing and striding, leading to a decrease in the amount of exercise that a horse can perform, as well as the overall quality of the horse's movement. Pain has been found to contribute to an increased heart rate in horses (Rietmann et al., 2004), and heart rate and heart rate variability have been used as an indicator of stress in horses (Mohr et al., 2000; Visser et al., 2002). Given that the horses wearing the bitted bridle had the highest heart rate and heart rate variability during long reining, we could conclude that these horses were in more pain and experiencing higher stress levels than those wearing the bitless bridle during foundation training.

It should be noted that any conclusions drawn from these results should be done so with caution, as the low number of horses used will have influenced the outcomes. The small sample size not only prohibited reliable statistical analyses to be conducted, but would also have prevented subtle differences from being statistically detected (Berndtson, 1991; Simpson, 2002). In addition, when dealing with untrained horses in an applied setting, insisting that each horse does exactly the same exercise is not always possible, especially when safety of students must also be ensured. Although every effort was made to standardize all activities, the results for both heart rate and heart rate variability could be attributed to inconsistencies in the amount of locomotion each horse was performing, especially during the long reining and riding sessions.

Although the results of this study have revealed some interesting outcomes that should stimulate some consideration of the equipment and methods employed with horses, there are also some challenges that need to be overcome when conducting further work in this area. First, working with horses is considered to be a high-risk activity; this was particularly important in the current study, as the horses that were used had previously had only minimal handling (i.e., had been haltered). Second, the study was integrated into the teaching of an undergraduate program, and as such, student safety and learning were paramount. Third, the aim of the study was to conduct the trial in an environment that accurately reflected standard practice of the horse industry, rather than in a closed environment of a treadmill laboratory, for example. Conducting research in applied settings can make it difficult to control every variable. Fourth, the resources required to maintain large numbers of horses for research purposes makes it prohibitive to do so. Collectively, the above mentioned points contributed to the current study having a low number of horses, different handlers for some parts, and that the exact exercise that

each horse did on each test day may not have been precisely the same every time.

When conducting research with horses, especially when testing is being carried out in the field as opposed to a laboratory, depending on the type of study being conducted, it is important that the methodology accurately reflects what occurs as standard practice in the horse industry. This then enables the results to be more relevant to a greater proportion of the horse industry. Furthermore, it should make the application of the findings more readily acceptable to participants in the horse industry, as they can be seen as being more practical than results obtained in environmentally controlled laboratories.

However, these problems do not necessarily mean that the research should not be conducted. Preliminary investigations set an important baseline for further work. For instance, subsequent trials of a similar focus should be conducted using additional measurements, such as a rein tension meter, to quantify any variability in the amount of tension applied to the reins (Warren-Smith et al., 2007), as well as greater numbers of horses.

Conclusions

Horses wearing the bitted bridle exhibited more chewing, opening of the mouth, pawing the ground, and tail swishing than those in the bitless bridle. The horses wearing the bitless bridle exhibited more head lowering during long reining compared to those in the bitted bridle. The frequency of chewing, opening the mouth, and head raising decreased as training progressed. During long reining, the number of steps taken after the application of the halt stimulus was greater for the horses in the bitted bridle compared with those in the bitless bridle. During long reining, the heart rate and heart rate variability were higher for horses in a bitted bridle compared with those in a bitless bridle. If the use of bitted bridles does cause discomfort to horses, as suggested by some, then the use of bitless bridles could be beneficial and certainly warrants further investigation. In the interest of the welfare of horses in training, there is a need to conduct further work in this area, using larger numbers of horses, to determine conclusively the benefits of using bitless bridles in preference to bitted bridles.

Acknowledgments

The authors would like to thank Stephen Mannix, Caroline Moon, Shana Wilkinson, Bartłomiej Bronicki, Amelia Brydon, Felicity Casey, and Teena Hough for their assistance in this trial.

References

- Anon., 1986. The complete riding and driving system: advanced techniques of riding, Book 2. Official instruction handbook of the German

