Effect of detomidine on postural sway in horses

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Abstract
The objective of this study was to apply postural sway analysis to measure balance deficits after intravenous administration of detomidine. Six healthy horses were treated intravenously with detomidine (10 μg kg⁻¹, 20 μg kg⁻¹) and saline in random order, with three days between treatments. Postural sway was measured immediately after administration and at 15 min intervals until 120 min had elapsed. Horses stood squarely with all four hooves on a force platform, while the location of the centre of pressure (COP) was recorded continuously for 10 s at 1000 Hz. Five 10 s recordings were analysed and average values calculated for mediolateral COP range of motion, craniocaudal COP range of motion, mean COP radius, COP area and mean COP velocity. All COP variables increased immediately after sedation, but generally returned to normal limits within 15 and 30 min of detomidine administration at 10 and 20 μg kg⁻¹, respectively. The head was lowered for at least 90 min after administration. Balance is affected by detomidine and normal balance is regained later after a higher dose. Procedures requiring balance should not be performed within 15–30 min of detomidine administration. COP variables are a good indicator of the effect of sedation on postural sway, but head position is not.

Keywords: balance; posture; stability; sedation

Introduction

Maintenance of posture requires that the body be supported against gravity with the centre of mass being maintained above and within the base of support. The sensorimotor system interacts with the external environment to maintain an animal’s stability and balance¹. Postural sway analysis offers a method of quantifying the stability of balance by tracking movements of the centre of pressure (COP) during quiet standing. Postural control is a relatively new and expanding area of research². In human subjects, postural sway analysis provides information characterizing balance mechanisms in bipedal stance and the alterations that occur with age³⁴. It has been applied to assess imbalances associated with, for example, neurological diseases⁵, solvent exposure⁶ and microgravity⁷. Postural sway analysis has also been used extensively in cats to study postural control in quadrupedal stance¹⁸. The original motivation for measuring postural sway in horses was to investigate whether this technique might be of diagnostic value for differentiating horses with mild neurological disease from horses with mild lameness. In the population of horses presented to our clinic, mild neurological deficits due to diseases such as cervical stenotic myelopathy, equine protozoal myelitis or West Nile disease are sometimes difficult to distinguish from mild lameness. A pilot study showed that horses with cervical stenotic myelopathy had different postural sway patterns than clinically normal horses⁹, and indicated areas that required further investigation before applying postural sway analysis as a diagnostic aid.

A study was performed to establish the reliability of postural sway analysis for measuring balance in horses. COP variables, which describe the amount and type of motion of the COP, were reported for young, healthy horses standing quietly, and confidence limits of reliability were established using Agreement Boundary

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an analysis\textsuperscript{10}, which provides a measure of agreement between datasets in the same units as the measured variable. The postural sway variables in horses, listed in order of greatest to least reliability, are COP velocity ($\pm 3 \text{ mm s}^{-1}$), craniocaudal range of COP motion ($\pm 4 \text{ mm}$), COP radius ($\pm 2 \text{ mm}$), mediolateral range of COP motion ($\pm 8 \text{ mm}$) and COP area ($\pm 62 \text{ mm}^2$). These reliability values can be used to set limits; values that exceed these limits are indicative of balance deficits.

It is important to quantify the effects of sedation on postural sway for several reasons. First, it is difficult to collect postural sway data in horses that have not been trained to stand still, since the technique requires the horse to stand quietly on the force plate for periods of 10 s. If sedation were to be used to facilitate data collection, it would be important to know how long to allow after administration for the postural sway variables to return to normal limits. Second, sedation may facilitate data collection in horses with neurological disease. In people with labyrinthine disease, sedation facilitates measurement of postural sway data and reduces sway in 80% of subjects\textsuperscript{11}. Third, sedation is often used to facilitate minor procedures in intractable horses. It would be useful to know how soon after sedation balance is restored sufficiently that it is safe to perform minor procedures, such as farriery, that require horses to maintain a balanced stance.

The sedative detomidine is used frequently in veterinary practice, either at a low dose rate (10 \(\mu\text{g kg}^{-1}\) intravenously) to facilitate minor procedures or at a higher dosage rate (20 \(\mu\text{g kg}^{-1}\) intravenously) as a pre-anaesthetic medication. Studies of the physiological effects of detomidine in horses have shown that the response is dose-dependent, with higher doses producing a longer duration of action\textsuperscript{12,13}. The effects include decreased heart rate, drooping of the head and neck, and reduced sensitivity to painful and environmental stimuli\textsuperscript{14}. Side-effects, including ataxia, staggering, salivation, sweating, diuresis and penile prolapse, are not generally regarded as harmful\textsuperscript{15}.

