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Pressure Algometry in Icelandic Horses: Interexaminer and Intraexaminer Reliability

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ABSTRACT

Reliability of pressure algometry as an outcome measure in equine research and therapy needs to be studied. The aim of the present study was to establish interexaminer and intraexaminer reliability of pressure algometry in Icelandic horses and to determine reference mechanical nociceptive threshold (MNT) values for that particular breed. Another aim was to create cutoff values, for clinical monitoring of asymmetry in musculoskeletal sensitivity in the Icelandic horse. Nine clinically sound Icelandic horses were tested with a pressure algometer on 11 anatomic landmarks on the neck, back, and croup, each by two examiners. Three weeks later, the procedure was repeated. Interexaminer reliability was good (intraclass correlation [ICC] = 0.64; $P < .001$). Short-term intraexaminer reliability over three repeated measurements was comparable to other studies. Intraexaminer reliability over 3 weeks was moderate for examiner 1 (ICC = 0.46; $P < .001$) and good for examiner 2 (ICC = 0.78; $P < .001$). Measurements of examiner 1 differed significantly from those of examiner 2 ($P < .001$). For each anatomic landmark and examiner, mean MNT values (standard deviation) were calculated. Asymmetry values were calculated for bilateral anatomic landmarks. It was concluded that the reliability of pressure algometry in a population of sound Icelandic horses was moderate to good. Future research is needed to assess the interexaminer and intraexaminer reliability of pressure algometry in horses with musculoskeletal pain.

1. Introduction

Pressure algometry is a technique whereby an examiner increasingly applies pressure to soft tissue or bony anatomic landmarks, to determine the mechanical nociceptive threshold (MNT). The MNT is defined as the minimum pressure that causes a pain response [1], at which point the pressure is stopped. Higher MNT values are thus associated with reduced pain and lower values with an increase in painfulness or sensitivity [2]. Handheld pressure algometers (PAs), automated devices, cuffs, and an algometer fixation device (stand) are among the different types and procedures that are being used. Pressure algometry has shown to be a reliable and valid method to objectively assess musculoskeletal pain in humans; intraexaminer and interexaminer reliability are moderate to excellent, depending on the PA and procedure used [3–7]. Around the turn of the century, pressure algometry made its entrance in the field of equine research. It was welcomed as a potentially objective technique to assess nociception in the horse [8,9], as an outcome measure for various treatment modalities [10,11] and in experimental models on analgesics [12,13].

In equines, reliability of pressure algometry has mainly been defined by the short-term intraexaminer reliability of three repetitive measurements, taken at one site, with approximately 3 seconds in between [8,10,12,14]. The

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difference between the outermost MNT values is calculated and is termed the "range" over which the examiner measured MNTs at that site within 3 to 4 seconds. The values may increase from the first until the third measurement (this is taken to reflect habituation), decrease (this is taken to reflect sensitization to the measurement), or the values may show no specific pattern or be equal for the three measurements [8]. The ranges are averaged to calculate the "mean range," that is the general short-term reliability during a study. Intraexaminer reliability increases as the range over the three repeated measurements decreases. In contrast with short-term intraexaminer reliability, both intraexaminer reliability over a longer timelapse and interexaminer reliability between two examiners have not yet been determined systematically in horses. Any examination or procedure viewed as reliable would need to produce similar results regardless of time, environment, or examiner [15]. For use in veterinarian and physiotherapeutic clinical practice, it is important to gain more insight in the interexaminer and intraexaminer reliability of pressure algometry [16]. To our knowledge, however, no study has explicitly determined interexaminer and intraexaminer reliability of pressure algometry measurements of the equine neck, back, and croup over a period of 3 weeks, while comparing two observers using a handheld PA. An examination interval of 3 weeks is commonly used in veterinarian and physiotherapeutic clinical practice.

