### August 17th

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<td>oral session 1: General Locomotion 1</td>
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<td>oral session 7: Surface</td>
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<td>9:15-10:00</td>
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<td>BALANCE IN THE DRESSAGE HORSE: FACTS AND FALLACIES</td>
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<td>10.24-10.36</td>
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<td>Hobbs, S.J., Bertram, J.E.A. and Clayton, H.M.</td>
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<td>10.48-11.00</td>
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<td>THE EFFECT OF JUMP HEIGHT ON FORCES AND IMPULSES DURING JUMP TAKE-OFF AND LANDING IN LARGE AGILITY DOGS</td>
<td>Knight, S., Davies, L., Doyle, G., Sparkes, E., Pfau, T.</td>
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BALANCE IN THE DRESSAGE HORSE: FACTS AND FALLACIES

Hilary M. Clayton, BVMS, PhD, Dipl ACVSMR, MRCVS
Professor and McPhail Dressage Chair Emerita, Michigan State University, Sport Horse Science, 3145 Sandhill Road, Mason, MI 48854

The dressage horse is trained to perform the gaits and movements of the sport with an advanced level of balance and in a state of self-carriage. The associated kinematic changes include lowering of the haunches, primarily as a result of increased stance phase flexions of the stifle and tarsal joints, together with elevation of the forehand which is achieved using a more vertical forelimb strut [1]. In equestrian texts and, indeed, sometimes in the scientific literature, statements have been made regarding the horse’s balance that are clearly erroneous. For example, it is often claimed that the postural adjustments associated with self-carriage move the center of mass (COM) so far caudally within the body that the horse’s weight becomes equally distributed between the fore and hind limbs. This talk will summarize recent research on equine balance and current thoughts on how the horse’s balance changes as dressage training progresses.

The COM is a unique point at which the body mass is considered to be concentrated and at which external forces are considered to be applied to the body. The horse manipulates the forces between the hooves and the ground (ground reaction forces, GRF) to control movements of the COM and rotations around the COM during locomotion. It is proposed that trunk orientation, fore and hind limb position, and rotations around the COM are more influential in controlling the horse’s balance than changes in location of the COM within the body.

Coordination of the GRFs of the fore and hind limbs provides the horse with gravitational support together with inertial forces to accelerate and decelerate the COM, maintain the horse’s forward progression, and control trunk orientation. The center of pressure (COP) is the point at which the force vector representing the summation of the concurrent GRFs is considered to act. In the sagittal plane, the position of the COP depends on the fore:hind ratio of the vertical GRFs. Note that the COP is not the same as the vertical projection from the COM to the ground. Movements of the COP control the position and movements of the COM.

During standing, the horse is in static balance which implies maintaining the COM within the relatively large base of support (BOS), the perimeter of which is defined by the hoof contacts with the ground. The body is supported and stabilized by forces acting between the hooves and the ground. In standing the forelimbs carry 58.6% of the vertical GRF and the COP is located at 58.6% of the distance from the hind limbs to the forelimbs [2] and is in close proximity to the COM. The COM can move by a small amount as a result of postural changes. For example, the head and neck, representing 10% of body mass [3] which are cantilevered in front of the horse’s trunk, are influential in determining COM position. When a horse that appears to be standing motionless, muscular contractions act continuously to move the COP so that it controls the COM position within narrow limits [4].

Although the COM and COP are maintained in close proximity during standing, this changes during locomotion when there is a more complex relationship between the BOS, COM and COP. The BOS changes periodically in a limb support pattern that is characteristic of each gait. The COM moves forward continuously relative to the BOS but with small changes in velocity that reflects the effects of the braking and propulsive longitudinal GRF components [5]. The COM is sometimes outside the BOS, especially when moving at high speed. Limited information is available describing the COP location during quadrupedal locomotion. In the trotting horse, the initial COP position coincides with the first hoof to make ground contact, in other words, it reflects the pattern of diagonal dissociation. Through the majority of diagonal stance, the COP is almost stationary in a position closer to the forelimb than the hindlimb, in accordance with the relatively higher forelimb GRF. In terminal stance the COP moves forward to the position of the fore hoof, which is usually the last limb of the diagonal pair to leave the ground [5]. As a result of the changing relationship between the positions of the COM and COP, the lengths of the moment arms of the vertical GRF components in the fore- and hindlimbs are constantly changing [5].
The coordinated fore- and hindlimb GRFs provide gravitational support together with inertial forces to accelerate and decelerate the COM, maintain the horse’s forward progression, and control trunk orientation. Equestrians equate the ability to control trunk orientation with the horse’s balance. Both the magnitudes of the vertical and longitudinal GRF components of the fore- and hindlimbs and the lengths of their moment arms affect the torque around the COM. The moment arms of the vertical GRFs vary with the position and movements of the COM relative to the grounded hooves. The development of an advanced level of balance control involves manipulating the size, shape and position of the BOS and the magnitude and orientation of the GRF vectors of each limb relative to the COM position. Contrary to popular opinion, the location of the COM within the horse’s body shows little change; more relevant are changes in limb positioning relative to the COM which alter the moment arms of the vertical GRFs, and changes in magnitude of the longitudinal GRFs which are limited to small changes in their moment arms.

References

LEVERAGING ADVANCES IN HUMAN GAIT ANALYSIS FOR APPLICATION IN THE FIELD OF EQUINE SCIENCE: A SCOPING REVIEW

1Egan, S., 2Brama, P., 3McGrath, D.

1Institute for Sport and Health, University College Dublin, Ireland, 2School of Veterinary Medicine, Veterinary Science Centre, University College Dublin, Ireland, Email: denise.mcgrath@ucd.ie

Reasons for performing study: A scoping review is presented that maps the existing evidence in the field of equine gait analysis, from years 1972 – 2015. The purpose is to identify potential opportunities where recent advances in human gait analysis can be leveraged in the equine field. Objectives: To map the diverse equine gait analysis evidence base in terms of research topics. Study design: Scoping review, including development of a-priori review protocol. Methods: Search terms were chosen based on the ‘PICO’ framework and included keywords such as: Equine, Gait, Kinematics, Motion, Analysis and Posture, applied across a number of databases. Abstracts were excluded based on pre-determined criteria by two researchers working separately. Results: 473 relevant articles were reviewed and categorised as follows: 33% of studies were “descriptive” i.e. describing movements (gait/jumping characteristics) of different breeds and sporting disciplines. 23.5% of studies were based upon the development and refinement of gait analysis methodologies (6.8% using wearable inertial sensor technology). 16.7% were intervention studies, employing gait analysis parameters as outcome measures. 5.1% were computer modelling studies. 5.1% focused on racing surfaces. 4.2% focused on horse/ rider interaction. 4% of studies focused on shoeing. 3.8% of studies used gait analysis in a diagnostic capacity, predominantly for lameness and tendonitis. 3.1% of studies investigated motor development during maturation. 1.5% of studies investigated postural control. Conclusions: “Quantified Self” and “Big Data” are two key paradigms in human gait analysis, based on wearable sensor technology. They involve longitudinal, self-referential monitoring of a person’s movements to uncover new insights about health and performance. Whilst 6.8% of studies have used wearable sensors for gait analysis, large holistic data collections and manipulations are not reflected in the current equine gait analysis literature and thus represent an important opportunity for this field. Ethical Approval: Not applicable. Sources of Funding: Institute of Sport and Health, University College Dublin, Ireland Competing Interests: None declared.