Investigations of a range of dosage rates indicated that maximal sedation was achieved with a dose of 20 \(\mu\text{g kg}^{-1}\) intravenously, and increasing the dose beyond this did little to increase the level of sedation but did prolong the duration from less than 1 h to almost 4 h\textsuperscript{14}. A lower detomidine dose of 8 - 10 \(\mu\text{g kg}^{-1}\) was adequate to control restless horses during procedures such as radiology\textsuperscript{16}. Many of the procedures that are facilitated by sedation require the horse to maintain its balance. Since ataxia has been described as a side-effect of detomidine administration\textsuperscript{12,13,15}, it may increase the risk of injury to horse or handler during certain procedures. Based on subjective assessment\textsuperscript{5}, ataxia has been reported to persist for approximately 15 min when detomidine is administered intravenously at 10 \(\mu\text{g kg}^{-1}\), increasing to about 60 min when the dosage rate is 80 \(\mu\text{g kg}^{-1}\).

The duration of balance deficits following treatment with detomidine at different dosage rates has not been measured. The objective of this study was to use postural sway analysis to measure and compare the effects of two detomidine dosage rates on the horse’s balance. The null hypotheses are:

- the postural sway variables are no different after sedation with detomidine at two dosage rates compared with saline; and
- there is no dose-dependent effect of sedation with detomidine.

### Materials and methods

The study protocol was approved by the All University Committee for Animal Use and Care.

### Subjects

The subjects were a group of six, healthy, two-year-old horses: body mass 313 - 359 kg; height 1.35 - 1.50 m at the withers.

### Sedation protocol

Postural sway data were collected from each horse under three conditions: unsedated control (0.9% saline solution), low-dose (10 \(\mu\text{g kg}^{-1}\)) and high-dose (20 \(\mu\text{g kg}^{-1}\)) sedation with detomidine (Domosedan\textsuperscript{5}, Pfizer, New York, NY). All treatments were administered intravenously via the jugular vein. The three conditions were applied in random order with an interval of 72 h between successive treatments\textsuperscript{13}. Postural sway data were collected immediately after administration of detomidine or saline (time 0) and at intervals of 15 min until 120 min after administration (times 15, 30, 45, 60, 75, 90, 105 and 120 min). Since collection of five trials of 10 s duration has been shown\textsuperscript{2} to take an average of 213 s, data collection at time 0 occupied the first 3 - 4 min after administration of detomidine, when sedation is usually most marked.

### Kinematic analysis

Video recordings (60 Hz) were made using two synchronized camcorders. The recording volume was calibrated using a frame measuring 1.00 m $\times$ 1.35 m $\times$ 1.60 m, with 30 non-collinear reflective markers. Spherical reflective markers, 2.5 cm in diameter, were placed at the four corners of the force platform to locate the platform within the data collection volume. Markers attached to the horses on the mid-dorsal aspect of the four hooves just below the coronet, and to the center...
of the forehead between the *supra-orbital processes*, were recorded throughout the collection of COP data.

The video fields were grabbed and stored digitally, then the markers were manually digitized using a motion analysis system (APAS; Ariel Dynamics Inc., Trabuco Canyon, CA). The raw data were transformed using a direct linear transformation\(^\text{17}\) and smoothed with a fourth-order Butterworth digital filter, with a cut-off frequency of 6 Hz. The locations of the four hooves on the force platform were determined from the video coordinates of the hoof markers using custom-written code (Matlab 5.3; The Mathworks, Natick, MA), and the area of the base of support was calculated as the area encompassed by the four hoof contacts with the ground. The height of the head was measured as the vertical distance of the head marker above the fore-hoof markers.

**Postural sway analysis**

Postural sway data were collected by having the horses stand with all four hooves on a 0.6 m $\times$ 1.2 m force platform (LG6/4/8000; AMTI, Watertown, MA). The horse’s craniocaudal axis was aligned with the longitudinal axis of the force platform, and all horses faced in the same direction. The hooves were arranged so that the cannon bones were oriented approximately vertically in the frontal and sagittal planes, and the head and neck were held in a relaxed position. Two handlers stood in front of and behind the horse to discourage it from moving. The handler in front of the horse held a shank loosely, but neither handler had direct physical contact with the horse. Between the 45 and 60 min recordings, horses were removed from the force platform and allowed to urinate. The hooves were repositioned as closely as possible to their original positions.

Data were collected for continuous periods of 10 s at a sampling rate of 1000 Hz, with five trials being recorded at each evaluation time. The force data were displayed graphically as a stabilogram, which is a plot of the time-varying coordinates of the COP in the horizontal plane. It shows the craniocaudal position of the COP plotted against the mediolateral position of the COP. Each data point represents an instant in time during the 10 s period of data collection. The centroid of all the points comprising the stabilogram is located at the origin.

