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Osseous spinal pathology and epaxial muscle ultrasonography in Thoroughbred racehorses

N. C. STUBBS*†, C. M. RIGGS‡, P. W. HODGES§, L. B. JEFFCOTT¶, D. R. HODGSON¶, H. M. CLAYTON** and **C. M. McGOWAN†††**

*Mary Anne McPhail Equine Performance Center, Large Animal Clinical Sciences, College of Veterinary medicine, Michigan State University, East Lansing, USA; †The School of Animal Studies, Faculty of Natural Resources, Agriculture and Veterinary Science, The University of Queensland Gatton, Australia; ‡Department of Veterinary Clinical Services, Equine Hospital, Sha Tin Racecourse, Hong Kong; §NHMRC Centre for Clinical Research Excellence in Spinal Pain, Injury and Health School of Health and Rehab Sciences, The University of Queensland, Brisbane, Australia; ¶Faculty of Veterinary Science, The University of Sydney, Veterinary Teaching Hospital L Block (CO8L-01-102), Camden, New South Wales, Australia; **Department of Large Animal Clinical Sciences, VA-MD Regional College of Veterinary Medicine, Virginia Tech, Duck Pond Drive (0442), Blacksburg, Virginia, USA; and ††School of Veterinary Science, Faculty of Health and Life Sciences, University of Liverpool, Leahurst, UK.*

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Summary

Reasons for performing study: **The *multifidus* muscle plays a key role in spinal stabilisation. *Multifidus* atrophy ipsilateral to the side of osseous pathology has been demonstrated in man and pigs but has not been investigated in horses.**

Objectives: **To measure cross-sectional area (CSA) left/ right symmetry of equine *multifidus* ultrasonographically and relate asymmetry of *multifidus* with osseous spinal pathology in Thoroughbred racehorses. We hypothesised that ipsilateral *multifidus* CSA would be reduced when osseous pathological changes are present leading to left/right asymmetry in CSA.**

Materials and methods: **Twenty-two racehorses presented for euthanasia for primary reasons other than back pain were examined clinically. Ultrasonographic images on left/right sides were acquired at 5 thoracolumbosacral levels and CSA's of *multifidus* or *sacrocaudalis dorsalis* calculated. At necropsy, osseous pathological of the TL spine and pelvis were recorded by spinal level, anatomical site, and graded (*0–3*) according to severity. The mean typical measurement error in estimating *multifidus/sacrocaudalis dorsalis* CSA was used to determine the significance of left/right asymmetries. An association between *multifidus* CSA asymmetry and asymmetrical grading of pathological lesions was sought using Pearson's χ^2 analysis.**

Results: **All horses had significant left/right asymmetry of *multifidus* CSA at >2 spinal levels, most commonly at L5 with total of 74 sites affected (22 horses). Seventeen horses had severe (*grade 3*) pathology, 16 of these had ipsilateral atrophy of *multifidus/sacrocaudalis dorsalis*. There was a significant association between pathological grade and degree of *multifidus* asymmetry.**

Conclusions: **Severe osseous pathological changes were common in this population of Thoroughbred racehorses and were associated with measurable left/right asymmetry in *multifidus* at or close to the level of pathology.**

Potential relevance: **Ultrasonography of *multifidus* may be a useful clinical tool in diagnosis of back problems in horses.**

Introduction

Back pain is a common problem in the performance horse. Jeffcott (1980) reported that the prevalence of back pain varied according to the type of practice: 0.9% in general veterinary practice, 13% in mixed equine practice and 47% in spinal research clinics. This is in comparison to an equine chiropractic clinic whereby 94% of cases were reported to have back dysfunction/pain (Haussler 1999a). In a survey of 11,363 registered dressage horse owners in the UK, 40% reported that their horse had a 'back problem' although the majority of these (80%) had not been diagnosed by a veterinary surgeon (Murray *et al*. 2009). Thoroughbred racehorse trainers in Sydney, Australia reported back problems to be in the top quartile of ranked conditions and one of the most common injuries preventing training and racing (Bailey *et al*. 1997).

The relationship between pain, pathology and spinal function has not been established in horses. Equine back pain may result from a wide variety of pathological processes. Jeffcott (1980) reviewed 443 cases identifying the major pathological lesions associated with thoracolumbar (TL) pain as: vertebral lesions 39%, soft tissue injuries 25%, sacroiliac strain 13% and nonTL lesions 13%. In the literature, the most commonly reported vertebral lesions are impingement or overriding of the dorsal spinous processes (DSPs) (Jeffcott 1979, 1980; Townsend *et al*. 1986; Haussler 1999b). Degenerative changes have also been reported in TL synovial intervertebral articulations (facet joints), inter-transverse joints and sacroiliac articulations (Haussler *et al*. 1999; Girodroux *et al*. 2009; Cousty *et al*. 2010), along with stress fractures of the vertebral lamina and pelvis in Thoroughbred racehorses (Haussler and Stover 1998). Soft tissue lesions have been reported to mainly affect the *longissimus dorsi* muscles and supraspinous ligament in the caudal withers and cranial lumbar regions (Jeffcott 1979, 1980; Valberg 1999; Quiroz-Rothe *et al*. 2002; Henson *et al*. 2007).