ENERGETICS OF QUADRUPEDAL LOCOMOTION: THE IMPACT OF COLLISIONS

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Reasons for performing study: Legged locomotion involves dynamic organism/substrate interactions which have been well described for a range of animals, gaits and locomotor conditions. It is however not clear why specific strategies are selected for each movement circumstance, functional demand or organism form. Objectives: We use models to calculate the energetic consequences of quadrupedal movement. Collision loss is largely neglected, but has been recognized as a key mechanism determining important aspects of legged locomotion energetics. Study design: In silica. Methods: Simple models using strut-like limbs to predict the influence of limb function on quadrupedal gait were compared to movements employed in natural circumstances. The energetic consequences associated with specific movements were evaluated. Optimization predictions of stride frequency and length, and phase relationships between fore and hind limbs were compared to observed gaits of quadrupeds. Results: The optimization predictions matched many movement strategies used by horses and dogs, indicating that many aspects of these gaits can be explained based on direct energetic factors. This was particularly clear for the gallop and trotting gaits. The least ‘dynamic’ gait, quadrupedal walking, indicates some nuances that challenge simple explanation. Differences between the model predictions and observed movements helped indicate those aspects of locomotion not included in the energy cost dominated dynamics model. The analyses indicated the role of dynamics in determining the most functional options available, providing insight into why gaits are selected. Conclusions: Collision-based loss and its relationship to the energetic cost of movement must be considered in order to interpret the function of limbs in quadrupedal locomotion. Although relatively simple, a modelling approach where optimization is determined from within the broad range of possible movement options holds substantial promise as a tool to consider gait options that are not evident in the natural world, and understand why naturally expressed gait characteristics exist.

Ethical Animal Research: Not applicable. Sources of funding: Natural Science and Engineering Research Council, Canada. Competing interests: None declared.

THE INFLUENCE OF DIAGONAL DISSOCIATION ON DYNAMIC PARAMETERS IN TROTTING HORSES

Reasons for performing study: Although the trot is described as a diagonal gait, movements of the limb pairs are not usually perfectly synchronized. Subtle alterations in dissociation timing between contacts of each diagonal pair could have consequences on gait dynamics and provide insight into related functional strategies. Objectives: To explore the mechanical effects of different diagonal dissociation patterns between individuals. It was hypothesised that diagonal dissociation at contact could reduce collision-based energy losses and preferred dissociation patterns would be evident. Study Design: Observational. Methods: 17 horses of mixed breed with (mean ± s.d.) height 1.50 ± 0.06 m and mass 465 ± 34 kg trotted in hand on a loose rope over 4 force platforms recording at 960 Hz. Kinematic data were captured at 120 Hz by a 10 camera motion analysis system. A full body marker set was used to calculate temporal, speed, GRF, postural, mass distribution, moment, and collision dynamics parameters. One successful, speed-matched trial per horse was selected that provided a comparable number of hind-first (n=12; 3.28±0.11 ms⁻¹), synchronous (n=11; 3.26±0.15 ms⁻¹) and fore-first (n=11; 3.24±0.20 ms⁻¹) dissociations for each diagonal. ANOVA was used to determine differences between dissociations and diagonal pairs for each variable separately. Results: The COP moved systematically and significantly (P=0.001) from more caudally in hind-first dissociation (mean location = 0.41±0.04) through synchronous (0.36±0.02) to more cranially in fore-first dissociation (0.32±0.02). Other important differences, including functional, postural and balance parameters, were found when either synchronous or fore-first were compared to hind-first dissociation. Notably, hindlimb peak forces and mean collision angle were greater (P<0.05) for synchronous compared to hind-first dissociation. Conclusions: The results indicate that dissociation assists in stabilising trunk pitch through management of the location of the centre of pressure COP.

Ethical Animal Research: Study was approved by the Institutional Animal Care and Use Committee, Michigan State University, USA under protocol number 02/08-020-00. Owner consent was not stated. Sources of funding:
University of Central Lancashire, the McPhail endowment at Michigan State University and the University of Calgary. **Competing interests:** No competing interests are declared.

**GROUND REACTION FORCES IN COLLECTED TROT AND PASSAGE**

1Clayton, H.M. and 2Hobbs, S.J.

1Sport Horse Science, 3145 Sandhill Road, Mason, MI 48854, USA, 2University of Central Lancashire, Centre for Applied Sport and Exercise Sciences, Preston, UK, Email: claytonh@cvm.msu.edu

**Reasons for performing study:** Published data describing ground reaction forces (GRF) of passage are limited to vertical forces and impulses during treadmill locomotion. **Objectives:** To compare sagittal plane GRFs of collected trot and passage during overground locomotion. **Study design:** Repeated measures. **Methods:** Vertical and longitudinal GRFs were recorded in 8 elite dressage horses (4 Warmbloods, 4 Lusitanos) ridden over force plates to record GRFs for three forelimb and hindlimb stance phases per horse at collected trot and passage. Peak values, their times of occurrence and respective impulses were determined for vertical, longitudinal braking and longitudinal propulsive GRF components. Differences between breeds were evaluated using independent samples t-tests and between gaits and limbs using repeated measures ANOVA (P<0.05). **Results:** Mass-normalized forelimb and hindlimb vertical impulses for collected trot were significantly higher in Warmbloods than Lusitanos. Longer stance durations resulted in higher vertical impulses in passage (foreslimbs: 2.85±0.08 Ns/kg; hindlimbs: 2.43±0.13 Ns/kg) compared to collected trot (forelimbs: 2.44±0.20 Ns/kg; hindlimbs: 1.81±0.14 Ns/kg) even though peak vertical forces were similar. In the longitudinal direction there was greater variability in passage. Compared with collected trot, passage showed significantly smaller peak braking force in the hindlimbs (collected trot: -0.51±0.16 N/kg; passage: -0.24±0.23 N/kg) and peak propulsive force in the forelimbs (collected trot: 0.77±0.28 N/kg; passage: 0.48±0.32 N/kg). **Conclusions:** Vertical forces and impulses recorded overground were similar to those on the treadmill with the exception of forelimb peak vertical force in passage, which was ~10% lower and considerably more variable in this study. In passage the demand for large vertical excursions of the centre of mass while moving with low forward momentum is achieved with markedly convergent GRF vectors, and the inherent challenges to the horse’s balance are reflected by high inter-horse and inter-stride variability in longitudinal GRFs.

**Ethical Animal Research:** Study performed with approval from the institutional animal care and use committee, Michigan State University, USA under protocol number 02/08-020-00. Owner consent was not stated. **Sources of Funding:** McPhail endowment at Michigan State University. **Competing interests:** None declared.

**THE EFFECT OF JUMP HEIGHT ON FORCES AND IMPULSES DURING JUMP TAKE-OFF AND LANDING IN LARGE AGILITY DOGS**

1Knight, S., 2Davies, L., 3Doyle, G., 1Sparkes, E., 1Pfau, T.

1Department of Clinical Science and Services, The Royal Veterinary College, London, UK, 2SmartVetWales, Swansea+Cardiff, UK, 3University of East London, London, UK, Email: tpfau@rvc.ac.uk

**Reasons for performing study:** In UK dog agility different jump heights are used for large dogs in UK agility (UKA) and Kennel Club (KC) competitions. The number of injuries in agility dogs related to jumping [1] might be related to high forces. **Objectives:** To quantify kinetics of take-off and landing for agility dogs jumping obstacles of 55cm (UKA) and 65cm (KC) height. **Study design:** Quantitative experimental study. **Methods:** 14 large agility dogs (N=7 <0.5m withers height; N=7 ≥0.5m) performed three successful repeats of two consecutive jumps set at either 0.55m or 0.65m. Vertical and horizontal forces and impulses were recorded with 7 Kistler force platforms covered by artificial turf. Mixed models (P<0.05) were employed with dog as random factor, jump height and dog height category as fixed factors and forces and impulses (normalized to bodyweight) as dependent parameters. **Results:** Comparing 0.65m obstacles to 0.55m obstacles, increased vertical force at take-off and landing was found in the front limbs at 65cm height (4.6x respectively 4.2x body weight for combined front limbs at landing, P=0.047) and higher decelerative force and impulse at take-off in the hind limbs (P<0.031). The smaller dogs showed 33 to 40% more decelerative force and impulse at take-off (P<=0.048). **Conclusions:** Compared to maximum speed bend running (up to 5 times bodyweight, [2]) jump landing elicits smaller vertical forces. Acceleration/deceleration is mechanically costly, hence the smaller dogs may show fatigue earlier. Further studies should hence investigate the relationship between fatigue and injury during jumping.
Ethical Animal Research: The study was approved by the Royal Veterinary College Ethics and Welfare committee. Informed owner consent was obtained for all animals used in the study. Sources of funding: Kennel Club Charitable Trust. Competing interests: None declared.

