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The effect of manually facilitated flexion of the thoracic spine on the interspinous space among horses with impinging dorsal spinous processes of the thoracic vertebrae

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ABSTRACT

Impinging dorsal spinous processes (IDSP) are typically diagnosed and graded using radiography, during which the effect of the horses' thoracolumbar posture on the interspinous spaces is not commonly considered. Posture can be altered from a spontaneous, relatively extended, or lordotic, position by manual facilitation of thoracic flexion ('thoracic lift'). This study aimed to ascertain if the thoracic vertebral interspinous space distances were increased by using facilitated thoracic flexion to alter the posture in horses diagnosed with IDSP. Seven horses of mixed breed and sex, median age 9.1 years (interquartile range, 7.2–12.4 years), with a diagnosis of thoracic IDSP with no history of spinal surgery, were included in the study. Two sets of radiographs were obtained. The initial set was taken in the horses' spontaneous posture and the second in the manually facilitated flexed posture. Each image was anonymised allowing blinded measurement of the interspinous spaces. Analysis was performed using Hodges-Lehmann median differences estimates. An increase in the median interspinous space distance was achieved after manual facilitation of thoracic flexion at every thoracic intervertebral space (5th-18th thoracic [T] vertebra). The greatest median increase was seen between T7-T8 and T12-T13 (3.1 mm and 3.0 mm, respectively) whereas the lowest median increase was seen between T17-T18 (0.7 mm). In this study, thoracic interspinous space distances could be increased by using manual facilitation to alter the thoracic posture in horses with IDSP, which could affect grading and decision making.

Introduction

Impinging dorsal spinous processes (IDSP) is a condition frequently described in horses, although it has also been reported in dogs, cats, and humans (Gutierrez-Quintana et al., 2011; Filippiadis et al., 2015; Clayton and Stubbs, 2016; Thierry et al., 2016). This multifaceted, variable condition has been associated with a number of clinical and functional problems among riding horses. Signs such as behavioural change, poor performance, vague lameness, resistance to tacking up, bucking or subtle changes in the way the horse feels when being ridden are common (Jeffcott, 1980; Walmsley et al., 2002; García-López, 2018). Physical findings may include epaxial muscle spasm, tenderness on palpation of the spinous processes, hypomobility of the thoracic spine, such as reduced flexion, extension, and lateral movement, and muscle atrophy (Zimmerman et al., 2012; de Graaf et al., 2015; García-López, 2018).

In horses, IDSP is diagnosed most frequently between the 10th thoracic (T) vertebra and the 2nd lumbar (L) vertebra (Denoix and Dyson, 2011; Turner, 2011; Zimmerman et al., 2011). Diagnosis involves the evaluation of clinical signs and use of diagnostic tools such as radiography, scintigraphy, and ultrasound (Erichsen et al., 2004; van Zadelhoff et al., 2018). Structural changes that are visible on radiographs include transformation of the top of the spinous process, sclerosis of the cortical margins, narrowing of the interspinous space and abnormal orientation of the spinous process (Jeffcott, 1980; Haussler et al., 1999; Erichsen et al., 2004; Turner, 2011). An incremental grading scale (0–7) described by Zimmerman et al. (2012) is often used to quantify the radiographic changes and degree of IDSP.

Equine spinal movement occurs in three-dimensions. Flexion-extension is defined as the rotation about the transverse plane, and movement of the vertebral bodies in this manner coincides with axial

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rotation of the sacrum (van Weeren et al., 2010). Facilitation of posture is a commonly used technique in equine physiotherapy whereby an external stimulus is used to create a muscular contraction resulting in a gross spinal movement and postural change (McGowan and Goff, 2016). For example, spinal posture can be changed manually by using pressure or scratching along the horses' sternum, which facilitates abdominal and hypaxial muscle contraction resulting in thoracic flexion or a 'thoracic lift'.

A lordotic posture is often associated with IDSP (Jeffcott, 1980). Concomitantly, a decrease in interspinous space is emphasised if the horse is in a lordotic, extended thoracolumbar posture (Clayton and Stubbs, 2016). Given that diagnostic imaging is normally performed with the horse sedated and in whichever spontaneous posture the horse stands, it is possible that decreasing any lordotic posture might increase the spaces between the processes and alleviate the degree of IDSP. Therefore, the aim of this study was to ascertain if the space between spinous processes was increased by facilitation of thoracic flexion in horses diagnosed with IDSP. Our hypothesis was that manual facilitation of thoracic flexion would increase the interspinous space distance in horses with IDSP and potentially lower the grade of impingement and change the diagnostic and therapeutic approach.