The predominant sign of back pain in horses is loss of performance (Jeffcott 1980, 1999; Jeffcott *et al*. 1982; Denoix 1998, 1999; Haussler 1999a; Peham *et al*. 2001). The insidious

*Corresponding author email: stubbsn@cvm.msu.edu
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nature of the back pain syndrome makes it a difficult condition to diagnose. Presenting signs vary from overt lameness or pain responses on palpation of the back, to subtle gait alterations or behavioural changes (Denoix and Dyson 2003). There is a strong association between lameness and back problems (Landman *et al*. 2004) which may pose a diagnostic challenge. Due to variability in presenting signs and altered kinematics of the back and limbs as a result of back pain and or lameness (Gomez-Alvarez *et al*. 2007a,b, 2008) back pain may be underdiagnosed.

Pathoanatomical diagnosis is complicated by the complex anatomy of the area, the inherent difficulties in using diagnostic equipment in the equine vertebral column and the need to use a variety of ancillary aids, including invasive techniques such as infiltration of local anaesthetic to confirm the clinical problem (Jeffcott 1980; Jeffcott *et al*. 1982; Denoix 1998, 1999; Gellman 1998; Holm *et al*. 2006). Horses suspected of having back pain are often treated on the basis of clinical examination only, with the treatment response being used to determine the need for further investigations, such as ultrasonography, radiography, scintigraphy and thermography (Munroe 2009). As in man, pathoanatomical diagnosis in horses may be complicated by the high prevalence of pathological changes (Jeffcott 1980; Haussler 1999b; Girodroux *et al*. 2009). Determining the significance in terms of pain and dysfunction may be the more important diagnostic approach and this is achieved in human medicine by examination of the *multifidus* muscle (Hides *et al*. 2008).

The *multifidi* provide intersegmental stabilisation and stiffen the spine, contributing two-thirds of the total increase in spinal stiffness imparted by muscular action (Wilke *et al*. 1995). *In vivo* studies in pigs confirmed that the *multifidi* are also a major stabiliser of the quadrupedal lumbar spine (Kaigle *et al*. 1995). In human back pain patients, *multifidus* is reduced in cross-sectional area (CSA) on the ipsilateral side and at the same intervertebral level where pathology is present (Hides *et al*. 1994). In a recent study the density of *multifidus/erector spinae* was associated with facet joint osteoarthritis, spondylolisthesis and disc narrowing (Kalichman *et al*. 2009). This also occurs within 3 days after a unilateral experimental lesion to an intervertebral disc in pigs (Hodges *et al*. 2006). Further, *multifidus* does not automatically resume its normal function following recovery from or resolution of an episode of acute back pain (Hides *et al*. 1996). Specific physiotherapeutic interventions are required to restore the size and function of *multifidus* after an episode of acute back pain in people and these interventions reduce the rate of recurrence of injury from 84% in untreated controls to 30% (Hides *et al*. 2001). In horses, generalised secondary atrophy of the epaxial muscles, especially *longissimus dorsi* and *gluteus medius* have been reported in horses with back pain (Jeffcott *et al*. 1982; Quiroz-Rothe *et al*. 2002) although changes in *multifidus* have not been reported.

In the field of human physiotherapeutic rehabilitation, ultrasonography has emerged as an invaluable tool for objective assessment and management of low back and pelvic girdle pain and dysfunction (Jull and Richardson 2000; Pietrek *et al*. 2000; Richardson *et al*. 2002; Hodges and Cholewicki 2007; Whittaker *et al*. 2007). Ultrasonographic measurements of *multifidus* CSA and function has proven to be a reliable, objective guide in the assessment, management and prevention of recurrence of back pain in man (Hides *et al*. 2008). Several measurements of muscle size provide a method of direct assessment of muscle function by indicating whether the muscle is of normal size, atrophied or hypertrophied, which is very important in rehabilitation for monitoring effectiveness of treatment over time (Rantanen *et al*. 1993; Stokes *et al*. 2005; Whittaker *et al*. 2007). Ultrasonography is used extensively in equine veterinary practice and many practitioners already have an ultrasound machine. The objective of this study was to investigate whether atrophy or asymmetry of *multifidus* occurs in association with pathological changes in the equine thoracolumbosacral spine. This study is based on the hypothesis that the human physiotherapeutic approach to back pain can be applied to the horse and that the use of ultrasonography to measure epaxial muscle size, especially *multifidus*, will be valuable in developing assessment tools and management strategies in horses suffering from back syndromes. The experimental hypothesis was that severe osseous pathological changes identified at necropsy in the thoracolumbosacral spine are associated with reduced *multifidus* CSA on the ipsilateral side at the same intervertebral level.