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KINEMATIC ASSESSMENT OF THE EQUINE CERVICAL VERTEBRAL COLUMN

1Zsoldos, R.R., 2Modenese, L., 3,4Licka, T.F.

1Department of Sustainable Agricultural Systems, University of Natural Resources and Life Sciences Vienna, Vienna, Austria, 2INSIGNEO Institute for in silico medicine, Department of Mechanical Engineering, The University of Sheffield, 3Movement Science Group, University of Veterinary Medicine Vienna, Vienna, Austria, 4Royal (Dick) School of Veterinary Studies, University of Edinburgh, Edinburgh, Scotland, UK, Email: rebeka.zsoldos@boku.ac.at

Reasons for performing study: Realistic modeling of individual spinal movements will give further insights into intervertebral forces, however this is challenging and further optimization is necessary. Objectives: To investigate the kinematic behavior of the equine cervical vertebral column using an anatomically and functionally realistic three-dimensional biomechanical model of the equine neck. Study design: Proof of concept study. Methods: In one horse, 23 markers were recorded (head to T4) during quiet stance, walk, trot, and neck movements at stance. Model constraints for vertebral motion were based on literature data [1], and relative motion of the cervical vertebrae and the head was described using seven degrees of freedom. Tasks were then simulated using an OpenSim model scaled to the horse, and differences in measured and simulated marker locations were documented. Results: Mean maximum marker differences were 1.84 ± 0.15 cm (walk) and 2.11 ± 0.21 cm (trot). Maximum marker differences ranged between 0.38 to 9.6 cm at chin-between-carpi exercise, between 0.93 to 10.61 cm at chin-to-cervical, between 0.43 to 8.16 cm at chin-to-girth and 0.75 to 8.10 cm at chin-to-hip. Marker differences were largest for C4, C5, C6, and for the head. Conclusions: During locomotion, marker location differences were comparable to human gait modeling, while in the large neck movements at stance, the differences were larger possibly due to skin movement artifacts [2]. This shows that in this horse the scaled model in its current form is more suitable for simulating the neck during locomotion than during large neck movements at stance. Ethical Animal Research: Experiments were carried out under the University of Veterinary Medicine Vienna’s animal experiment license and were approved by the institutional ethics committee. Sources of funding: RZS is supported by a grant from the Austrian Science Fund (Project number: 11532-B23) and this work is part of the GeMMQuad project. Competing interests: None declared.


THE EFFECT OF BLINDFOLDING ON SPATIOTEMPORAL GAIT CHARACTERISTICS OF HORSES WITH AND WITHOUT SPINAL ATAXIA

1,2Olsen, E., 3Fouche, N., 1,4Jordan, H., 1Pfau, T., 4Piercy, R.

1: Structure & Motion Laboratory, Department of Clinical Science and Services, The Royal Veterinary College, London, UK, 2: Department of Clinical Sciences, Cornell University Hospital for Animals, Cornell University, College of Veterinary Medicine, Ithaca, NY, USA, 3: Institut suisse de médecine équine ISME, Vetsuisse Fakultät, Bern University, Bern, Switzerland, 4: Comparative Neuromuscular Diseases Laboratory, Department of Clinical Sciences and Services, The Royal Veterinary College, London, UK, Email: eo248@cornell.edu

Reasons for performing study: Agreement amongst experienced clinicians can be poor when assessing presence and severity of ataxia, especially when signs are mild. Objectives: Vision is thought to have a feed forward effect on gait and we therefore hypothesize that blindfolding significantly increases variation of spatiotemporal gait-characteristics for horses with spinal ataxia compared to horses without spinal ataxia. Study design: Case-control study. Methods: Twenty-one horses underwent gait laboratory measurements and clinical neurological assessment. The horses were walked across a runway surrounded by a 12-camera motion capture system (Qualisys) with a sample rate of 240Hz, walked normally and with a blindfold for at least 3 trials. Three to four strides per trial were processed using semi-automated custom-written Matlab (Mathworks) scripts. Displacement of reflective markers on head, fetlock, hoof, L4, tuber coxae and sacrum were processed. The horses were considered ataxic if they had a median ataxia grade ≥2/4 during clinical neurological assessment. Descriptive statistics and two-way ANOVA were performed with outcomes being displacement for the factors blindfold/no blindfold and ataxia/no ataxia as well as ROC analysis of sensitivity and specificity of blindfolding. Results: A total of 11 horses were considered ataxic and 10 horses non-ataxic. Stride duration was 1238ms walking without blindfold and 1220ms with the blindfold. The coefficient of variation (CV) for swing duration was not
CENTRE OF PRESSURE BETWEEN THE FORELIMBS IN A COHORT OF THOROUGHBRED RACEHORSES

1Lichtenauer, E., 2Fitch, G., 3Colborne, G.R., 2Reid, K., 13Back, W., 2Rogers, C.W.

1Dept of Equine Science, Utrecht University, The Netherlands, 2Massey Equine, IVABS, Massey University, Palmerston North, New Zealand. 3Dept. of Surgery and Anaesthesia of Domestic animals, Ghent University, Belgium, Email: C.W.Rogers@massey.ac.nz

Reasons for performing study: Centre of pressure (CoP) under and between the limbs of a standing horse might be a useful measurement for detection of sway alterations or uneven weightbearing due to lameness.

Objectives: To quantify changes in CoP during 8 weeks flat race training. Study Design: longitudinal cohort.

Methods: CoP data were captured using a 0.5m Footscan pressure plate over an 8-week period from 15 Thoroughbred racehorses. The horses were from one training stable, at differing stages of the race preparation programme with no observable lameness. The horses stood with both forelimb hooves on the pressure plate. Data were collected at 15 Hz for three sequential one minute recordings per week. The CoP data were filtered using a discrete wavelet transformation with a cut-off frequency (of reversal) of CoP displacement were calculated. Results: At week 8 there was an increase in the frequency of the CoP displacement in the mediolateral axis compared to week 1 (0.28 ±0.01 vs. 0.30±0.01 Hz, P=0.03). There was no difference in velocity (1.88 ±0.3 vs. 1.87 ±0.25 mm/s) or amplitude (27.3 ±5.1 vs. 22.6 ±3.7mm). Pressure distribution was consistently greater under the right than the left limb (55±1% vs. 45±1%, P<0.01), with no effect of week. The majority of the pressure was located under the cranial half of the hoof (61.1±0.9% vs 38.8±0.9%, P<0.01). For left limbs the pressure was higher under the medial than the lateral hoof (24.1 ±0.6% vs. 21.6±0.5%, P<0.01). The medial pressure distribution was greatest under the right hoof than left hoof (27.5 ± 0.6% vs. 22.7 ±0.5%, P<0.01). Conclusion: The counterclockwise training regimen may have caused the unloading of the left limb and the lateral side of the left hoof as they sustain the most strain.

Ethical animal research: All procedures were approved by the Massey University Animal Ethics Committee. Trainer provided informed consent. Sources of funding: This project was funded in part by the New Zealand Equine Trust. Competing interests: None declared.