Materials and methods

The study protocol was approved by the University of Helsinki Viikki Campus Research Ethics Committee (Approval number, 4/2019; Approval date, 4 March 2019) and the University of Liverpool International Research Ethics Committee (Approval number, 4/2019; Approval date, 28 February 2019). A signed informed consent form was obtained from the owners of the enrolled horses.

Horses

Data collection was carried out in the Veterinary Teaching Hospital of the University of Helsinki between 1 March 2019 and 31 December 2019. Horses over 3 years of age with mature vertebral bony development that presented to the equine hospital for veterinary assessment of back pain or with a previously established IDSP diagnosis of the thoracic spine (minimum of one space $<$4.0 mm) were included. Horses with previous surgical treatment of thoracic IDSP were excluded. Shetland ponies and miniature horses were also excluded due to their different conformation from horses.

Radiographic examination

Prior to radiographic examination, the horse's position was standardised. All horses were made to stand in a square position, the head was held by the handler and the mouth was kept level with the point of the horse's shoulder. This position was maintained throughout the initial and second set of radiographs. Sedation was administered by the attending veterinarian to ensure the horse remained motionless during imaging and for the safety of the handler and investigator. In five horses, a combination of Domosedan 0.01 mg/kg (Detomidine, Orion) and Butordol 0.01 mg/kg (Butorphanol, Intervet International) was used. Two of the horses were sedated with Xysolve 0.2 mg/kg (Xylazine, CP-Pharma Handelsgesellschaft).

Metal markers were placed along the midline of the back for clear identification of vertebral levels and to ensure the same area was imaged in the facilitated posture. The investigator was situated below the radiograph camera, laterally to the horse's thoracic cage to effectively stimulate the postural change, whilst being safely positioned in relation to the radiological beam. Protection from radiation was ensured for all involved personnel by means of protective lead aprons and neck covers. A personal dosimeter was also used by the investigators, in accordance with university radiology safety guidelines. Three lateral radiographs were taken between T5 and T18.

Two sets of radiographic images were obtained. The first set included standard baseline images to confirm the diagnosis of IDSP in horses standing in the standardised spontaneous posture. Prior to the second set of images, an investigator (SO'S or HKH) manually facilitated thoracic flexion by vigorously scratching along the sternum to produce a lift of the thoracic cage and reduce the lordotic posture of the thoracic spine. At the point of greatest postural change, the radiographer was instructed by the investigator to take the image.

Radiographic measurement

The digital images were anonymised by one investigator (HKH). The investigator measuring the interspinous space (SO'S) was therefore blinded to the horse and owner identification, as well as the posture of the horse (i.e., either spontaneous or thoracic flexion) when the images were taken. Imaging software (JiveX, VISUS Health IT) was used to measure the distance in millimetres between interspinous processes in all digital images.

All measurements were taken from the narrowest cranio-caudal distance between each spinous process, along the most dorsal 6.0 cm of each spinous process. The smallest distance between dorsal spinous processes (DSP) was recorded. The fifth thoracic vertebra (T5) was defined as the highest DSP, which was then used to count DSP caudally. The last clearly visible interspinous space for all images was at T17/18. Each measurement was carried out three times by the same investigator (SO'S) with the mean of the three measurements used for analysis.

For this study, only the interspinous spaces were investigated and measured. Other radiographic signs of IDSP such as degree of opacity, presence of radiolucency and evidence of re-modelling were not considered. Grade of IDSP (modified from Zimmerman, et al., 2012) was therefore defined as follows: Grade 0 corresponded to an interspinous space of $\geq$ 4 mm. Grade 1 was an interspinous space of 3.9–3.0 mm. Grade 2 was an interspinous space of 2.9–2.0 mm. Grade 3 was an interspinous space of 1.9–1.0 mm. Grade 4 was an interspinous space of 0.9–0.0 mm. The more severe grades 5, 6 and 7 were not determined because contacting or overlapping spinous processes resulted in absent interspinous spaces. Each IDSP was assessed and graded individually.

Conformational measurement

Conformation and body proportion measurements were determined for descriptive purposes. Length of the thoracic spine (cm), height at the withers (cm), bodyweight (kg) and thoracic circumference (cm) were determined. The thoracic spine length was measured from the cranial angle of the first palpable thoracic DSP (T3) to the caudal angle of the last thoracic DSP. Height at the withers was measured vertically using a rigid tape measure and a spirit level across the highest palpable thoracic DSP (i.e., at T5) during the standardised standing position. Body weight was measured using a calibrated scale. Thoracic circumference was determined using a flexible measuring tape over the horse's back behind the withers, ensuring the tape passed around the girth area fully and securely.