Reference MNTs of sound horses provide a standard to which horses with suspected or known pain can be compared. Furthermore, subject status and breed appear to be of influence on MNT values. Clinical problems may also present as asymmetry in MNTs between left-sided and corresponding right-sided anatomic landmarks [8].

The aim of the study was to assess interexaminer and intraexaminer reliability of pressure algometry in Icelandic horses over a 3-week period and to determine reference MNTs for several clinically relevant anatomic landmarks. As a parameter for diagnosing and treating Icelandic horses with neck, back, and croup pain, we calculated cutoff values for asymmetry.

2. Materials and Methods

2.1. Ethical Approval

The study design was approved by the institutional Ethics Committee on the Care and Use of Experimental Animals in compliance with Dutch legislation on animal experimentation (2009.III.06.049).

2.2. Animals

Nine clinically sound Icelandic horses from one barn were tested, including four mares, four geldings, and one stallion. Mean (standard deviation [SD]) age was 13.3 (7.7) years, and mean (SD) height at the withers was 1.4 (0.04) m. Soundness was investigated by one of the examiners, an experienced animal physiotherapist (G.B.). The horses varied from being riding school horses ($n = 4$) to elite level Icelandic sport horses ($n = 4$). One horse was retired. The horses were all kept in the pasture with a shelter. Workload for the horses at the time of the study consisted of riding at their specific level, for approximately 1 hour a day, 5 days per week, except for the retired horse.

2.3. Pressure Algometer

A handheld PA with a 1-cm^2 tip and a range of 3 to 30 kg force/cm^2 was used (Wagner instruments, model FDK 60). In this model, the rate of building the pressure has to be controlled by the examiner. The maximum force applied during testing is retained by the instrument. Pressing a peak hold button resets the PA, so that the next MNT can be obtained.

2.4. Method

The horses were tested on 2 days, with 3 weeks in between. Mechanical nociceptive thresholds were determined at 11 anatomic landmarks (Fig. 1). These anatomic landmarks were adopted from Haussler and Erb [8] and de Heus et al [14], reflecting musculoskeletal sites that are reported to be frequently involved in musculoskeletal pain. The anatomic landmarks were marked with correction fluid. Two board certified animal physiotherapists applied the pressure, after practicing the use of the PA. A metronome was used for audible feedback on speed of application and was combined with visual feedback from the algometer, until a steady rate was accomplished. The examiners then practised together on recognizing local avoidance reactions on a horse not involved in the study. The pressure was increased gradually with approximately 3.3 kg force/cm^2/s until the horse displayed a local avoidance reaction like skin twitching, local muscular contractions, induced lordosis, or stepping away. The pressure was then stopped, and the corresponding value on the PA was noted by an assistant, to ensure that the examiners were blinded to the MNT values. In the case of technical failures during measurement, like slipping off anatomic landmarks or the horse being obviously distracted by an external stimulus, the specific MNT value was discarded and an extra measurement was obtained.

The physiotherapists, called examiner 1 and examiner 2 from now on, each tested the horses on all 11 anatomic landmarks. The horses were given a 15-minute break between the sessions of both examiners, during which they could rest in a stable. At each anatomic landmark, three consecutive measurements with the PA were taken, with approximately 3 to 4 seconds in between [8]. The examiners were both right handed and used their right hand in holding the PA. The order in which the examiners tested the horses was alternated. For the first horse, examiner 1 started with pressure algometry measurements, the second horse was first tested by examiner 2, the third by examiner 1, and so forth, to prevent an effect of starting order of examiners. On the second research day, examiner 2 started with pressure algometry measurements on the first horse, the second horse was first tested by examiner 1, and so forth.