INFLUENCE OF HOOF MASS ON FORE HOOF SWING PHASE TRAJECTORY AND VELOCITY AT IMPACT IN TÖLTING ICELANDIC HORSES

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Reasons for performing study: Specific shoeing methods are used in Icelandic horses to enhance gait performance (e.g. expressiveness of forelimb movement, clearness of 4-beat footfall rhythm). High and long hoof conformation or weighted boots increase maximal protraction height (PHmax) in forelimbs at tölót. How far these changes of the swing phase trajectory affect the impact velocity of the hoof, is unknown. Objectives: To study the combined effect of high-long hoof conformation and weight on length and velocity of the hoof trajectory, as well as on hoof velocity immediately before impact. Study design: Experimental study. Methods: Simultaneous GRF measurements for stride-split and kinematic gait analysis (Qualisys AB, Sweden) for hoof trajectory coordinates were carried out at 480Hz on an instrumented treadmill. Twelve sound Icelandic horses were measured at the tölót (3.9m/s) with hooves trimmed according to standard shoeing principles (S00) and with high-long front hooves, without (S10) and with weighted boots of 240grams (S120). Differences were analysed with 1-
way RM ANOVA (P<0.05). **Results:** At S0, stride duration was 0.523±0.021s and PHmax 209±56mm. With increasing hoof mass, stride duration increased up to 4.2% (S0 vs. S120) and PHmax up to 35% (S0 vs. S120). Swing trajectory length increased by only 32mm when comparing S0 with S120; the higher trajectory was compensated by a proportional reduction of pro-retraction ROM. Average hoof velocity during swing phase decreased by 3.7% due to longer swing duration. Vertical velocity at impact remained unchanged (range: 2.19-2.24m/s), whereas horizontal hoof velocity at impact decreased by 45% (S0 2.83m/s; S120 1.57m/s) with increasing weight. **Conclusions:** Additional weight changed the shape of the hoof trajectory and increased the differences between horizontal hoof velocity at impact and treadmill belt speed which may result in higher breaking forces. Swing trajectory velocities remained closely matched to treadmill speed independent of hoof mass.

**Ethical animal research:** The study was approved by the Animal Health and Welfare Commission of the Canton of Zurich (206/2010). Owner informed consent was obtained. **Source of funding:** Haldimann Stiftung, Swiss Metall Union, Stiftung Temperatio, Swiss Veterinary Office and Islandpferde Vereinigung Schweiz. **Competing interests:** None declared.

**THE EFFECT OF INCLINE ON THORACOLUMBAR FLEXION-EXTENSION IN HORSES WALKING AND TROTTING ON A TREADMILL**

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**Reasons for performing study:** The effect of inclined locomotion on thoracolumbar flexion-extension range of movement (FE-ROM) has implications for injury prevention and rehabilitation. **Objectives:** To compare thoracolumbar FE-ROM on a flat and inclined treadmill. **Study Design:** Within-subject randomised trial. **Methods:** Six horses walked (1.4 m/s) and trotted (3.0 m/s) on a 0, 3 and 6% incline. Reflective markers on T6, T10, T13, T18, L3, L5, S3 and left hind hoof were tracked using 7 Proreflex cameras (240 Hz). Angular motion patterns were obtained for T10, T13, T18, L3 and L5 based on data from adjacent markers using a 2D projection approach. Values of peak extension (AMPmin) and peak flexion (AMPmax) for T10, T13, T18, L3, L5 and L5 obtained over 20 seconds in each condition were used to calculate FE-ROM. The effect of incline on FE-ROM, AMPmin and AMPmax were tested using ANOVA and post hoc testing following Bonferroni correction (P<0.017). **Results:** In walk, AMPmin increased (towards extension) with incline (between 1.6° (T10) - 2.4° (T18) change at 3%; 2.9° (T10) - 4.8° (T18) at 6%) and was significantly greater in all regions at 3% and 6% (P≤0.016; P≤0.002, respectively) than at 0%. In trot, AMPmin increased with incline (between 0.6° (T10) - 2.5° (T18) change) at 3% and was significantly greater for T13, T18, L3, L5 (P<0.001 all cases). AMPmax was significantly lower in trot at 3% for T13, T18, L3, L5 (P≤0.001 all cases; between 0.9° (T10) - 2.7° (L3) change) and at 6% in all regions (between 2.6° (T10) – 5.3° (T18 and L3) change; P≤0.004 all cases). There was no significant effect of incline on FE-ROM in either gait. **Conclusions:** Exercise on an inclined treadmill results in postural change towards increased extension of the thoracolumbar spine. Inclined exercise should be avoided in horses with extended thoracolumbar posture.

**Ethical Animal Research:** The study was approved by Hartpury University Centre’s Research Ethics Committee. **Sources of funding:** None. **Competing interests:** None declared.

**VERTICAL DISPLACEMENT OF THE EQUINE PELVIS AND WITHERS DURING TROT ON AN AQUA TREADMILL**

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**Reasons for performing study:** Aqua-Treadmills are increasingly applied within the equine industry for exercise and rehabilitation but little research exists on the efficacy or optimal protocol. **Objectives:** To quantify vertical displacement of horses trotting on the aqua-treadmill at increasing water depths. **Study Design:** Kinematic analysis. **Methods:** Seventeen sound horses were habituated to aqua-treadmill exercise and trotted on an aqua-
treadmill at four different water depths (third phalanx (P3), mid fetlock, mid third metacarpal (MC3), and mid carpus). Data were recorded using an optical motion capture system (Qualisys©) and an inertial sensor system (Xsens©). Markers and sensors were located on the tuber sacrale, tuber coxae and withers. Data were cut into strides with accelerations double integrated to generate displacement amplitudes for statistical testing. Two-way ANOVAs tested for significance in displacement with post-hoc Tukey tests determining direction, and paired t-tests compared pelvis against withers at each depth. Kruskal-Wallis tested for symmetry and absolute change in position was determined using Friedman’s Rank. **Results:** Increasing water depth significantly increases vertical displacement amplitude of the pelvis and withers ($P<0.01$) while having no significant effect on symmetry ($P>0.05$). At each depth, displacement amplitude of the pelvis was significantly greater than the withers ($P<0.001$). Both minimum and maximum pelvic and withers vertical position decreased and increased significantly with increasing water depth ($P<0.05$). **Conclusions:** Deeper water increases vertical displacement of both pelvis and withers suggesting an intensification of physical activity, with the pelvis displacing significantly more than the withers suggesting that the forehand of the horse can compensate depth of water by bending at the carpus. At increasing water depths, minimum positions of the pelvis and withers both alter with increasing water depth suggesting an increase in limb compression during the stance phase. This information may be useful in informing current hydrotherapy practice.

**Ethical Animal Research:** Ethical approval was obtained from the Ethics Review Committee at Moulton College. Owner consent was obtained. **Sources of Funding:** Thomas Harrison Trust at Moulton College. **Competing Interests:** None declared.

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**THE EFFECT OF THE A-FRAME ON FORELIMB KINEMATICS IN EXPERIENCED AND INEXPERIENCED AGILITY DOGS**

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**Reasons for performing the study:** The A-frame is a component of canine agility courses regardless of the experience of competing dogs. A-frames are associated with a higher risk of injury [1]; these risks could be related to how dogs tackle the equipment. **Objectives:** We hypothesised that forelimb (FL) and spinal kinematics would differ throughout the A-frame phases: incline, apex and decline, in experienced and inexperienced agility dogs. **Study design:** Experimental study. **Methods:** Inexperienced dogs (ID: <4 years training; n=4, 1.7±0.93yrs) and experienced dogs (ED: >4 years training; n=4, 4.75±0.96yrs), of mixed breed and age, undertook 3 videoed runs over the A-frame. Reflective markers were placed on each dog’s carpus (Ca), radiohumeral (RH) and scapulohumeral (SH) joints, Atlas, C3 and L3. Video footage was transferred to Dartfish™ to enable FL joint angles to be calculated for the approach (last stride), incline (FL contact), apex (FL over), decline (FL touchdown and FL departure). Wilcoxon signed rank analyses, with Bonferroni correction applied (P<0.02), identified if kinematics differed for ED and ID between the phases. **Results:** Similar kinematics patterns were observed through all phases for C3 and L3, however trends for greater ROM was found for ED: C3 and ID: L3. For atlas, ED stayed in flexion for all phases whilst ID movement varied: approach-incline extension, incline-apex: flexion, apex to decline extension followed by flexion. No significant differences in FL joint angles existed. **Conclusions:** Dogs display non-significant differences in limb angles and spinal kinematics over the A-frame regardless of experience level; ID varying their head and neck position more than ED. Further research utilising more dogs is required to confirm these preliminary findings.