Statistical methods

Descriptive statistics were used to report age, bodyweight, and other conformational variables and were expressed as medians and interquartile ranges (IQR). Exact, rank-based Hodges-Lehmann estimates of the median differences were calculated to assess the difference in distances between interspinous processes when horses stood in a spontaneous position and subsequently in a facilitated thoracic flexion position. The Hodges-Lehmann estimates were calculated for each individual vertebral segment (T5/6 – T17/18) for all horses. Statistical analysis was performed using SPSS 25 (IBM Corporation) and SAS System for Windows, V.9.4, (SAS Institute).

Results

Seven horses, four geldings and three mares, were included. The median age was 9.1 years (IQR, 7.2–12.4 years). There were four Finnish Warmbloods and one Shire, one Arab, and one Knapstrupper. The median length of the thoracic spine was 53 cm (IQR, 52–65 cm) and the median height was 163 cm (IQR, 158–168 cm). The median body weight was 555 kg (IQR, 500–570 kg) and the median thoracic circumference was 195.0 cm (IQR, 187.5–197.0 cm).

Figs. 1a and 1b are radiographs with normal interspinous space measurements (≥4.0 mm), with IDSP (<4.0 mm), and a Grade 4 IDSP (0.9–0.0 mm) in the same horse standing with spontaneous posture and with facilitated posture, respectively. Fig. 2 shows box and whisker plots illustrating interspinous space distances (mm) for all seven horses at each thoracic vertebral segment (T5 to T18), before and after thoracic facilitation, the 75th and 25th quartiles and the median interspinous distance (mm). The Hodges-Lehmann median difference estimators between the two positions, spontaneous and facilitated for each thoracic vertebral segment also are shown. The largest difference was at the mid-thoracic spine (T7-T13), with a 2.1–3.1 mm change. Specifically, the greatest median distance change was between T7-T8 and T12-T13 (3.1 mm and 3.0 mm, respectively). The smallest median distance change was between T17-T18 (0.70 mm). None of the differences in the median interspinous spaces between the two positions were negative. Only two (2.2%) measurements of the interspinous space distance did not change following facilitation, with all other interspinous space distances (97.8%) increasing.

Multiple IDSP were identified in each of the seven horses. Using the modified grading system established for this study, each horse presented with at least two and up to four IDSP. In total, there were 20 IDSP, graded 1–4, located between T12-T18 across the seven horses. There were four intervertebral segments with Grade 1 (an interspinous space of 3.9–3.0 mm), eight intervertebral segments with Grade 2 (2.9–2.0 mm), three segments with Grade 3 (1.9–1.0 mm), and five with Grade 4 (0.9–0.0 mm). Six horses had between two and four IDSP identified in the T12-T16 area. One horse had two IDSP more caudally at T16/17 and T17/18. Impinging dorsal spinous processes were found most frequently at T13/14, T14/15, and T15/16 with four of the seven horses demonstrating IDSP at each of these latter intervertebral segments.

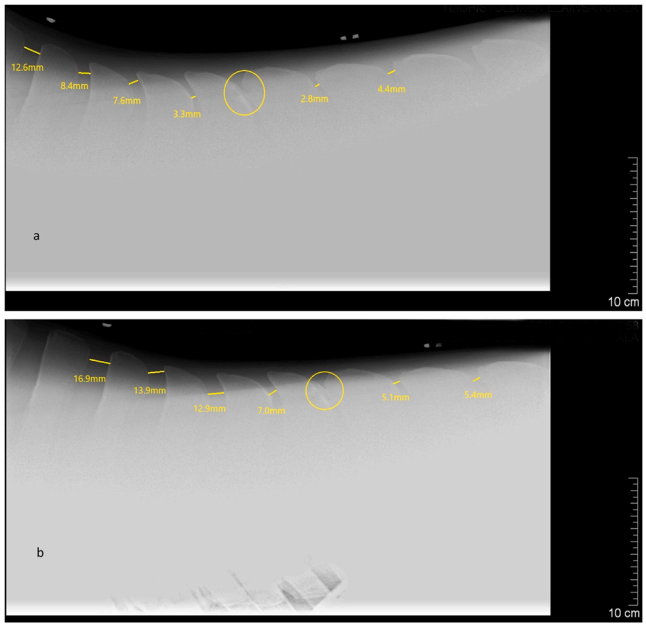

Fig. 1. Examples of radiographs from the same horse with the interspinous space measurements of normal vertebral segments (≥4.0 mm), diagnosed Impinging dorsal spinous processes (<4.0 mm), and an impinging vertebral segment (circled) in (1a) spontaneous posture and (1b) facilitated posture.

