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1 Equine Posture Analysis: Development of a simple tool to record equine thoracolumbar posture

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6

7 **Abstract**

8 Background: Musculoskeletal assessment of horses includes assessment of conformation, symmetry
9 and postural alignment of the equine spine however objective methods to analyse the spine have high
10 costs and are logistically complex.

11 Objective: This study aimed to assess the intra- and inter-rater reliability of simple methods designed
12 to objectively measure thoracolumbar (TL) posture from photographs.

13 Methods: A sample of horses (n=190) were photographed with a digital camera in two positions of
14 stance and also a static image was captured from video at the toe off phase of the right hind in walk.
15 Measurements of TL angle, depth and area of lordosis were tested for intra and inter reliability.

16 Results: Repeated measures of TL angle showed no significant differences between measurements
17 taken by one observer but TL depth and surface area measures were not found to be consistently
18 reliable. Inter-rater reliability was poor for all measurements across three observers.

19 Conclusion: TL angle method of recording thoracolumbar posture in horses has the potential to be
20 used to gain an objective measure of posture when standardised positioning is applied by a single
21 experimenter or clinician.

22

23 **Highlights**

- 24 • Musculoskeletal assessment of horses includes assessment of posture
- 25 • Objective, simple measures of equine thoracolumbar posture have not been tested for
26 reliability
- 27 • Calculation of equine thoracolumbar angle is reliable with one observer but not with
28 multiple observers
- 29 • Calculation of equine thorocolumbar depth or area is not reliable for either one or more
30 observers.
- 31 • The thoracolumbar angle method could be used to objectively measure outcome of
32 treatment interventions if repeated by a single observer

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36 **Introduction**

37 Musculoskeletal assessment of horses includes assessment of conformation, symmetry and postural
38 alignment of the equine spine [1,2,3]. In the quadruped mammal, the thoracolumbar (TL) spine is
39 aligned horizontally, with a position of relative extension described as lordotic and in the horse, if this
40 lordosis is increased, may contribute to osseous and/or soft tissue injuries [4]. Vertebral problems
41 have been associated with changes in neck posture [5] as well as roundness of neck and back shape
42 [6], and higher muscle activity (via surface electromyography) has been measured at the level of
43 affected vertebrae [7]. These changes may also TL lordosis and therefore the relative TL posture.
44 Anecdotally TL lordotic posture has been related to spinal pain and pathology in the TL regions.
45 However objective methods to analyse the spine for pathology underlying a change in posture, such
46 as radiography, ultrasonography or scintigraphy have high costs, are logistically complex and require
47 extensive training for the clinician as well as presenting risks such as exposure to radiation. An
48 objective, simple and economic measure of equine spinal posture that could be incorporated into daily
49 practice 'in the field' would be beneficial, allowing assessment of posture change with following
50 treatment and rehabilitative training.

51 Posture of the spine is routinely assessed in human patients to examine its relationship to low back
52 pain [8,9] and a pilot study, with a small sample size, of equine posture also assessed sagittal view
53 photographs in neutral 'square' stance [1], finding good reliability of measures of thoracolumbar
54 posture with a single observer. However, positioning a horse in a single standardised position is
55 challenging, time consuming and therefore for ease of practical application it would be more
56 convenient to be able to measure TL posture in horses during relaxed stance or during gait, similar to
57 neck posture in ridden [5] and in standing horses [7]. The reliability of such data have not been tested
58 to date, therefore this study aimed to assess the intra- and inter-rater reliability of simple methods
59 designed to objectively measure thoracolumbar posture from a single image image of a horse in