Five variables were calculated and averaged over the five trials at each evaluation time to quantify the movements of the COP:

- the mediolateral range of COP motion was the range of motion along the $x$-axis;
- the craniocaudal range of COP motion was the range of motion along the $y$-axis;
- the COP radius was the average distance between the centroid of all data points and each individual data point;
- the COP area was the area encompassed by the stabilogram; and
- the COP velocity was the average velocity of the COP between each two successive data points.

**Statistical analysis**

Mean values and standard deviation were calculated for each variable, and Agreement Boundary analysis\(^\text{18,19}\) was used to establish 95% confidence interval limits for the COP variables\(^\text{10}\). These limits were based on the overall mean of the values at the nine time intervals for the unsedated condition. If data points for the sedated condition fell outside these limits, it was inferred that sedation had disturbed the variable.

**Results**

During the first 10–15 min after detomidine administration, all horses showed visible signs of ataxia, including trembling, locking and unlocking of joints, weight shifts and obvious swaying. These signs diminished or disappeared within 15–30 min. Sweating was observed in all horses.

The hoof locations on the force platform were similar, but not identical, before and after moving the horse off the force platform between 45 and 60 min recordings. The base of support was within the $\pm 0.057$ m agreement boundary established for this variable at all evaluations.

Representative stabilograms for the unsedated and high-dose sedation conditions at time 0 (Fig. 1) show obvious increases in motion of the COP in the craniocaudal and mediolateral directions after administration of detomidine. The five COP variables had similar patterns when their values were plotted at the nine time intervals (Fig. 2). At time 0, values for both the low- and high-dose sedation were well outside the 95%
Following low-dose sedation, values returned to the 95% confidence interval within 15 min for mediolateral range, COP radius and COP velocity, and within 30 min for craniocaudal range and COP area. Following high-dose sedation, values of COP variables were above the 95% confidence interval at 0 and 15 min, but had returned to the normal limits by 30 min after administration for all variables except craniocaudal range, which took 45 min. These findings do not support the null hypotheses that sedation with detomidine does not affect postural sway variables or that there is no dose-dependent effect of sedation with detomidine.

The head was lowered below the 95% confidence interval at time 0 at both dosage rates, and did not return to the 95% confidence interval until 90 min after low-dose sedation and 105 min after high-dose sedation (Fig. 2).

**Discussion**

Sedatives are used in equine practice to provide restraint during a diverse range of procedures. Detomidine is a non-opioid analgesic that is commonly used to provide restraint or analgesia during minor management or surgical procedures. The two-year-old horses in this study, which had been handled minimally before the start of the study, represented a typical population of horses for which sedation might be used for procedures such as farriery or loading and travelling in a trailer. Ataxia, associated with detomidine administration, may compromise safety during procedures that require the horse to maintain its
balance. The results of this study are in general agreement with the subjective assessments that have reported ataxia as persisting for about 15 min after 10 µg·kg⁻¹ intravenous detomidine and longer after administration at higher dosage rates. The sedative effects of detomidine persist considerably longer than the effects on balance.

It has been reported that the head was lowered significantly from the normal position for almost an hour when detomidine was administered intravenously at a dose of 10 µg·kg⁻¹, increasing to 2.7 h when a higher dose of 80 µg·kg⁻¹ was administered, which is similar to the findings presented here. It should be noted that lowering of the head persisted for considerably longer than the balance deficit, indicating that head position is not a valid indicator of a horse's balance after administration of detomidine.

The size and sensitivity of the force platform imposed some limitations on the selection of subjects. The horses used in the study were small enough to fit within the platform's dimensions of 0.6 m × 1.2 m, yet heavy enough to provide accurate postural sway data. The main problem encountered was that it was sometimes difficult to persuade the subject to stand still on the force platform for a prolonged period of time without physical restraint. In human subjects, it has been shown that collection of postural sway data continuously over a period of 30 s gives the most reliable results. A long period of data collection is necessary for statistical analysis using diffusion analysis; the general driving principle of this method of statistical mechanics is that, although the outcome of an individual random event is unpredictable, it is still possible to obtain definite expressions of the probabilities of various aspects of a stochastic process or mechanism.

Preliminary studies in horses indicated that 10 s was the longest time that most horses would stand still after administration of detomidine. On the basis of the results presented here, it is recommended that a period of at least 15 min after intravenous administration of detomidine at 10 µg·kg⁻¹, or at least 30 min after administration at 20 µg·kg⁻¹, be allowed for the horse's balance to be restored before performing procedures that rely on a balanced stance, such as farriery or trailering.

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References

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