**Ethical animal research:** Ethical approval for the study was granted by the UWE (Hartpury) Ethics Committee. **Competing interests:** None declared. **Sources of funding:** This study was funded by R. Jackson and Hartpury College.

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HEAD AND PELVIC MOVEMENT SYMMETRY IN DOGS WITH INDUCED SUPPORTING LAMENESS.

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Reasons for performing study: Limb loading in lameness compensation have been studied in dogs, however, little is known about how these compensations relate to the movement of the head and pelvis. Objectives: To describe the pattern of the vertical head and pelvic movement in dogs with induced supporting limb lameness in the fore- or hind limb at trot. Study Design: Experimental study. Methods: Ten sound dogs were trotted on a treadmill before and after induced transient lameness scored 2/5 in each one of their limbs in a randomized order. Lameness was induced by securing a cotton wad under the paw. Reflective markers were located in head, pelvis and right forelimb. Data was captured with a motion capture system. The differences between the two highest positions of the head (HDmax) and pelvis (PDmax) and between the two lowest positions (HDmin and PDmin) were calculated for each trial. The values for each induction were compared to the sound condition and differences were tested with Wilcoxon Signed rank test. Results: Induction of supporting limb lameness resulted in significant differences between the two lowest displacements of the head and pelvis. Differences were increased in HDmin during supporting fore limb lameness and in PDmin during supporting hind limb lameness (p<0.005). Additional compensatory mechanisms were observed during supporting fore and hind limb lameness: forelimb lameness showed differences in the PDmin and hind limb lameness showed differences in the HDmin (p<0.005).

Conclusions: The lowest vertical position of head and pelvis is an excellent indicator of supporting fore and hind limb lameness, respectively; and compensatory mechanisms in the ipsilateral and contralateral limbs can be expected, therefore lameness in these limbs must be always ruled out.

Ethical Animal Research: Ethical Committee on Animal Experiments of SLU. Competing Interests: None declared. Sources of funding: Agria Animal Insurances.

INERTIAL SENSORS BASED SYSTEM FOR LAMENESS DETECTION IN TROTTING DOGS WITH INDUCED LAMENESS.

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Reasons for performing study: Lameness detection can be challenging in dogs and this is reflected in the low inter-rater agreement when visually assessing lameness. Objectives: To use a wireless inertial sensor-based system, developed for objective lameness identification in horses (Lameness Locator, Equinosis), to detect and quantify lameness in dogs. Study Design: Experimental study. Methods: Ten clinically sound dogs were equipped with inertial measurement units attached to the head, pelvis and right distal limb. Vertical head and pelvic movement symmetry were measured, while dogs were trotting on a treadmill (mean speed ±SD, 1.9±0.1 m/s) before and after moderate induction of supporting (a cotton wool wad under the paw) or swinging fore-and hindlimb lameness (a custom made weight (200 g) above the elbow and tarsal joint, respectively). Visual lameness assessment was also performed. Four symmetry variables were calculated for each trial consisting in the differences between the two highest positions of the head (HDmax) and pelvis (PDmax) and between the two lowest positions (HDmin and PDmin). Pair-wise comparisons for each lameness induction to the sound measurement were performed using Wilcoxon signed rank test, P<0.01. Results: Forelimb supporting lameness showed significant changes in HDmin; and hindlimb supporting lameness showed significant changes in PDmin. Swinging limb lameness in the forelimb and hindlimb showed significant changes in HDmax and PDmax respectively. Additional ipsilateral forelimb and contralateral hindlimb compensatory movements were also detected. The results were confirmed in a parallel study from simultaneous high speed motion capture data.
**Conclusions:** Symmetry of vertical head and pelvis motion are important variables for lameness detection in dogs. Inertial sensor-based systems can successfully be used to detect and quantify induced lameness and differentiate between supporting and swinging limb lameness in dogs trotting on a treadmill. Further studies are needed to evaluate the method for clinically lame dogs trotting over ground.

**Ethical Animal Research:** The study design was approved by Ethical Committee for Animal Experiments, Uppsala, Sweden. **Competing Interests:** None declared. **Sources of Funding:** AGRIA animal insurance, Sweden

**MOVEMENT SYMMETRY OF THE WITHERS CAN BE USED TO DISCRIMINATE PRIMARY FORELIMB LAMENESS FROM COMPENSATORY FORELIMB ASYMMETRY IN HORSES WITH INDUCED LAMENESS**

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**Reasons for performing study:** Horses with primary hindlimb lameness sometimes also present with compensatory ipsilateral forelimb lameness. This compensatory movement asymmetry can be difficult to distinguish clinically from primary forelimb lameness. **Objectives:** To investigate the effect of induced fore- and hindlimb lameness on movement symmetry of the withers. **Study design:** Experimental study. **Methods:** Lameness was induced (sole pressure model, subjective lameness grade 0.5-3/5) in a randomized order in all limbs, one at a time, in 10 sound Warmblood horses. The horses were equipped with reflective markers at predetermined anatomical landmarks and trotted in a straight line on a hard surface. Kinematic analysis was performed using a high-speed, motion capture system (Qualisys AB, Sweden) and the difference between the two displacement minima of the head (HDmin), pelvis (PDmin) and withers (WDmin) were calculated for each stride. Registrations without lameness induction (n=30) and with a successful forelimb induction (mean absolute HDmin >15mm) or successful hindlimb induction with ipsilateral compensatory forelimb asymmetry (mean absolute PDmin and HDmin >10mm)(n=30) were included for analysis. HDmin, PDmin and WDmin were compared before and after each lameness induction using a linear mixed model (all strides; 4-7 strides/trial; significance p<0.05). **Results:** HDmin and PDmin were significantly different from the corresponding sound measurements for all inductions. WDmin least squares means (sd) were significantly different from sound, for LF: -12mm (2.0), RF: 9mm (2.0), LH: 18mm (2.9), RH: -14mm (3.5). WDmin showed opposite sign for primary forelimb lameness versus compensatory forelimb asymmetry. **Conclusions:** Horses with primary forelimb lameness demonstrated unidirectional head and withers asymmetry but for primary hindlimb lameness the compensatory head and withers asymmetry showed opposite directions. Movement symmetry of the withers might therefore be used to discriminate true forelimb lameness from compensatory forelimb asymmetry caused by primary hindlimb lameness. This knowledge can be useful in clinical lameness evaluations.

**Ethical animal research:** The study protocol was approved by the Animal Health and Welfare Commission of the canton of Zurich (permission number 51/2013). Informed consent of the horse owners was obtained. **Sources of funding:** The Swedish-Norwegian Foundation for Equine Research. **Competing interests:** None declared.

**LACK OF A DOUBLE-PEAKED VERTICAL HEAD MOVEMENT IN MODERATELY LAME HORSES WITH INDUCED LAMENESS**

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Reasons for performing study: Commonly used methods for objective lameness assessment quantify vertical displacement of head and pelvis during trot. This typically generates a double sinusoidal signal with two peaks and two valleys per stride that can easily be detected and used to determine important asymmetry parameters such as differences in vertical displacement between the two minima and two maxima (i.e. minDiff and maxDiff). However, in clinically moderately lame horses it has been observed that one peak and one valley might be lost from this signal but this phenomenon has not been described objectively. Objectives: To investigate the occurrence of vertical displacement of the head with only one minimum and one maximum per stride in horses with induced forelimb and hindlimb lameness. Study design: Experimental study. Methods: Three different degrees of lameness were induced (sole pressure model, AAEP lameness grade 0.5-3/5) in a randomized order in all limbs, one at a time, in 10 sound Warmblood horses. The horses were equipped with reflective markers at predetermined anatomical landmarks and trotted in a straight line on a hard surface. Kinematic analysis was performed using a high-speed, motion capture system (Qualisys AB, Sweden). Results: In 9 of the 10 horses the highest grade of lameness resulted in vertical head displacement movement with only one minimum and maximum per stride, in 7 horses for all strides and in 2 horses for some of the strides. This was also seen in one horse with compensatory head movement asymmetry as a consequence of induced hindlimb lameness. Conclusions: For the optimal use of symmetry measures for objective lameness evaluation in more than subtly lame horses methods to estimate the missing peaks/valleys using signal processing techniques are needed. Several of these exist (e.g. extrapolating time indexes from withers data or signal decomposition) but they still need validation.