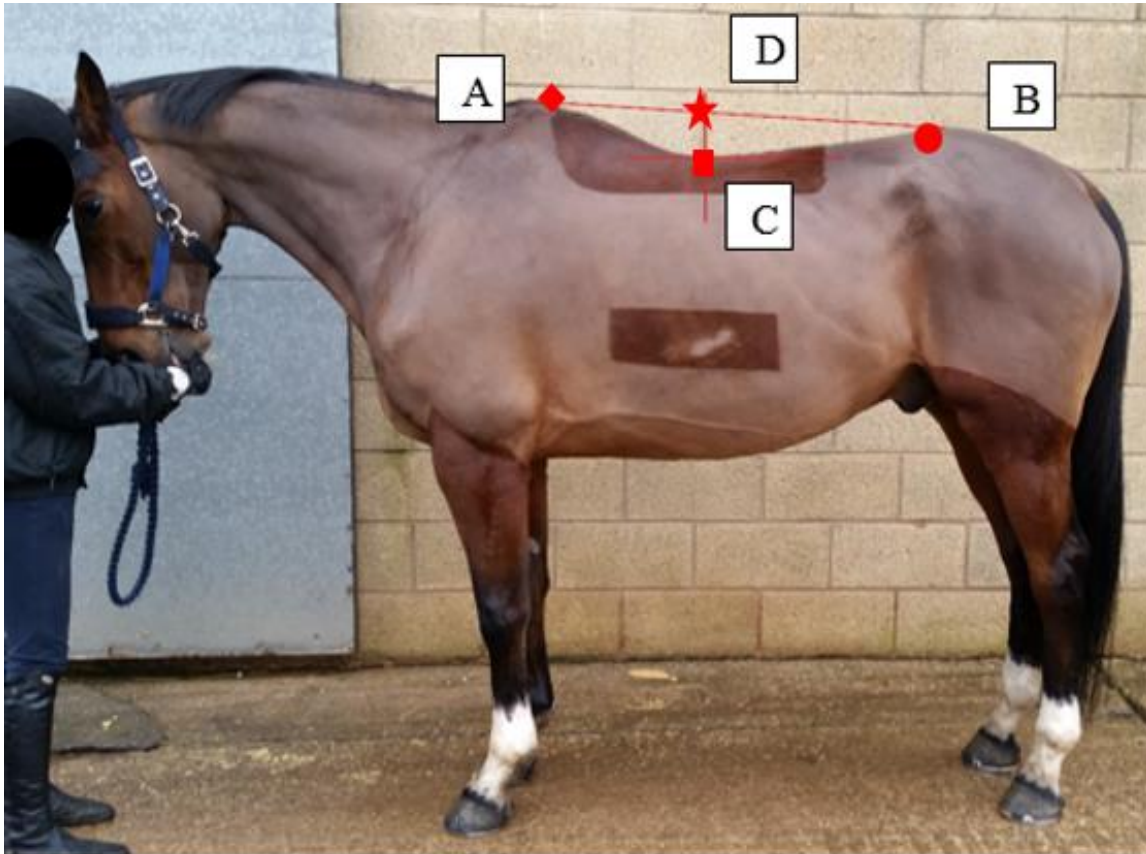
60 neutral and relaxed standing postures, and between images of stance and a single point during the
61 walk cycle..

62 **Methods**

63 The equine subjects were opportunistically selected from private stable yards and two equestrian
64 colleges. Inclusion criteria were: horses aged four years or above, in ridden exercise without any
65 current veterinary management for injury, lameness or illness. All horses wore their normal head
66 collar or bridle for controlling movement.

67 Two groups of horses were photographed with a Smartphone camera (8-megapixel resolution; camera
68 height level with mid thoracic spine, aligned to the longitudinal axis and 2 metres from horse), with a
69 visible marker of known length in the frame to allow for image calibration and accurate digital
70 measurement for measurement of TL depth in millimetres [10] (figure 1). Group one (n=90) horses
71 were stood on a concrete surface two positions, in random order: feet aligned or feet non-aligned
72 both positions with head aligned vertically, chin level with shoulder. For collection of a dynamic image
73 of posture group two (n=100) horses, after being photographed in stance with feet aligned, were also
74 walked, across a flat hard surface, perpendicular to the camera at approximately five metres from the
75 camera and a video recording (frame rate: 60 frames per second) was collected. Videos were viewed
76 in Windows Movie Maker (Microsoft Corporation, Redmond, WA, USA) to obtain a static image with
77 the horse's right hind leg in the toe off phase of gait, these were extracted for analysis [11].