Ninety percent ($n = 18/20$) of the IDSP graded 1–4, using the modified system, were reduced to a lower grade by the thoracic lift, with 55.0% ($n = 11/20$) reduced to a normal grade 0. Of these 18 IDSP, 61.1% ($n = 11/18$) were reduced by one grade, 33.3% ($n = 6/18$) by two grades and 5.6% ($n = 1/18$) by 3 grades after manual facilitation of thoracic flexion.

Discussion

The results of this study showed that manually facilitated thoracic flexion, resulting in a change of posture, increased the interspinous space of horses with a diagnosis of thoracic IDSP. Moreover, the change in an individual horse may be large enough to potentially affect IDSP grading. Although this study used a modified system to grade interspinous space distance change, and several additional criteria of the Zimmermann grading system were not evaluated, even the smallest change found in this study (0.7 mm) may be clinically and diagnostically important, given that IDSP grading is made with 0.9 mm intervals (Zimmerman et al., 2012). As IDSP in combination with clinical signs may be an indication for invasive, surgical treatment (Walmsley et al., 2002; Coomer et al., 2012; Jacklin et al., 2014), these findings are important to consider when diagnosis and treatment decisions are being made in affected horses based on radiographic grading.

These results also highlight that interspinous spaces in horses with IDSP may not be fixed and that baseline posture should be considered when imaging horses with suspected IDSP. Given these horses are frequently diagnosed in a spontaneous (often lordotic) position, interspinous space measurement in the facilitated posture, if included within the examination protocol, may help to differentiate true static impingement cases from functional, or poor postured, cases. As more than half of the horses diagnosed with variable grades of IDSP in this study were subsequently found to have grade 0 IDSP following facilitation, it is possible that in these horses the IDSP was not true static impingement, and was more likely to be functional, or due to poor posture.

The results of this study showed that change in the median interspinous space distance after facilitation in most of the caudal spaces (T13-T18) was less than in the cranial spaces (T5-T13). A possible reason for this may be that the caudal section of the thoracic spine is less structurally mobile than the cranial section (Townsend et al., 1983). A second reason may be that facilitation was performed on horses from the sternal or girth area, which directed muscle activation and movement on the more cranial, and more mobile, section of the thoracic spine. Given that IDSP in horses have been reported to occur most frequently between T10-L2 (Denoix and Dyson, 2011; Turner, 2011; Zimmerman et al., 2011), there may be value in directing the facilitation more caudally, should this procedure be included in examination protocols.

In this study, the sedation dose varied for each horse and in some cases an additional dose was administered to ensure the horse was adequately calm during imaging. It is possible that more sedation resulted in less spinal movement following manually facilitated thoracic flexion. Conversely, sedation may have resulted in posture being more relaxed and lordotic at baseline, potentially exaggerating the initial assigned IDSP grade and making change harder to detect. In general, sedation at the doses used in this study is a routine part of radiographic examination for IDSP and regardless of the likely minor consequences of sedation, the results of this study suggested that manually facilitated thoracic flexion increased the interspinous spaces of horses with IDSP.

The standardisation of the head position was important to ensure that the spinal position was comparable for each image. The position of the head and neck has been shown to play a role in the distance between interspinous spaces during radiographic imaging (Berner et al., 2012). The relative distances between T15/16 and T16/17 were significantly wider in the low position than in the high position. In the high position,