Materials and methods

The study was approved by the Animal Experiments Ethics Committee, Faculty of Medicine, Chinese University of Hong Kong and covered by license DH/ORIH/8/2/8/Pt.2 issued by the Department of Health, the Government of the Hong Kong SAR.

Subjects

Twenty-two Thoroughbred racehorses (mass: 493.2 ± 25.5 kg; age 6.2 ± 1.9 years; height 164.8 ± 3.7 cm) from the HKJC presented for euthanasia for primary reasons other than back pain were recruited. Retrospective clinical history was obtained from clinical case files to determine whether the horse had any prior history of back pain and or had been treated by a veterinarian, chiropractor and/or physiotherapist for back pain/spinal dysfunction.

Ultrasonographic evaluation

Ultrasonographic images of the left and right *multifidus* muscles were acquired at 4 TL locations (T13, L1, L3, L5) and of the *sacrocaudalis dorsalis* (SCD) muscles, the caudal continuation of *multifidus*, at the level of the third sacral vertebra (S3) (Fig 1). Ultrasonographic examination[1] was performed with the horses lightly sedated and standing in stocks using standard skin preparation methods and different curvilinear probes (5–10 MHz) dependant on the depth of penetration required. Three ultrasonographic images were acquired at each level on the left and right sides and were stored using the software on the ultrasound machine. Image analysis to measure *multifidus*/SCD CSA was performed 3 times for each image using proprietary software[2].

Pathological evaluation

A full necropsy was performed. Gross soft tissue lesions of muscle, ligament and fascia were noted and photographed. The thoracolumbar spine and sacropelvis were removed intact. The soft tissues were removed by gross dissection then a steel rod was passed through the spinal canal and fixed at both ends to maintain vertebral alignment. The spine was boiled to remove all remaining soft tissues and was stored until examination for evidence of gross bone pathology by one of the investigators (NCS) who was blinded to the identity using a coding system.

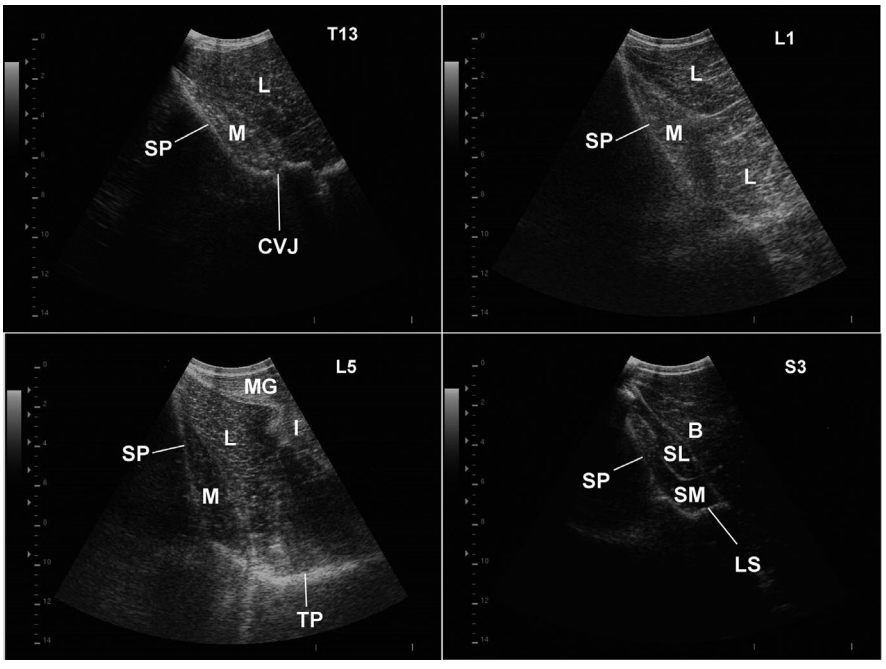

Fig 1: Ultrasound images of multifidus *(M),* sacrocaudalis dorsalis medialis *(SM) and* sacrocaudalis dorsalis lateralis *(SL) muscles at the levels of (left to right) the 13th thoracic vertebra (T13), the 1st and 5th lumbar vertebra (L1, L5) and the 3rd sacral vertebra (S3). The vertebral spinous process (SP) is seen forming the medial border of these muscles.* Longissimus dorsi *(L) lies on the lateral side in the thoracolumbar region and* biceps femoris *(B) is on the lateral side at S3. The ventral border at T13 is the costovertebral joint (CVJ), at L5 the transverse process (TP) and at S3 the lateral sacral crest (LS). The middle gluteal (MG) and* iliocostalis *(I) muscles are also shown.*