78 Digital images were exported to ImageJ™ software (NIH, Bethesda, Maryland, USA) for analysis. The
79 dorsal angle of thoracolumbar spine (TLangle) (Angle ACB°), the depth of the thoracolumbar lordosis
80 (TLdepth) (Length DC: cm) and the area of the lordosis (TLsa) (Area between line AB and curve of the
81 dorsal profile AB: cm^2) (figure 1) were measured three times with the observer blinded to previous
82 measurements and a median calculated [1]. To test inter-rater reliability 50 images, randomly
83 selected from the photographs of stationary group 2 horses, the TLangle, depth and area were
84 measured once by three different measurers.



86

87

88 *Markers shown on an equine subject, stood with forefeet and hind feet aligned with equal left/right weight*
 89 *bearing and head aligned vertically, chin level with shoulder joint. Symbols added to represent locations used*
 90 *for thoracolumbar posture measurements: A/◆ = Highest point of withers; B/● = Highest point of lumbar or*
 91 *pelvis region; C/■ = Lowest point of thoracolumbar region; D/★ = point on line AB where vertical line from C*
 92 *bisects.*

93

94 Figure 1. Marker location for measurement of sagittal alignment.

95

96 A-priori sample size calculations identified the minimum sample size required to reduce the potential
 97 for type I (alpha: 5%) and type II (beta: 20%) errors [12]. A minimum of 80 horses and more than 2
 98 experimenters were identified to meet these criteria to give a valid representation of inter and intra
 99 reliability with an effect size of 0.5.

100 *Statistical Analysis*

101 Data did not meet the requirements for parametric statistical analysis, therefore non-parametric
 102 analyses were undertaken using SPSS statistical package version 23 (SPSS Inc, Chicago, IL). Repeated
 103 measures of each image were tested with related samples Friedman's two way analysis of variance.

104 Intraclass correlation estimates (ICC) and their 95% confident intervals (CI) were calculated based on
 105 a mean-rating (k = 3), absolute-agreement, 2-way mixed-effects model [13]. To assess for differences
 106 between thoracolumbar posture in static and dynamic images, and between neutral and relaxed
 107 postures, a series of Wilcoxon signed-rank tests were used. For all tests alpha was set at 0.05.

108 **Results**

109 A total of 380 images were obtained and analysed (table 1).

110 Table 1: Equine thoracolumbar posture measurements

111 *Median and interquartile range (IQR) measurement for each group of images for thoracolumbar angle*
 112 *(TLangle), depth (TLdepth) and surface area (TLsa).*

Measurement Method	Group 1		Group 1 total sample size	Group 2		Group 2 total sample size
	Static Neutral	Dynamic		Static Neutral	Static Relaxed	
TLangle (°)	Median: 150.5 IQR = 4.4 n=90	Median: 155.8 IQR = 4.8 n=90	n = 180	Median: 149.1 IQR = 4.6 n=100	Median: 148.6 IQR = 5.4 n=100	n =200
TLdepth (cm)	Median: 9.1 IQR = 1.9 n=33	Median: 11.1 IQR = 3.2 n=33	n=66	Median: 9.8 IQR = 1.7 n=72	Median: 9.6 IQR = 1.7 n=72	n =144
TLsa (cm ²)	Median: 331.5 IQR = 66.2 n=90	Median: 600.8 IQR = 254.8 n=33	n = 66	Median: 462.4 IQR = 113.2 n=72	Median: 457.1 IQR = 105.9 n=72	n =144

113 *Intra-rater reliability*

114 Intra-rater reliability was excellent between each of the three measures for TLangle with no significant
 115 differences found within experimenters (Group 1: $\chi^2(2)=1.872$, $p=0.392$; ICC: 0.989; CIs: 0.986-0.991;
 116 Group 2: $\chi^2(2)=2.790$ $p=0.248$; ICC: 0.987; CIs: 0.983-0.990) [13]. In contrast, reliability differed
 117 between the two groups assessed for TLdepth and TLsa. Measurement of TLdepth in Group 1 images
 118 was not consistent ($\chi^2(2)=7.826$ $p=0.020$; ICC: 0.994; CIs: 0.991-0.996) however intra-rater reliability
 119 was excellent for Group 2 ($\chi^2(2)=3.737$ $p=0.154$; ICC: 0.989; CIs: 0.981-0.989). For TLsa measurement,
 120 Group 1 demonstrated excellent intra-rater reliability ($\chi^2(2)=2.279$ $p=0.320$; ICC: 0.997; CIs: 0.996-