Ethical animal research: The study protocol was approved by the Animal Health and Welfare Commission of the canton of Zurich (permission number 51/2013). Informed consent of the horse owners was obtained. Source of funding: The Swedish-Norwegian Foundation for Equine Research and The Swedish Research Council Formas. Competing interests: None declared.

ALTERATIONS IN THORACOLUMBAR MOVEMENT WHEN PAIN CAUSING LAMENESS HAS BEEN IMPROVED BY DIAGNOSTIC ANALGESIA

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Reasons for performing study: Lameness and thoracolumbosacral pain and stiffness often coexist. A better understanding of factors influencing thoracolumbosacral stiffness in quadrupedal animals is needed. Objectives: To determine if thoracolumbosacral movement of horses changes when pain which causes lameness is improved by diagnostic analgesia. Study design: Cohort. Methods: Thirty lame horses were trotted in straight lines and lunged on a 12 metre diameter circle on the left and right reins before and after lameness grade was subjectively substantially improved by diagnostic analgesia. Inertial sensor data was collected from the withers, thirteenth (T13) and eighteenth thoracic (T18) vertebrae, third lumbar (L3) vertebra, tubera sacrale (TS), and left and right tubera coxae. Range of motion (ROM) of rotational variables (pitch, roll, yaw), translational movement (dorsoventral, lateral-lateral) and movement symmetry were quantified at each thoracolumbar site. Hiphike difference and minimum difference (MinDiff) for the pelvic sensors were measured. Percentage changes for before and after diagnostic analgesia were calculated and mean±standard deviations (SD) were determined. Statistically significant results are presented (P<0.05). Results: Five and eight horses had unilateral and bilateral hindlimb lameness, respectively. Three and two horses had concurrent sacroiliac joint region pain or forelimb lameness, and one horse had both. After resolution of lameness the stride length (quantified as velocity times stride-time) increased, mean±SD 5±2%. The hiphike differences decreased by 31±37%. MinDiff of T13, T18, L3 and TS decreased by 45-52±42-81%. ROM of all rotational variables and the translational movement in lateral-lateral direction increased at all regions, ranging between 1-33%. There was greatest increase at T13 (33±54% pitch ROM, 18±35% roll ROM, 9±18% lateral-lateral ROM, 6±12% yaw ROM). Improvement in lameness did not alter ROM of the translational movement in the dorsoventral direction. Conclusions: Thoracolumbar asymmetry and stiffness associated with lameness can be reduced immediately by improvement in lameness using diagnostic analgesia.

Ethical Animal Research: The study was approved by the Ethical Review Committee of the Animal Health Trust and there was informed owner consent. Sources of Funding: Line Greve is funded by a Royal Veterinary College PhD Studentship through the Mellon Trust. Competing Interests: None declared.
DO LAME HORSES WIN RACES?

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**Reasons for performing study:** Lame horses are at greater risk of injury [1] with implications for horse and rider’s safety. We investigate the relationship between gait asymmetry (lameness) during in-hand assessment and race outcome. **Objectives:** To test for differences in the proportion of placed/not placed horses between objectively sound and lame flat racing Thoroughbreds (TBs). **Study Design:** Retrospective study in racing TBs undergoing 4-weekly routine inertial sensor gait analysis. **Methods:** Gait analysis results (at each horse’s training yard) were selected retrospectively from 1101 trot-ups recorded between November 2014 and November 2015 on 280 TBs racing at one race track. Inclusion criteria: gait exams performed up to 14 days before racing. Horses were considered lame if head or pelvic movement asymmetry exceeded 8mm. The first chronological episode of lameness was used. Gait analysis results and racing records (placed; not placed: 4th or worse) of 21 horses categorised as sound at one point and lame at a different time point were included. Proportions of sound/lame vs placed/not placed were compared by McNemar’s X² t-statistic and 95% CI calculated. **Results:** No difference was found in the proportion of placed/not placed horses between sound and lame TBs (any lameness, N=21, X²=1.71) or between sound and forelimb lame (N=14, X²=2.4); or between sound and hindlimb lame (N=5, X²=1.5) or between sound and multilimb lame (N=7, X²=0.16) horses. **Conclusions:** Preliminary results in a limited number of racing TBs suggest that gait asymmetry in-hand does not affect race outcome.

**Ethical Animal Research:** This study was approved by the Royal Veterinary College Ethics and Welfare Committee. Trainers provided informed consent. **Sources of funding:** Horserace Betting Levy Board. **Competing interests:** None declared. **Acknowledgements:** Singapore Turf Club.


MORPHOMETRIC CHANGES IN 15 SKELETAL MUSCLES OF HORSES AFTER 8 WEEKS OF AQUATRAINING

1Van de Winkel, D., 1de Bruijn, M., 2Touwen, N., 3Duchateau, L., 3Goethals, K., 4Oosterlinck, M., 5Pille, F., 4Van derperren K., 3Delesalle, C.

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**Reasons for performing study:** Water treadmill exercise is increasingly incorporated into equine training and rehabilitation. Little is known about the physiological and biomechanical responses to aqua training. **Objectives:** To identify the main skeletal muscles showing an increase in muscle cross sectional area after 8 weeks of aquatrainning. **Study design:** Nonrandomized trial. **Methods:** Five healthy untrained horses completed a 8-week aquatrainning program (20 min/session, 5 days/week, water height: ±40cm, water 7°C, belt speed 1.25m/s) preceded by 2 weeks of acclimation. Morphometric assessment of 15 strategically chosen muscle groups was performed on 3 occasions (at start, after 4 weeks and after 8 weeks) using transcutaneous ultrasound (Esaote MylabOne, macroconvex, 2.5-7.5MHz). Data were analyzed using analysis of variance (α=0.05). **Results:** The cervical part of the trapezius muscle, the m. brachiocephalicus and the thoracal part of the m. erector spinae significantly increased in muscle mass (more pronounced for the right than the left side). The thoracal part of the trapezius muscle and the quadriiceps femoris vastus lateralis significantly increased in muscle mass (only at the left side). The m. semitendinosus and m. semimembranosus significantly increased in muscle mass after 10 weeks. The m. biceps brachii, m. triceps brachii caput longum, m. pectoralis profundus, lumbal part of the m. erector spinae, m. rectus femoris, m. gluteofemoralis and the m. biceps femoris were only minimally influenced.
**Conclusions:** The applied training protocol causes hypertrophy of specific muscles in the forelimb, back, and hind limb, particularly muscles involved in elevation and forward movement of the forelimb, flexion of the hind limb and muscles used for extension of the spine. Asymmetric effects may be associated with laterality of horses, although this warrants further investigation. The lack of a control group receiving dry training precludes stating that the observed changes are specifically linked with aquatraining.

**Ethical Animal Research:** Ethical approval AVD262002015144. **Sources of Funding:** none. **Competing interests:** None declared.
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DO HOCK AND BACK KINEMATICS AT TAKE-OFF CHANGE WITH REPEATED JUMPING EFFORTS?

Walker, V., Tranquille, C., Murray, R., Dyson, S.