When pathological changes were found the following data were recorded: TL level of the lesion, side of occurrence (left, right, bilateral) and the anatomical site. The sites were classified as vertebral body or end plate; facet joint or articular process; dorsal spinous process or lumbar transverse process; lumbosacral complex (intertransverse joints, lumbosacral joint) and sacroiliac complex (CSA of the sacroiliac joint and presence of degenerative joint disease of the sacral and iliac joint surfaces). The following pathological abnormalities were sought: fractures; spondylosis; evidence of lysis and/or periosteal new bone formation (determined by the presence of an irregular cavity in or irregular, porous bone on the periosteal surface of the bone); or other lesions. Each lesion was graded according to severity on a scale of 0–3 in noncumulative fashion; *0*: no pathological changes; *1*: mild changes; *2*: moderate changes and *3*: severe changes (Stecher 1962; Jeffcott 1980; Townsend *et al*. 1986; Haussler *et al*. 1999). Active new bone formation was considered a major finding and was required in order to grade a lesion as severe.

Statistical analysis

To calculate symmetry/asymmetry between left vs. right *multifidus*/SCD CSA the mean typical measurement error was established for each spinal level based on 3 measures at that level and side for each horse. The minimal detectable difference outside of the measurement error was established using coefficients of variation (CV) of 4, 8 and 12% (95% CI) for each level across all horses (Hopkins 2000). Pearson's Chi-squared analysis was used to determine whether there was an association between the presence of significant left/right asymmetry of *multifidus*/SCD CSA at a specific spinal level and the presence of asymmetrical osseous pathology grades at that level within individual horses. Pearson's Chi-squared analysis was also used to determine if there was an association between pathological *grade* (*1–3*) and spinal asymmetry of *multifidus*/SCD CSA at each spinal level to determine if left/right asymmetry in *multifidus*/SCD CSA was associated with left/right asymmetry of pathological grade at the same level and to determine whether a significant reduction in *multifidus*/SCD CSA was associated with a higher asymmetrical grade of pathology on the same side and at the same level within an individual horse.

Results

Pathology

Osseous pathology was found at all spinal levels examined (84) and all horses had mild or moderate changes at each level with at least one lesion that was *grade 2* or greater. Evidence of severe (*grade 3*) spinal pathology was found in 17/22 horses (77%). All horses had at least one osseous lesion of *grade 1* or higher at each spinal level (T13, L1, L3, L5, S3), comprising 36 levels with *grade 1* lesions, 47 levels with *grade 2* lesions, and 33 levels with *grade 3* lesions (Table 1). At T13 there was a higher prevalence of *grade 1* lesions (16/22 horses), with L5 having the greatest number of *grade 3* osseous pathological lesions (12/22).

While none of the horses was subjected to euthanasia as a direct result of back pain, 15 horses (68%) had a prior history of back pain previously treated by veterinarians, chiropractors and/or physiotherapists. Within this group, 12 (80%) had a *grade 3* spinal lesion. Of the 7 horses without any specific history of back pain 6/7 (86%) had a *grade 3* lesion. A complete clinical examination was able to be performed in 20/22 horses, 18 showed clinical signs of TL-pelvic back pain just prior to euthanasia. Not all ultrasonographic CSA images could be analysed at some levels due to poor image quality.

TABLE 1: Pathological grades of osseous lesions for the 5 spinal levels at which ultrasonographic images of *multifidus* or *sacrocaudalis dorsalis* were evaluated

Level	*Grade 1*	*Grade 2*	*Grade 3*	Total
T13	16	5	1	22
L1	7	8	7	22
L3	6	12	4	22
L5	3	7	12	22
S3	3	13	6	22
Total	35	45	30	110

TABLE 2: Number of horses showing left/right asymmetry of *multifidus* or *sacrocaudalis dorsalis* at 5 spinal levels based on 4, 8 and 12% coefficients of variation (CV) and the total number of horses with ultrasound scans of these muscles at each level

	T13	L1	L3	L5	S3	Total
CV 4% (0.6 cm^2)	9	8	11	18	9	55
CV 8% (1.2 cm^2)	4	6	7	13	6	36
CV 12% (1.8 cm^2)	1	2	5	11	4	23
Number of horses with images	12	19	14	22	18	85

The mean typical measurement error was established for each level across all horses resulting in minimal detectable difference in *multifidus*/SCD CSA between the left and right sides of 0.6 cm^2 for CV 4%; 1.2 cm^2 for CV 8% and 1.8 cm^2 for CV 12%. Table 2 shows the number of horses with significant left/right differences in *multifidus*/SCD CSA at each level using CVs of 4, 8 or 12%. For comparison with pathological changes a CV 4% (0.6 cm^2) was used to determine left/right asymmetry.