121 0.998) however this was not repeated for Group 2 data, were significant differences between
122 measurements were found ($\chi^2(2)=11.014$ $p=0.004$; ICC: 0.995; CIs: 0.994-0.996).

123 As significant differences between measurements occurred for TLdepth and TLsa, only TLangle data
124 were analysed for differences by position. Significant differences were found for TLangle between the
125 group 1 static and dynamic postures as well as group 2 static neutral and static relaxed images (Group
126 1: $z=8.201$, $p=0.000$, $r=.86$; Group 2: $z=-3.661$, $p=0.000$, $r=-.37$).

127 *Inter-rater repeatability*

128 TLangle, depth and surface area measurements were all significantly different (TLangle $\chi^2(2)=72.840$
129 $p=0.000$; ICC: 0.765, CIs: 0.182-0.910; TLdepth $\chi^2(2)=34.120$ $p=0.000$; ICC: 0.915; CIs: 0.818-0.956; TLsa
130 $\chi^2(2)=14.68$ $p=0.001$, ICC: 0.933; CIs: 0.887-0.961) demonstrating poor inter-rater reliability between
131 the measurements assessed.

132 **Discussion**

133 Three methods were used to obtain measurements of posture from sagittal images of horses standing
134 square, in a relaxed position and images from walking gait. TLangle method showed no significant
135 differences between measurements taken by one observer supporting the results obtained previously
136 [1] suggesting that TLangle method could be used to measure of thoracolumbar posture. Differences
137 were noted between the stance positions assessed for TLangle, therefore it would be essential that
138 the horse is positioned with the same feet and head alignment to ensure reliability when assessing
139 posture. However the current study was limited to only measuring each horse at one moment in time,
140 with no repeated photographs taken to see if posture altered over time. Tabor and Randle [1] took
141 three images of each horse at 30-minute intervals and found no differences in repeated measures but
142 concluded that this may be due to the absence of extraneous factors that could influence posture
143 occurring in that time frame.

144 The depth and surface area method were not found to be consistently reliable; this may be due to the
145 increased accuracy required to measure the distances, AB and CD (figure 1) and trace the dorsal profile
146 with the cursor in Image J™. Therefore, these methods of recording posture of the equine
147 thoracolumbar spine should not be considered reliable. There were also significant differences when
148 comparing TLangle from photographs of a horse stood square and the same horse in walk. This
149 indicates that the spinal posture was different in these two conditions, supporting the need for
150 consistency in the position used and subsequent repeatability of positioning, for taking measures at
151 different time periods.

152 Inter-rater reliability was poor for all measurements across the three observers, suggesting that none
153 of these methods are suitable for use when more than one assessor is assessing spinal posture.

154 **Conclusions**

155 Analysis of equine posture can be made by a single observer measuring the angle of the thoracolumbar
156 spine from a single image of a horse stood in a neutral position. However measurement of TL depth
157 or surface area was not repeatable by a single observer and measurement of TL posture during gait
158 did not relate to posture in stance. None of the methods tested were repeatable with more than one
159 observer. The TLangle method of recording thoracolumbar posture in horses, used by the same
160 observer, has the potential to be used to gain an objective measure of posture when standardised
161 positioning is applied by the experimenter or clinician. Therefore, this measure is useful and clinically
162 applicable if the same person assesses posture throughout of treatment, for example. The validity of
163 this objective measure could now be tested to assess changes in TL posture and potentially used to
164 document the outcome of intervention effects on spinal posture.

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166 for-profit sectors.

167 **Ethics:** Ethical approval gained from the University Centre Hartpury Ethics Committee

168 Conflicts of interest: none

169

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