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Reasons for performing the study: There is limited information regarding consistency of an individual horse’s jumping profile, how a horse’s profile changes over multiple jumping efforts and variation among horses. Improved understanding may help identification of variations reflecting subclinical pain. Objectives: Investigate consistency of hock and back kinematics at take-off over 8 jumping efforts and determine if there was an effect on technique from the first to last jumping effort. Study design: Prospective cohort study. Methods: Ten showjumping horses (British Showjumping ≥ Grade C (mean age: 8 years, height: 168cm) were ridden by three professional riders. Each horse jumped an upright (1.2m high) and parallel fence (1.2m high and 0.6m wide) four times each, equally off each rein, in a cross-over design. Kinematics were determined using high-speed video (240Hz). Descriptive statistics assessed variation within and among horses for hock, thoracolumbar (TL) and lumbosacral (LS) angles at maximal stance hock flexion, and distance from the fence at take-off. Paired Students t-test’s were used to compare variables for the first and last jumping attempt for each horse for trailing (T) and leading (L) hindlimbs. Results: Mean±standard deviation (sd) for variables for all horses pooled for all jumping efforts: hock: L=123.9°±7.0; T=123.4°±8.9; TL=186.5°±4.2; LS=168.3°±6.5; distance from fence: L=194.9cm±28.2, T=199.8cm±30.3. Means and sd’s of individual horses varied within the group. Variations were horse specific; 5 horses were more consistent than the others. Alterations within an individual were variable specific. For all horses no significant difference was detected between the first and eighth jumping efforts (P>0.05). Conclusions: Some horses had consistent take-off profiles, but there was variation among horses. Deviations in take-off profiles within a single horse may be abnormal and could reflect subclinical injury. Take-off profiles did not change between the first and eighth jumping efforts, suggesting that there was no fatigue effect.

Ethical Animal Research: Approved by the Ethical Review Committee of the Animal Health Trust (project number: AHT 32-2014) and all owners gave informed consent. Sources of Funding: The Peter Harrison Foundation. Competing interests: None declared. Acknowledgements: We thank the riders and Russell Guire, Mark Fisher, Diana Fisher, Charlotte Bullard, Jessica Cooke, Teresa Cordovil, Siobhan Gilligan and Isabelle Pettit.

MOLDABLE, THERMOPLASTIC, GLUE-ON HEART-BAR SHOES MODIFY GROUND REACTION FORCES UNDERNEATH THE HOOF IN NORMAL SHETLAND PONIES.

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Reasons for performing study: Thermoplastic, glue-on, heart-bar (Imprint®) shoes are used in practice to provide support in patients with acute laminitis. Personal and anecdotal positive experiences with these shoes exist, however scientific evidence is lacking. Objectives: To determine the effect of these heart-bar shoes on ground reaction forces. Study design: Nonrandomized trial. Methods: Sound Shetland ponies (n=10) were led at walk and trot over a combined pressure and force plate system after trimming (T0), immediately after shoeing (T1) and 72 hours after shoeing (T2). At each time point, five valid measurements per forelimb were collected. A linear mixed model with time point as fixed effect, random intercept and each pony as its own control was used for statistical analysis. Results: Measured velocity was within 0.80-1.40 m/s at walk and 2.50-3.50 m/s at trot and did not change significantly between time points. At walk, the vertical impulse Vl(Ns/kg) (T0:2.28±0.5, T1:2.01±0.4,T2:2.57±0.5) the Vl of the toe zone (T0:1.57±0.5, T1:1.40±0.4, T2:1.77±0.4) and the total peak vertical force (PVF) (T0:5.35±1.0, T1:4.82±0.9, T2:6.07±0.9) decreased from T0 to T1 and increased from T1 to T2 and from T0 to T2 (P<0.05). The Vl of the heel zone (T0:0.70±0.3, T1:0.61±0.2, T2:0.70±0.4) decreased from T0 to T1 and increased from T0 to T2 (P<0.05). At trot, the Vl (T0:1.11±0.3, T1:1.12±0.3, T2:1.13±0.2), the Vl of the toe (T0:0.72±0.3, T1:0.76±0.3, T2:0.86±0.2) and the heel zone (T0:0.38±0.1, T1:0.37±0.1, T2:0.45±0.2), and the PVF (T0:8.07±1.7, T1:8.04±1.7, T2:9.77±1.6) increased from T0 to T2 and from T1 to T2 (P<0.05). Conclusions: Ground reaction forces underneath the hoof during locomotion are affected by application of glue-on, heart-bar shoes. The observed increase in the measured variables after application of these shoes might suggest...
that these animals became more comfortable over time.

**Ethical Animal Research:** The study was approved by the local ethics committee. **Sources of funding:** Imprint® Equine Foot Care ([http://www.imprintshoes.co.uk/](http://www.imprintshoes.co.uk/)). **Competing interests:** None declared.

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**REPEATABILITY OF GAIT ANALYSIS MEASUREMENTS IN THOROUGHBREDS IN TRAINING.**

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**Reasons for performing the study:** Lameness majorly contributes to training days lost in Thoroughbred (TB) racehorses. It is important to specify gait analysis protocols for inertial measurement unit (IMU) gait analysis for detection of lameness in TBs in training based on measurement repeatability. **Objectives:** To quantify limits of agreement (LoA) for head and pelvic movement symmetry in TBs in training. **Study Design:** Repeatability study. **Methods:** Thirteen TBs in training were equipped with IMUs (100 Hz, +/-10G, +/-1200deg/s, +/-750mGauss) on poll, sacrum, right and left tuber coxae (LTC, RTC) and trotted in-hand in a straight line. Measurements were repeated once a day for five consecutive days and once a week for 5 consecutive weeks. Range of motion (ROM) and movement symmetry, difference between displacement minima (MinDiff) and maxima (MaxDiff) during and after contralateral stance phases, were quantified for each trot stride and median values calculated for each repeat assessment. Mean difference (bias) and standard deviation (SD) of differences between measurements were calculated for daily and weekly repeats. **Results:** Valid IMU data (4836 strides, 38+/23 strides/horse) were collected. Bias and SD values were smallest for sacrum ROM for daily repeats (0.63 and 6.13mm) and for sacrum MinDiff for weekly repeats (-0.29 and 7.41mm). Bias and SD values were largest for poll MinDiff for daily repeats (0.88 and 12.7mm) and for RTC MinDiff for weekly repeats (-2.47 and 15.52mm). **Conclusions:** LoA of gait parameters for daily and weekly repeats in TBs in training are wider than reported between assessments conducted over a short time span. Individual gait differences due to age and training over time need to be taken into account when using gait assessments in TBs for lameness detection.

**Ethical Animal Research:** This study was approved by the Royal Veterinary College Ethics and Welfare Committee. Trainers provided informed consent. **Sources of funding:** Horserace Betting Levy Board. **Competing interests:** None declared. **Acknowledgements:** Singapore Turf Club.


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**ELECTROMYOGRAPHIC CHANGES IN MAJOR HINDLIMB MUSCLES IN FATIGUED THOROUGHBRED HORSES**

Takahashi, Y., Mukai, K., Matsui, A., Ohumura, H., Takahashi, T.

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**Reasons for performing study:** Major hindlimb muscle functions are important for high speed galloping. However, the fatigue-induced electromyographic changes in these muscles remain unclear. **Objectives:** To quantify fatigue-induced electromyographic changes in major hindlimb muscles in horses. **Study Design:** Intervention study. **Methods:** Seven healthy Thoroughbred horses were used for surface electromyography (EMG) recording of the *longissimus dorsi* (LD), *tensor fasciae latae* (TFL), *gluteus medius* (GM) and *biceps femoris* (BF). Hoof strain gauge was attached to confirm stride cycle. Each horse galloped on a treadmill inclined to 3% at a constant speed (12.6–14.7 m/s) to make each horse fatigued after approximately 6 min. Before and after this exercise, 3.5 m/s trot was performed. Integrated EMG (iEMG) for a stride and median frequency (MF) during muscle discharge were calculated every 30 s. Each value was the average for 5 consecutive strides. Stride frequency (SF), iEMG, and MF were compared at the start and end of galloping for lead and trail limb and trotting before and after fatigue using a paired t-test. **Results:** SF significantly decreased (2.16 ± 0.03–2.05 ± 0.05 strides/s, P<0.01). iEMG of GM and BF in both lead and trail limbs significantly decreased after fatigue (P<0.05), whereas that of LD and TFL did not change. No changes were observed in MF in all muscles at a gallop after fatigue.
Neither iEMG nor MF changed at a trot after fatigue. **Conclusions:** Fatigue decreases iEMG of GM and BF during high speed galloping.