To obtain MNTs of the bilateral transverse process of C5, the opposite transverse process of C5 was stabilized by the

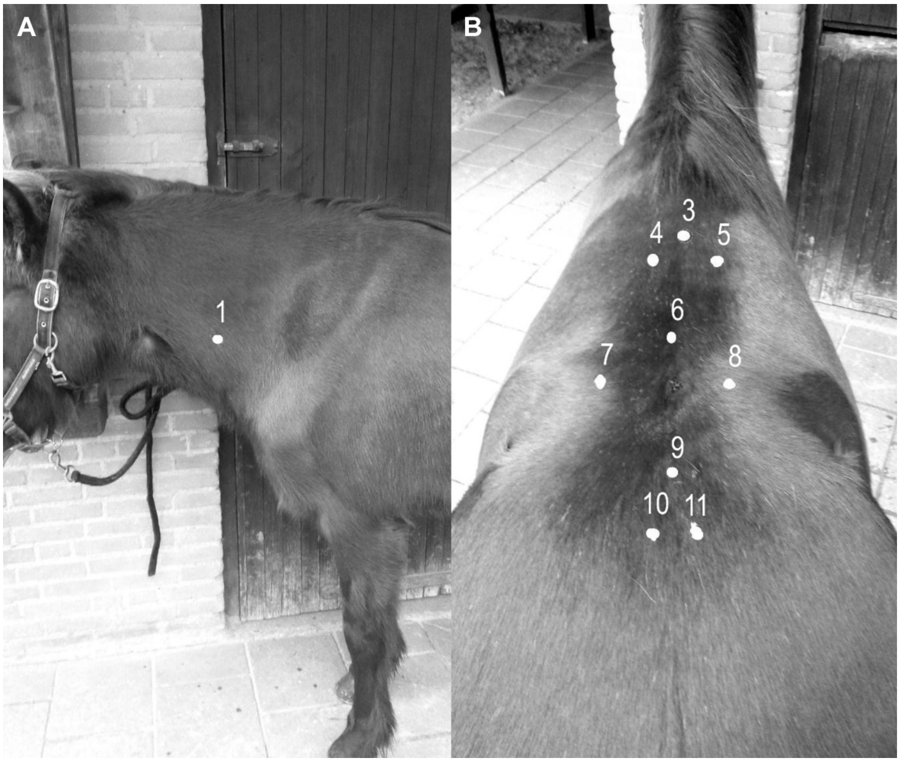

Fig. 1. The selected anatomic landmarks for measuring mechanical nociceptive thresholds. (A) (1) Lateral view of the (bilateral) anatomic landmark at the dorsolateral aspect of the caudal portion of the fifth cervical transverse process. (2) Not displayed: the right-sided anatomic landmark at the dorsolateral aspect of the caudal portion of the fifth cervical transverse process. (B) Dorsal view of the selected anatomic landmarks, from cranial to caudal: (3) the dorsal apex of the spinous process of the 10th thoracic vertebra; (4) and (5) the bilateral anatomic landmarks in the thoracic longissimus muscle, 2 cm lateral to the dorsal midline at the 13th thoracic level; (6) the dorsal apex of the spinous process of the 18th thoracic vertebra; (7) and (8) the bilateral anatomic landmarks at the midportion of the middle gluteal muscle at the third lumbar vertebral level; (9) the dorsal apex of the spinous process of the sixth lumbar vertebra; (10) and (11) the bilateral anatomic landmarks at the dorsal aspect of the sacral tuber.

hands of the assistant, to prevent the horses' cervical spines from being pushed to the side by the examiner.

2.5. Data Processing and Statistical Analysis

Statistical analysis was performed using SPSS version 22.0. Statistical significance was accepted at $P < .05$. Pressure measurements are reported in kg force/cm^2 [8]. The median of the three repeated measurements was used in all analyses [8], except for the short-term intraexaminer reliability. On the second research day, examiner 2 obtained a floor effect for the right-sided anatomic landmark on the transverse process of C5. He was able to touch the horse with the PA, but not to build the pressure beyond the lowest reading of the algometer (3 kg force/cm^2) because the horses instantly displayed a withdrawal reaction. Therefore, MNTs from the right transverse process of C5 obtained by examiner 2 on the second measurement day were excluded from the analysis.