Association between osseous pathology and muscle asymmetry

Analysis of the relationship between osseous pathology grades and the presence of asymmetries in ultrasonographic CSA are shown in Figure 2 with *grade 1* osseous lesions associated with asymmetrical *multifidus*/SCD CSA at 12/24 sites; *grade 2* 24/31 sites; and *grade 3* at 18/26 sites. When the maximum pathological grade was calculated for each level examined, there was no significant association between the grade of pathology and symmetry/asymmetry of *multifidus or SCD* CSA; however, there was a trend at L1: P = 0.06. Of the 84 levels examined 55 were symmetrical left-right within grade of multiple osseous pathologies; 27 had symmetrical left/right *multifidus* CSA and 28 asymmetrical, there was no significance between the groups (P = 0.82). However, 29 spinal levels showed left/right asymmetry in the pathological grade and this was significantly associated with left/right asymmetry in *multifidus* CSA (P = 0.04). Twenty levels showed left/right asymmetries in both *multifidus*/SCD CSA and pathological grade. Asymmetry in *multifidus*/SCD CSA had a significant association with the occurrence of *grade 3* pathological lesions but not with *grade 1* or *grade 2* lesions. When asymmetrical pathological lesions of *grades 1* and *2* were combined, there was a trend (P = 0.07) toward an association with asymmetry in *multifidus*/SCD CSA.

When the pathology was asymmetrical, the side with the higher pathological grade corresponded with the smaller *multifidus*/SCD CSA at 18/20 levels and this relationship was highly significant (P = 0.0003) (Table 3). Figure 3 is an example at L5 where the right osseous pathology (facet and neural arch fracture, with incomplete vertebral body spondylosis) matches the right reduction in CSA (left mean CSA 15.07 cm^2 s.d. 0.21; right mean CSA 11.21 cm^2 s.d. 0.24; absolute difference: 3.86 cm^2). This is a very large left/right difference, significant even when using 12% CV (1.8 cm^2) limits.

Discussion

Left/right asymmetry of osseous pathological lesion grade was associated with asymmetrical *multifidus*/SCD CSA at the same spinal level, with the side having the higher grade of pathology corresponding with the smaller *multifidus*/SCD CSA. Further, this asymmetry was associated with severe lesions showing active bone remodelling as opposed to other lesions of a lower severity (*grades 1* and *2*). Across all levels examined for pathology the prevalence of severe pathology was very high (80%) and all horses in the study had moderate or mild changes. While this finding is in agreement with the high prevalence of pathological lesions in Thoroughbred horses examined following catastrophic racecourse injuries (Haussler and Stover 1998; Haussler *et al*. 1999), it has not been possible to determine which lesions are painful or performance-limiting and which lesions are incidental or benign. In this study, the combination of severe pathology and *multifidus*/SCD atrophy or asymmetry strongly suggests that the lesions are clinically significant, although further work is required to investigate the relationship with pain. Ultrasonography is a noninvasive tool potentially able to differentiate active from the highly prevalent incidental osseous changes in the equine spine.

The prevalence of a prior history of back pain was also high considering the age (mean 6 years) and previous prevalence estimates, but is in agreement with figures reported for specialist back or chiropractic practice (Haussler 1999a). These findings highlight the importance of back pathologies and back pain in the racing population.

In the current study, the extremely high prevalence of multiple grades and types of pathology across all spinal levels was problematic for the analysis of asymmetry data due to the multiple variables affecting *multifidus* CSA. None of the levels examined ultrasonographically received *grade 0* for osseous pathology on both left and right sides at that level or at the next level. At many levels, pathology was bilateral or on the midline (facet joint osteoarthritis, DSP impingement, degenerative disc disease, vertebral spondylosis, sacroiliac disease). It is uncertain whether these osseous pathologies cause bilateral atrophy of *multifidus* and SCD complex. It is also only possible to compare left-right symmetry at the same level in each horse because CSA along the length of the vertebral column varies within and between horses (McGowan *et al*. 2007).

Despite these concerns, across the 22 horses examined, 55 levels had significant left/right *multifidus*/SCD CSA asymmetry. This type of asymmetry was not present in young horses (unbroken Australian stock horses and Thoroughbreds in prerace training), and is less prevalent in mature Standardbreds and other aged horses that are not ex-racehorses (McGowan *et al*. 2007). These findings further support that asymmetry of *multifidus*/SCD measured ultrasonographically may be an important diagnostic indicator of severe osseous pathology in horses and warrants further investigation in different populations of horses.