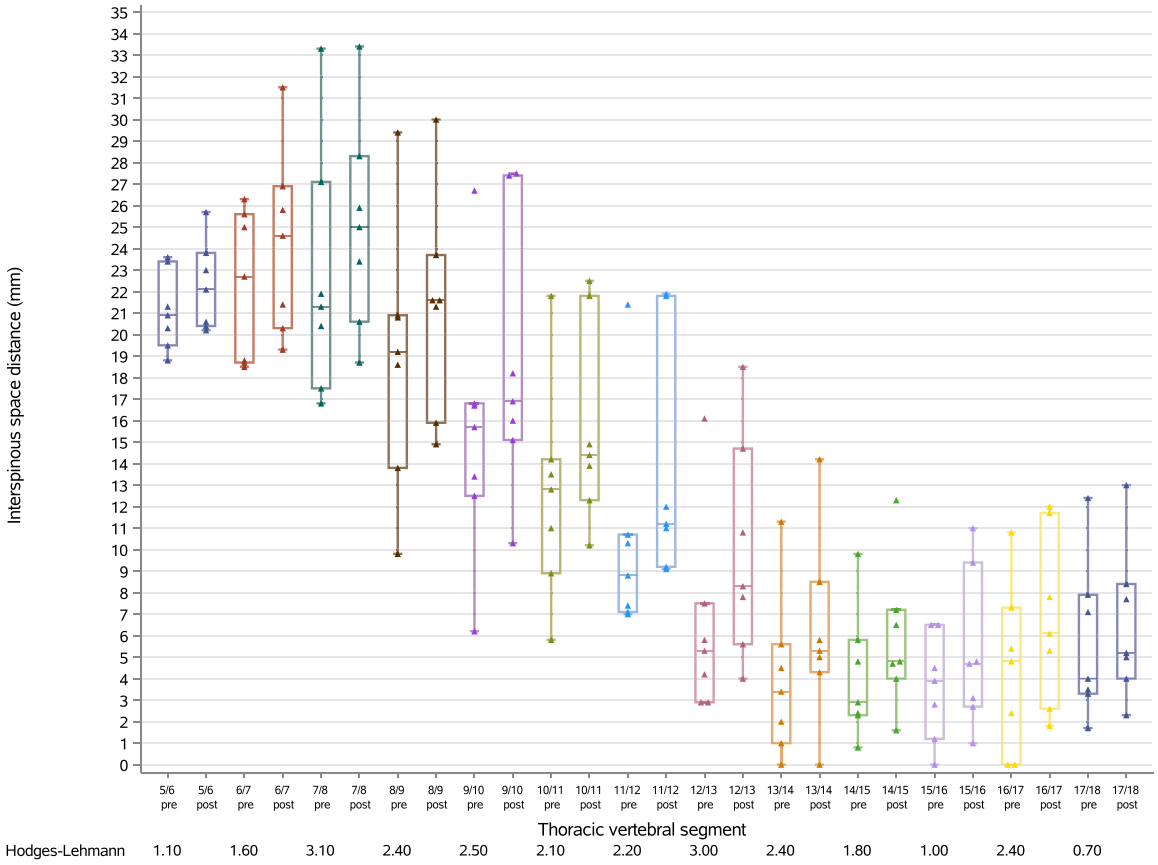

Fig. 2. Box and whisker plots illustrating interspinous space distances (mm) for all seven horses at each thoracic vertebral segment (T5 to T18) before (pre) and after (post) thoracic facilitation. Coloured triangles represent the measurements of each individual horse, horizontal limits define the upper and lower quartiles enclosing the central 50% of observations, with the median (mm) marked by a horizontal line within the box. The Hodges-Lehmann estimate for the median differences between the spontaneous (pre) and facilitated (post) posture for each thoracic vertebral segment is shown below the plots.

the relative intervertebral distances between T9/10/11/13/17 and their respective caudal adjacent processes were significantly narrower than in an intermediate position (Berner et al., 2012). For this reason, the intermediate position was used for each subject in this study, keeping the horse's mouth in line with the shoulder joint. The use of a table to rest the horses head was considered, but a trial with the first subject proved impractical and disruptive.

This study was not designed to investigate pain and clinical signs of IDSP. Some of the horses had an acute diagnosis at the time of the study and others had a more chronic presentation. It was unknown if pain and signs demonstrated among horses with IDSP were a consequence of the condition or if pain exacerbated the lordotic spinal posture and rigidity, which may predispose to IDSP (Jeffcott, 1980; de Graaf et al., 2015).

The small sample size of this study limited opportunity to obtain more definitive, statistical results and precluded reporting of 95% confidence intervals, which likely would have been wide, imprecise, and included zero, indicating statistical non-significance. However, these results still emphasised the clear clinical and functional significance of median interspinous distance change of between 0.7 and 3.1 mm across the T5-T18 interspinous spaces following thoracic facilitation in horses with IDSP. Future investigations using a larger sample size to confirm these findings and clarify the importance of baseline thoracic vertebral posture in the decision making leading to a definitive diagnosis of IDSP, and the development of a therapeutic and prognostic approach, are warranted. Additionally, further research could be directed towards the interplay between functional and static impingement and poor posture, and the effect of targeted therapeutic exercises to alleviate them.

Conclusions

The results of this small study demonstrated that the median distance between dorsal spinous processes of the thoracic spine increased following manual facilitation of thoracic flexion and resulted in a reduced thoracic spinal lordosis. The results support the need for a more dynamic and functional evaluation prior to a diagnosis of IDSP, particularly when radiographic grading based on this interspinous distance may result in invasive intervention.

Conflict of interest statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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