2.5.1. Linear Mixed Model

The effects of examiner, measurement day, and anatomic landmark on MNT values were tested by use of a linear mixed model on repeated measures, with horse as a random effect and examiner, measurement day and anatomic landmark as fixed effects and repeated factors.

2.5.2. Interexaminer Reliability

The intraclass correlation (ICC) coefficient was determined for both examiners on all anatomic landmarks, all horses and both days.

2.5.3. Short-Term Intraexaminer Reliability

From all ranges of the three repeated measurements (highest minus lowest of the three repeated measurements per anatomic landmark per individual session), mean ranges at each anatomic landmark were calculated and grouped per spinal region, per day, and per examiner. The percentage sensitization, habituation, and no change or no consistent pattern were calculated [8].

2.5.4. Longer-Term Intraexaminer Reliability

The ICC coefficients were determined for intraexaminer reliability of each examiner over the 3-week interval.

2.5.5. MNT Values for the Selected Anatomic Landmarks

For each examiner and each anatomic landmark, mean MNT values were determined.

2.5.6. Asymmetry Values

Asymmetry values were composed per region, by calculating the mean left-to-right difference + 2 × SD.

3. Results

3.1. Linear Mixed Model

Data were normally distributed based on Q-Q plots of residuals, linearity, and constant variance. Both anatomic landmark and examiner showed statistically significant effects on MNTs ($P < .001$), whereas measurement day did not show statistically significant effects on MNTs ($P = .53$).

3.2. Interexaminer Reliability

The ICC coefficient for interexaminer reliability between examiners 1 and 2 was 0.64 ($P < .001$).

3.3. Short-Term Intraexaminer Reliability

Mean ranges of the three repeated measurements per spinal region, per day, and per examiner are shown in Table 1. The three repeated measurements taken by examiner 1 per anatomic landmark showed no change or no consistent pattern in 62%, sensitization in 18%, and habituation in 20% of measurements. On day 2, she obtained no pattern in 70% of measurements, sensitization in 16%, and habituation in 14% of measurements. Examiner 2's measurements did not show change or showed no consistent pattern in 67% of measurements on day 1, followed by sensitization in 23% and habituation in 10% of cases, respectively. On day 2, 66% of measurements of examiner 2 did not show change or a consistent pattern. In 16% of measurements, horses showed sensitization and in 19% habituation.

3.4. Longer-Term Intraexaminer Reliability

The ICC coefficient for examiner 1 was 0.46 ($P < .001$). For examiner 2, the ICC coefficient was 0.78 ($P < .001$).

Table 1
Short-term intraexaminer reliability in mean range (SD) of three repeated measurements per anatomic landmark, pooled into four musculoskeletal regions, per examiner, and per day, in kg force/cm^2.

Region (Number of Anatomic Landmarks Included per Region)	Examiner 1		Examiner 2	
	Day 1	Day 2	Day 1	Day 2
Cervical (n = 2)	1.58 (0.96)	1.47 (1.23)	1.22 (1.04)	0.92 (0.60)
Thoracic (n = 4)	1.94 (1.50)	1.92 (1.29)	2.24 (1.84)	1.75 (1.23)
Lumbar (n = 3)	1.61 (1.63)	1.48 (1.78)	1.51 (1.07)	1.78 (1.69)
Sacral (n = 2)	1.96 (1.27)	1.78 (1.20)	2.26 (1.87)	1.67 (0.71)

Abbreviation: SD, standard deviation.
Regional anatomic landmarks consist of: cervical, the bilateral anatomic landmarks at the dorsolateral aspect of the caudal portion of the fifth cervical transverse process; thoracic, the dorsal apex of the spinous process of the 10th thoracic vertebra, the bilateral anatomic landmarks in the thoracic longissimus muscle, 2 cm lateral to the dorsal midline at the 13th thoracic level, and the dorsal apex of the spinous process of the 18th spinous process; lumbar, the bilateral anatomic landmarks at the midportion of the middle gluteal muscle at the third lumbar vertebral level and the dorsal apex of the spinous process of the sixth lumbar vertebra; sacral, the bilateral anatomic landmarks at the dorsal aspect of the sacral tuber.