- National Equestrian Federation. Threshold Books, London, UK, p. 160.
- Anon., 1988. The manual of horsemanship: the official manual of the British Horse Society and The Pony Club, 9th Ed. Kenilworth Press, Warwickshire, UK, p. 320.
- Anon., 1990. The complete riding and driving system: the principles of riding, Book 1. Official instruction handbook of the German National Equestrian Federation. Threshold Books, London, UK, p. 207.
- Berndtson, W.E., 1991. A simple, rapid and reliable method for selecting or assessing the number of replicates for animal experiments. *J. Anim. Sci.* 69, 67-76.
- Blignault, K., 1997. Successful schooling: train your young horse with empathy. J.A. Allen, London, UK, p. 187.
- Britton, V., 1995. The complete tack guide. The Crowood Press Ltd, Marlborough, UK, p. 144.
- Caanitz, H., O'Leary, L., Houpt, K., Petersson, K., Hintz, H., 1991. Effect of exercise on equine behavior. *Appl. Anim. Behav. Sci.* 31, 1-12.
- Chamove, A., Crawley-Hartrick, O., Stafford, K., 2002. Horse reactions to human attitudes and behavior. *Anthrozoös.* 15, 323-331.
- Cook, W.R., 1999. Pathophysiology of bit control in the horse. *J. Equine Vet. Sci.* 19, 196-204.
- Cook, W.R., Strasser H., 2003. Metal in the mouth: the abusive effects of bitted bridles. Sabine Kells Inc., Qualicum Beach, Canada, p. 138.
- de Cartier d'Yves, A., Ödberg, F.O., 2005. A preliminary study on the relation between subjectively assessing dressage performances and objective welfare parameters. In: McGreevy, P.D., McLean, A.N., Warren-Smith, A.K., Goodwin, D., Waran, N.K. (Eds.), *Proceedings of the First International Equitation Science Symposium*, Melbourne, Australia, pp. 89-110.
- Edwards, E.H., 2000. The complete book of bits and biting. David and Charles Inc., Newton Abbot, UK, p. 184.
- Edwards, E.H., Thomas, S., 1998. Fundamentals of riding: learning the essential skills. Swan Hill Press, Shrewsbury, UK, p. 160.
- Fédération Equestre Internationale, 2005. Rules for dressage events. Fédération Equestre Internationale. Switzerland, Lausanne, p. 89.
- Feist, J.D., McCullough, D.R., 1976. Behavior patterns and communication in feral horses. *Z. Tierpsychol.* 41, 337-376.
- Fraser, A.F., 1992. The behavior of the horse. CAB International, Wallingford, UK, p. 288.
- Hall, C.A., Cassaday, H.J., Derrington, A.M., 2003. The effect of stimulus height on visual discrimination in horses. *J. Anim. Sci.* 81, 1715-1720.
- Heffner, H.E., Heffner, R.S., 1983. The hearing ability of horses. *Equine Practice.* 5, 27-32.
- Kesel, L., Neil, D.H., 1998. Restraint and handling of animals. In: McCurnin, D.M. (Ed.), *Clinical textbook for veterinary technicians*, 4th Edition. WB Saunders, Philadelphia, PA, pp. 1-26.
- Kusunose, R., Yamanobe, A., 2002. The effect of training schedule on learned tasks in yearling horses. *Appl. Anim. Behav. Sci.* 78, 225-233.
- Luescher, U.A., McKeown, D.B., Halip, J., 1991. Reviewing the causes of obsessive-compulsive disorders in horses. *Vet. Med.* 86, 527-530.
- Macbeth, B., 2003. *Horsing Around*. Tertiary Press, Victoria, Australia, p. 464.
- MacDonald, E.K., 2003. Principles of behavioral assessment and management. *Pediatr. Clin. N. Am.* 50, 801-816.
- Marshall, L., 1981. *Novice to advanced dressage*. J.A. Allen, London, UK, p. 128.
- McBride, S.D., Hemmings, A., Robinson, K., 2004. A preliminary study on the effect of massage to reduce stress in the horse. *J. Equine Vet. Sci.* 24, 76-81.
- McDonnell, S.M., Poulin, A., 2002. Equid play ethogram. *Appl. Anim. Behav. Sci.* 78, 263-290.
- McLean, A.N., 2003. The truth about horses. Australian Equine Behaviour Centre, Victoria, Australia, p. 160.
- McLean, A.N., McGreevy, P.D., 2005. Behavioral problems with the ridden horse. In: Mills, D.S., McDonnell, S.M. (Eds.), *The domestic horse: the origins, development, and management of its behavior*. Cambridge University Press, Cambridge, UK, pp. 196-211.
- Mohr, E., Witte, E., Voss, B., 2000. Heart rate variability as stress indicator. *Arch. Tierz. (Special)* 43, 171-176.
- National Research Council, 1989. *Nutrient requirements of horses*. National Academies Press, Washington, DC, p. 100.
- Ödberg, F.O., 1973. An interpretation of pawing by the horse (*Equus caballus Linnaeus*), displacement activity and original functions. *Sonder. aus Sauger. Mitt.* 21, 1-12.
- Parelli, P., 1993. *Natural horsemanship*. Western Horseman Books, Colorado Springs, CO, p. 223.
- Podhajsky, A., 1967. *The Complete Training of Horse and Rider in the Principles of Classical Horsemanship*. Doubleday and Company. Garden City, NY, p. 287.
- Redbo, I., Redbo-Torstensson, P., Ödberg, F.O., Hedendahl, A., Holm, J., 1998. Factors affecting behavioral disturbances in race-horses. *Anim. Sci.* 66, 475-481.
- Rietmann, T.R., Stauffacher, M., Bernasconi, P., Auer, J.A., Weishaupt, M.A., 2004. The association between heart rate, heart rate variability, endocrine and behavioural pain measures in horses suffering from laminitis. *J. Vet. Med. Sci.* 51, 218-225.
- Roberts, M., 1996. *The Man Who Listens to Horses*. Arrow Books, London, UK, p. 258.
- Simpson, B.S., 2002. Neonatal foal handling. *Appl. Anim. Behav. Sci.* 78, 303-317.
- Vernon, H., 1998. *The Allen illustrated guide to bits and biting*. J.A. Allen and Co. Ltd, London, UK, p. 128.
- Visser, E.K., van Reenen, C., van der Werf, J., Schilder, M., Knaap, J., Barneveld, A., Blokhuis, H., 2002. Heart rate and heart rate variability during a novel object test and a handling test in young horses. *Physiol. Behav.* 76, 289-296.
- Waran, N., McGreevy, P.D., Casey, R., 2002. *Training Methods and Horse Welfare: In the Welfare of Horses*. Boston Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 151-180.
- Waring, G.H., 2003. *Horse Behavior*. Second edition. Noyes Publications, William Andrew Publishing, New York, NY, p. 442.
- Warren-Smith, A.K., McGreevy, P.D., 2008. Equestrian coaches' understanding and application of learning theory in horse training. *Anthrozoös.* 21, 153-162.
- Warren-Smith, A.K., Curtis, R.A., Greetham, L., McGreevy, P.D., 2007. Rein contact between horse and handler during specific equitation movements. *Appl. Anim. Behav. Sci.* 108, 157-169.
- Wolski, K., 1984. Equine behavior: patterns, types, and causes. *Vet. Tech.* 5, 250-258.