While the *multifidi* have a key role in the stability of the lumbar spine in man (Moseley *et al*. 2002), it is the role of the *mutifidi*

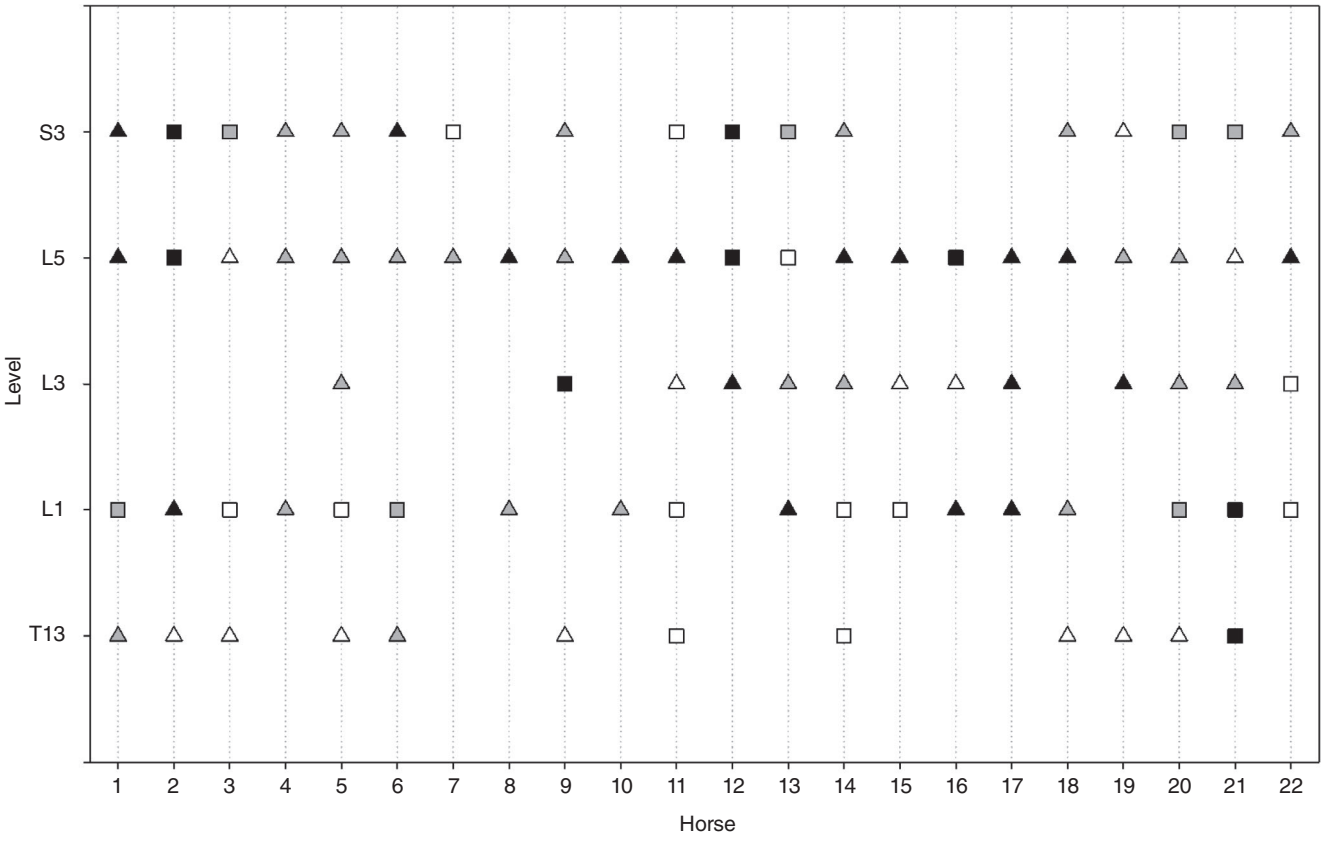

Fig 2: Scatterplot showing the relationship between osseous pathological grades and the presence of asymmetries in ultrasonographic CSA of multifidus *or* sacrocaudalis dorsalis*. Osseous lesions were associated with asymmetrical* multifidus *or* sacrocaudalis dorsalis *CSA at 12/24 sites for* grade 1 *lesions; 24/31 sites for* grade 2 *lesions; and 18/26 sites for* grade 3 *lesions. The graph plots horse on the x-axis and spinal level on the y-axis. Triangles represent no significant left-right difference in ultrasound CSA (CV 4%: 0.6 cm). Squares represent significant left-right difference in ultrasound CSA (CV 4%: 0.6 cm).White fill represents* grade 1 *osseous lesions, grey fill represents* grade 2*, black fill* grade 3*.*