Table 2
The obtained mean (SD) mechanical nociceptive threshold values in kg force/cm^2 on 11 selected anatomic landmarks, by two examiners, in nine Icelandic horses on 2 days.

Anatomic Landmark	Examiner 1	Examiner 2
1	4.6 (1.28)	4.26 (1.26)
2	4.53 (1.35)	4.5[a] (1.05)
3	6.03 (2.04)	9.43 (2.71)
4	6.35 (2.25)	9.01 (2.78)
5	6.06 (2.10)	8.44 (2.36)
6	4.76 (1.24)	6.57 (1.98)
7	4.71 (2.10)	6.21 (2)
8	4.56 (1.78)	5.69 (2)
9	6.93 (1.83)	9.35 (2.46)
10	7.21 (2.02)	9.88 (2.37)
11	7.53 (2.5)	9.63 (2.64)

Anatomic landmarks: (1) the dorsolateral aspect of the caudal portion of the left-sided fifth cervical transverse process, (2) the dorsolateral aspect of the caudal portion of the right-sided fifth cervical transverse process, (3) the dorsal apex of the spinous process of the 10th thoracic vertebra, (4) the left-sided anatomic landmark in the thoracic longissimus muscle, 2 cm lateral to the dorsal midline at the 13th thoracic level, (5) the right-sided anatomic landmark in the thoracic longissimus muscle, 2 cm lateral to the dorsal midline at the 13th thoracic level, (6) the dorsal apex of the spinous process of the 18th spinous process, (7) the left-sided anatomic landmark at the midportion of the middle gluteal muscle at the third lumbar vertebral level, (8) the right-sided anatomic landmark at the midportion of the middle gluteal muscle at the third lumbar vertebral level, (9) the dorsal apex of the spinous process of the sixth lumbar vertebra, (10) the dorsal aspect of the left sacral tuber, and (11) the dorsal aspect of the right sacral tuber.

[a] n = 18 for all anatomic landmarks (nine ponies on two measurement days), except for the right-sided landmark at C5 for examiner 2, where n = 9, due to the floor effect on day 2.

3.5. MNT Values for the Selected Anatomic Landmarks

Because of the difference between the examiners, it was not possible to create reference values for use in the Icelandic horse. Table 2 shows mean MNT values per anatomic landmark for both examiners.

3.6. Asymmetry Values

Table 3 shows asymmetry values per musculoskeletal region.

4. Discussion

This study aimed to establish interexaminer and intraexaminer reliability of pressure algometry in Icelandic

Table 3
Asymmetry values per bilateral anatomic landmark in kg force/cm^2.

Region	Mean	SD	Asymmetry Value
Cervical	0.92	0.89	2.7
Thoracic	1.68	1.44	4.56
Lumbar	1.69	1.43	4.55
Sacral	2.19	1.70	5.59

Mean = mean of absolute left-to-right differences per bilateral anatomic landmark. SD = standard deviation of mean absolute left-to-right differences. Asymmetry value = mean + 2 × SD. Cervical = the bilateral anatomic landmark at the dorsolateral aspect of the caudal portion of the fifth cervical transverse process; thoracic = the bilateral anatomic landmark in the thoracic longissimus muscle, 2 cm lateral to the dorsal midline at the 13th thoracic level; lumbar = the bilateral anatomic landmark at the midportion of the middle gluteal muscle at the third lumbar vertebral level; sacral = the bilateral anatomic landmark at the dorsal aspect of the sacral tuber.

horses. Reliability between the two examiners was good, although examiners 1 and 2 differed significantly in MNT values obtained. On visual inspection, it appeared that examiners 1 and 2 frequently differed more than 2 kg force/cm^2 per anatomic landmark, with examiner 1 obtaining the lowest MNT scores. An exception was formed by the anatomic landmark on the fifth cervical transverse processes, where there was more agreement in obtained MNT values on both days. This might be explained by the uniformity of reactions of the horses at these anatomic landmarks. Because of the stabilization of the heterolateral transverse process of C5, all horses reacted to an increase in pressure by lifting their head, whereas the local avoidance reactions of horses at the other anatomic landmarks showed more variation.