proprioceptive and preparatory function (neuromotor control) of the spine that is important in preventing unwanted vertebral motion and the occurrence or recurrence of back pain in man (reviewed in Hodges and Cholewicki 2007). In horses *multifidus* has similar muscular anatomy and structure and is thought to play a similar role in stabilising the spine (Stubbs *et al*. 2006). Similarly, the innervation of the *multifidus* in horses is similar to man, further supporting the similar role this muscle plays in the equine spine (Vandeweerd *et al*. 2007). Each lumbar articular facet and *multifidus* is innervated by the medial branches of the dorsal rami of the spinal nerves at the same level and one level cranially. Since the fascicles of *multifidus* from each spinal level cross between 1 and 4 intervertebral joints, an osseous pathological lesion can potentially affect the CSA up to 4 levels further caudally. However, this effect at 4 levels caudally may be insignificant due to only one fascicle crossing this level that originated at the level of the pathology (Stubbs *et al*. 2006). This important neuromotor control role of the *multifidi* probably explains why this group of muscles demonstrate atrophy most closely correlated with back pain syndromes in people (Hides *et al*. 2008). Ultrasonography is relatively inexpensive, portable, easy to use and enables rapid analysis by an experienced practitioner. Both objective and subjective scales of measurement are used (Genovese *et al*. 1997; Reef 1998; Pickersgill *et al*. 2001). These include comparison of contralateral tissues and determination of echogenicity using grey scale analysis and predetermined ordinal scales (Gillis *et al*. 1993; Martinoli *et al*. 1993; Tsukiyama *et al*. 2005). However, several inherent difficulties associated with the image acquisition and analysis process for measuring size of *multifidus* were highlighted in this study. At some levels poor image quality either during the acquisition and/or image analysis processes precluded analysis. However, in all 22 horses, *multifidus* CSA could be measured at L5 which is of particular interest as this is the region of maximal dorsoventral motion in the horse's TL spine (Townsend *et al*. 1983). It was also the site where the greatest number of *grade 3* lesions occurred. In some cases, artifacts were due to pathology, such as excessive bony proliferation of the dorsal spinous process and/or interspinous ligament attachment, or a change in spinous process morphology with increased mediolateral angulation of the spinous process which was frequently associated with overriding dorsal spinous processes at that level. Another source of artifact was the presence of adipose tissue along the lateral border of the spinous process and within the deeper fascicles of *multifidus* at the level of the pathology and associated with reduced *multifidus* CSA. The ability of newer ultrasound machines to identify fat will facilitate identification of these changes in the future.

In 2 horses the side of significantly reduced CSA did not match the side of the higher pathological grade, both at L4/L5, where the higher grade of pathology was on the left side (*grade 2*). The transverse processes of L4/L5 on the left side were undergoing active ankylosis and the intertransverse joint on the right was already ankylosed with smooth bone (*grade 1*). In addition, there was a mild degree of overriding of the dorsal spinous processes (*grade 1*). However, there was also a severe fracture of the facet

TABLE 3: Horses and levels that had left-right asymmetries of both osseous pathology grade and ultrasonographic (US) *multifidus* cross sectional area (CSA) based on a 4% coefficient of variation (CV: 95% CI)

	Osseous pathology			Ultrasound asymmetry				Osseous pathology
Horse	Max grade	Left grade	Right grade	Abs diff	Ratio	Match	Level	Max/level
19	1	0	1	1.13	1.11	Yes	S3	R. SID
10	2	1	2	0.90	1.08	Yes	L1	R. VB marginal osteophytes
10	3	1	3	1.97	1.17	Yes	L5	R. Active facet ankylosis, old facet #. Note: DSP and TP fused smooth ankylosis, ventral VB bone spurs and osteophytes
14	3	1	3	3.86	1.34	Yes	L5	R. Facet and neural arch #. Note: L5.6. incomplete ankylosis, VB spondylosis (osteophytes, ventral lipping)
17	3	1	3	1.47	1.29	Yes	L1	R. Facet OA, large periarticular osteophytes visible on US
18	3	1	3	1.14	1.09	Yes	S3	R. SID Note: R. TC # one month prior, acute L TC #
5	2	2	0	–1.82	0.86	Yes	S3	L. SID
10	2	2	1	–0.68	1.07	Yes	S3	L. SID
20	3	2	3	0.13	1.01	Yes	S3	R. SID
22	3	2	3	0.65	1.05	Yes	S3	R. SID, joint completely destroyed, chronic ilial #
9	3	3	2	–0.86	0.93	Yes	L1	L. Facet severe cleft # with obvious proliferation in the neural canal
9	3	3	2	–2.51	0.80	Yes	L3	L. Facet cleft #
12	3	2	3	3.00	1.29	Yes	L3	R. TP active ankylosis
15	3	3	1	–1.72	0.86	Yes	L5	L. IT active incomplete ankylosis. Note: R. IT smooth ankylosis; VB grade 3 eburnation and proliferation
17	3	3	2	–1.45	0.81	Yes	L3	L. Facet cleft #
19	3	3	2	–0.90	0.91	Yes	L3	L. Facet cleft #: Note OA IT
21	1	3	1	–3.50	0.75	Yes	L5	L. Facet cleft #
22	3	3	2	–1.75	0.86	Yes	L5	L. Complete facet # Note: L6 facet cleft #; unable to assess joint as ankylosed TP; old # R L5 TP smooth ankylosis
7	2	2	1	1.20	1.11	No	L5	L. Facet OA Note: severe R. L3/4 facet #, R. TP almost complete smooth ankylosis
8	3	3	2	0.63	1.06	No	L5	L. IT and LS OA Note: Grade2. L/R. facets clefts OA

For the US *multifidus* CSA, the difference is calculated by subtracting right CSA from left. The ratio is the difference between left and right CSA divided by the larger (left or right) CSA. Match indicates whether the side with maximal pathology grade matches with the side with smaller *multifidus* CSA. The osseous pathology does not include central lesions if the grade was lower than that for the unilateral pathology. R. right; L. left; US: ultrasound; SID: sacroiliac disease; VB: vertebral body; TP: transverse process; IT: intertransverse joint; #: fracture; TC: *tuber coxae*; OA: osteoarthritis.

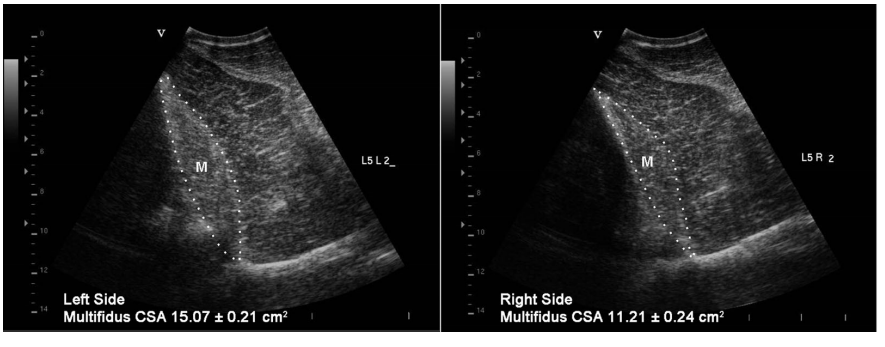

Fig 3: Left and right ultrasound images of multifidus *(M) cross-sectional area (CSA) at the 5th lumbar vertebra in* Horse 14. *The right osseous pathology (facet and neural arch fracture, with incomplete vertebral body spondylosis) matches the right reduction in CSA (left mean CSA 15.07 cm² s.d. 0.21; right mean CSA 11.21 cm² s.d. 0.24; absolute difference: 3.86 cm².*

joint at L3/L4 on the same side as the reduced *multifidus* CSA. As previously stated, *multifidus* crosses between 1 and 4 intervertebral discs (Stubbs *et al*. 2006), thus the L3/L4 facet fracture may account for the *multifidus* atrophy more caudally on that side. The other horse in which the pathological grade did not match the ultrasonographic asymmetry also had a *grade 3* lesion on the left and a *grade 2* lesion on the right. Bilateral L4/L5 facet degenerative joint disease was evident (*grade 2*) with moderate periarticular osteophytes and moderate asymmetry in the size of the facet joint/articular pillar, the right one being larger than the left, and this may have been the source of the *multifidus* asymmetry. However, the left side was graded higher due to the presence of marked intra-articular bone erosions of the inter-transverse joints (*grade 3* left, *grade 2* right). It is also uncertain whether these types of pathology result in atrophy of *multifidus*/SCD in the lumbosacral region as ultrasonographic CSA evaluation is not possible between L6–S2 due to the position of the ilium.

The lesions most commonly associated with both severe changes and *multifidus* asymmetry were stress fractures of the facet joints and/or associated degenerative joint disease. Pelvic fractures, sacroiliac dysfunction and lumbosacral degenerative joint disease were less common. Only one horse had overriding dorsal spinous processes as the primary finding and this horse had no asymmetry of its *multifidus* or history of back pain. Facet joint pathology was detected on the ultrasound images in many cases using the same technique as for the CSA of *multifidus* and represents an area where

pathology may be directly imaged in affected horses. This is consistent with recent practice trends demonstrating the value of musculoskeletal system ultrasonography of the back (Denoix 1999; Lamas and Head 2009).

This study indicates a clear association between osseous pathological findings at necropsy and objective ultrasonographic measurements showing atrophy and asymmetry of *multifidus* CSA at the same level and on the same side of the spine. It is concluded that ultrasonography of the epaxial muscles is a promising noninvasive tool for detecting spine pathology, likely to be associated with back pain in horses and for monitoring the response to treatment. The fact that atrophy of *multifidus* persisted in association with chronic pathological lesions suggests that in horses, as in man, there is a potential need for physiotherapeutic strategies for strengthening and recruiting this muscle during treatment and rehabilitation.

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Conflicts of interest

None declared.

Manufacturers' addresses

[1]VingMed System 5 Ultrasound Machine, http://www.gehealthcare.com/worldwide.html.
[2]Image J, http://rsbweb.nih.gov/ij/.

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