Short-term intraexaminer reliability was assessed by mean ranges over three repeated measurements per day, per spinal region, and per examiner. The reliability of the three measurements was comparable to Van Loon et al [13] and Sullivan et al [10] and slightly lower than reported by Haussler and Erb [8] and de Heus et al [14]. The percentage of sensitization, habituation, no change, or a consistent pattern over the three measurements was consistent with findings in literature [8,13].

Intraexaminer reliability over 3 weeks was good for examiner 2 and moderate for examiner 1. The difference in reliability between the examiners can be explained in part by the lower range of MNT values examiner 1 obtained, which might have skewed the ICC coefficient slightly to the lower side [4]. Other explanations for the difference in accomplished ICC coefficient between the examiners might be the significant difference in clinical experience with deep palpation in horses (2 vs. 26 years of practical clinical experience), a difference in (consistency of) the rate of application of force, a difference in (speed of) detecting the local avoidance reaction, or another unknown factor.

The technique that was used in measuring the cervical anatomic landmarks could be improved. Examiner 2 obtained a floor effect on all right-sided anatomic landmarks at C5 on the second research day. Horses were slightly more restrained by the technique of stabilization, which might eventually have led to sensitization. A PA with a smaller tip might provide an answer to the concern of simply laterally bending the cervical spine of the horse, instead of detecting the true MNT, because lower force will be required to reach the MNT [17], eliminating the need for stabilization of the cervical spine.

Because of the difference between the examiners, the MNT values they obtained could not be pooled into reference values for each anatomic landmark. Therefore, the MNT values of the examiners were displayed separately. To obtain reference values based on measurements of several examiners, the technique of measuring MNTs should be optimized and systematic differences between examiners should be minimized.

The asymmetry values we calculated in healthy horses can be used by clinicians as an adjunct in defining clinically relevant asymmetry in Icelandic horses and monitoring progression during and over therapy sessions. Using the mean of left-to-right differences plus two times the standard deviation, 97.5% of the left-to-right differences in MNTs in sound Icelandic horses will be smaller than the cutoff values. Left-to-right differences exceeding the cutoff values will most likely represent significant asymmetry between left and corresponding right MNT values, considering the fact that outliers caused by technical failures during measurement (slipping off anatomic landmarks or distraction of the horse) can be recognized and eliminated by the clinician.

Future research in clinical patients is needed to elucidate the clinical applicability and repeatability of MNTs and of asymmetry values. Furthermore, future research needs to address the question of the extent to which intraexaminer reliability is influenced by experience and how it can be optimized for examiners with less clinical experience. Considering the fact that the rate of pressure application recently was shown to be of influence on MNT values in equines [18], reliability of measurements could also benefit from using a PA with visible feedback on correct speed of pressure application.

5. Conclusion

This study shows that pressure algometry can be a reliable tool in veterinary and physiotherapeutic practice when used by a trained examiner. Interexaminer repeatability was good, and intraexaminer repeatability over a period of 3 weeks was moderate to good. Mechanical nociceptive thresholds should be combined with other clinical and available indicators of musculoskeletal pain, such as lameness, pain on palpation, hypertonicity, hypermobility or hypomobility, temperature changes of the skin, imaging techniques, and diagnostic anesthetics. The added value of pressure algometry is that it is a relatively cheap, portable, repeatable, and objective technique.

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References

[1] Fischer AA. Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. Pain 1987;30:115–26.
[2] Haussler KK, Hill AE, Frisbie DD, McIlwraith CW. Determination and use of mechanical nociceptive thresholds of the thoracic limb to assess pain associated with induced osteoarthritis of the middle carpal joint in horses. Am J Vet Res 2007;68:1167–76.
[3] Vanderweeen L, Oostendorp RA, Vaes P, Duguet W. Pressure algometry in manual therapy. Man Ther 1996;1:258–65.
[4] Chesterton LS, Sim J, Wright CC, Foster NE. Interexaminer reliability of algometry in measuring pressure pain thresholds in healthy humans, using multiple raters. Clin J Pain 2007;23:760–6.
[5] Aweid O, Gallie R, Morrissey D, Crisp T, Maffulli N, Mallarias P, et al. Medial tibial pain pressure threshold algometry in runners. Knee Surg Sports Traumatol Arthrosc 2014;22:1549–55.

[6] Fingleton CP, Dempsey L, Smart K, Doody CM. Intraexaminer and interexaminer reliability of manual palpation and pressure algometry of the lower limb nerves in asymptomatic subjects. J Manipulative Physiol Ther 2014;37:97–104.

[7] Melia M, Schmidt M, Geissler B, König J, Krahn U, Ottersbach HJ, et al. Measuring mechanical pain: the refinement and standardization of pressure pain threshold measurements. Behav Res Methods 2015;47:216–27.

[8] Haussler KK, Erb HN. Mechanical nociceptive thresholds in the axial skeleton of horses. Equine Vet J 2006a;38:70–5.

[9] Varcoe-Cocks K, Sagar KN, Jeffcott LB, McGowan CM. Pressure algometry to quantify muscle pain in racehorses with suspected sacroiliac dysfunction. Equine Vet J 2006;38:558–62.

[10] Sullivan KA, Hill AE, Haussler KK. The effects of chiropractic, massage and phenylbutazone on spinal mechanical nociceptive thresholds in horses without clinical signs. Equine Vet J 2008;40:14–20.

[11] L'Ami JJ, Van Loon JPAM, Sloet van Oldruitenborgh-Oosterbaan MM. Sublingual administration of detomidine in horses: sedative effect, analgesia and detection time. Vet J 2013;196:253–9.

[12] Van Loon JPAM, Menke ES, Doornenbal A, Back W, Hellebrekers L. Antinociceptive effects of low-dose lumbosacral epidural ropivacaine in healthy ponies. Vet J 2012a;193:140–5.

[13] Van Loon JPAM, Menke ES, L'Ami J, Jonckheer-Sheehy V, Back W, van Weeren R. Analgesic and anti-hyperalgesic effects of epidural morphine in an equine LPS induced acute synovitis model. Vet J 2012b;193:464–70.

[14] De Heus P, Van Oossanen G, Van Dierendonck MC, Back W. A pressure algometer is a useful tool to objectively monitor the effect of diagnostic palpation by a physiotherapist in warmblood horses. J Equine Vet Sci 2010;30:310–21.

[15] Lee KM, Lee J, Chung CY, Ahn S, Sung KH, Kim TW, Lee HJ, Park MS. Pitfalls and important issues in testing reliability using intraclass correlation coefficients in orthopaedic research. Clin Orthop Surg 2012;4:149–55.

[16] Luna SP, Lopes C, Rosa AC, Oliveira FA, Crosignani N, Taylor PM, et al. Validation of mechanical, electrical and thermal nociceptive stimulation methods in horses. Equine Vet J 2015;47:609–14.

[17] Taylor PM, Crosignani N, Lopes C, Rosa AC, Luna SP, Puoli Filho JNP. Mechanical nociceptive thresholds using four probe configurations in horses. Vet Anaesth Analg 2015. http://dx.doi.org/10.1111/vaa.12274 [Epub ahead of print].

[18] Grint NJ, Beths T, Yvorchuk K, Taylor PM, Dixon M, Whay HR, et al. The influence of various confounding factors on mechanical nociceptive thresholds in the donkey. Vet Anaesth Analg 2014;41:421–9.