**Ethical Animal Research:** The study was approved by the Animal Welfare and Ethics Committee of the Japan Racing Association Equine Research Institute. **Sources of funding:** Japan Racing Association. **Competing interests:** None declared.

**DISTAL LIMB MOVEMENT IN WALK ON A TREADMILL WITH AND WITHOUT WATER.**

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**Reasons for performing study:** Comparison of distal limb range of movement (ROM) in walk on a (land) treadmill and a water treadmill (WT) at speeds typically used in practice would inform the design of rehabilitation programmes using WT exercise. **Objectives:** To compare forelimb (FL) and hindlimb (HL) ROM in walk on a WT and a treadmill. **Study design:** Within-subject repeated measures, cross-over design. **Methods:** Eight horses walked on a WT (0.8 m/s) at hoof, fetlock, hock and stifle depth water, and on a treadmill (1.6 m/s) within the same session. Inertial motion sensor units (in waterproof packs) measured cannon angle (relative to the cannon angle when standing) continuously throughout exercise (102.4 Hz). Group mean maximum protraction (PRO), retraction (RET) and total ROM of each limb were calculated. Values for FLs and HLs were averaged (following t-tests) to give a single FL and HL value for each variable which were compared using repeated measures ANOVA and post hoc testing with Bonferroni correction (P<0.005). **Results:** FL ROM at hoof (62.0°), hock (62.5°) and stifle (58.6°) depths in the WT was significantly lower (P<0.001) than on the treadmill (71.6°). FL PRO was significantly lower at hock (12.9°, P=0.001) and stifle depths on the WT (12.4°, P=0.001) than on the treadmill (21.5°). HL ROM at stifle depth (74.6°, P=0.001) on the WT was significantly greater than HL ROM on the treadmill (57.9°). HL RET at hock depth (-25.2°, P=0.001) on the WT was significantly greater than on the treadmill (-17.8°). **Conclusions:** At speeds typical of those used in practice, walking on a water treadmill in high water results in a lower forelimb ROM but a higher hindlimb ROM than walking on a land treadmill. The effect of drag on limb ROM should be considered when designing rehabilitation programmes utilizing water treadmill exercise.

**Ethical Animal Research:** The study was approved by Hartpury University Centre’s Research Ethics Committee. **Sources of funding:** None. **Competing interests:** None declared.

**A SINGLE CASE STUDY INVESTIGATING LIMB FLEXION, RANGE OF MOTION, BODY AND METATARSAL ANGLE DURING LEVADE**

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**Reasons for performing this study:** Advanced movements (‘haute ecole’) are performed in European classical riding schools. According to classical literature, in levade, the horse maintains a haunched position at 30° to the ground, achieved by taking greater weight on the hindquarters, flexing the hindlimb joints and drawing the forelimbs into the body. To date, no objective measures of the movement exist within scientific literature. **Objectives:** To measure joint flexion (JF) in a static levade position and the range of motion between stance and the static levade position (ROM), compare the angle of the metatarsus to the horizontal (MTangle), the angle between the wing of atlas (WA) and tuber sacrale (TS) and the horizontal (LEVangle) in static levade and stance and the measurement variability over six levade repetitions. **Study Design:** Single case study. **Methods:** Skin fixed markers were placed on the lateral aspect of the centres of rotation on the left limb joints, on WAt and TS of a Lusitano Stallion trained in levade. Flexion of the shoulder, elbow, carpal, hip, stifle, tarsal joints, MTangle and LEVangle was measured during stance and in six static levade positions, using Dartfish™ and performed within parallel poles (1.5m apart), 4.5m perpendicular to a video camera (120 Hz). **Results:** JF in levade was shoulder: 80.8°±1.2°, elbow: 71.1°±1.5°, carpus: 60.5°±3.8°, hip: 79.7°±1.8°, stifle: 99.2°±4.2° and hock: 106.8°±3.2°. Mean ROM were: shoulder: 7.4°, elbow: 41.7°, carpus: 62.5°, Hip: 5.7°, stifle: 17.5° and hock: 29.0°. MTangle was 35.1° more acute and LEVangle (32.5°) was 23.4° greater in levade compared to stance.
**Conclusion:** Compared to stance, levade produced increased limb joint flexion and body angle, as described in the classical literature, and imposes a considerable load to joints in the hindlimb. Further investigation using more subjects is required to fully explore the kinematic demands of levade.

**Ethical Animal Research:** Study design approved by Hartpury College Ethics committee. Owner and rider consent was obtained. **Sources of Funding:** None. **Competing Interests:** None declared.

**SAGITTAL PLANE ROTATIONS OF THE EQUINE AXIAL BODY SEGMENTS AT WALK, TROT AND CANTER**

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**Reasons for performing study:** limited data are available describing rotational movements of axial body segments in different gaits. **Objectives:** to compare sagittal plane head, neck and trunk angles at walk, trot and canter. **Study design:** repeated measures. **Methods:** Four miniature horses were trained to walk, trot and canter on a loose rein at a range of speeds. A full body marker set was tracked in 3-D at 120 Hz using standard motion capture techniques. Angles of the trunk, neck and head segments were measured relative to the horizontal and angle-time graphs were plotted for each gait. Minimal and maximal angles were extracted, their timing was related to limb stance phases, and ranges of motion (ROM) were calculated. Repeated measures ANOVA identified differences between gaits and horses and detected speed-dependent effects within gaits (P<0.05). **Results:** All segments oscillated twice/stride in walk and trot and once/stride in canter. Neck angle was maximally lowered and head angle was maximally ahead of the vertical during forelimb overlap in walk and during mid-diagonal stance in trot and canter. Minimal and maximal angles of the trunk and neck segments but not the head segment differed significantly between gaits. In addition, minimal and maximal trunk angles increased with speed indicating greater trunk elevation at faster speeds. ROM was largest in canter for the trunk (walk: 6.1±1.1 deg; trot: 2.3±0.7 deg; canter: 8.1±1.7 deg) and head (walk: 13.0±5.1 deg; trot: 12.0±7.0; canter: 14.5±8.0 deg) but neck ROM was largest in walk (walk: 17.7±4.5 deg; trot: 9.2±4.3 deg; canter: 14.0±4.5 deg). **Conclusions:** the magnitude and timing of axial segmental rotations show differences with gait and speed that are relevant to understanding control of the horse’s balance and the compensatory movements of the rider’s axial body segments, as well as the cyclic patterns of rein tension.

**Ethical Animal Research:** The study was approved by the Institutional Animal Care and Use Committee, Michigan State University, USA under protocol number 02/08-020-00. Owner consent was not stated. **Sources of Funding:** McPhail endowment at Michigan State University. **Competing interests:** None declared.

**BALANCE STRATEGIES USED IN PASSAGE**

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**Reasons for performing study:** Although passage is known to differ from trot in footfall patterns and peak ground reaction forces the intricacies of balance management and the mechanical demands on the passing horse have yet to be fully explored. **Objectives:** To measure biomechanical characteristics of passage and evaluate their influence on balance. **Study Design:** Observational. **Methods:** Three Lusitano elite dressage horses of mass 607 ± 9 (kg) were captured at 120 Hz by a 10 camera motion analysis system performing ridden passage over 4 force platforms recording at 960 Hz. A full body marker set was used with the segmental method [1] to determine the centre of mass (COM) and balance variables, which included centre of pressure, pitching moments, dissociation timing, peak force production, and limb and trunk posture. Twenty passage steps were extracted in total and partial correlation (accounting for horse) used to investigate significant (P<0.05) relationships between balance variables. **Results:** The only variable that correlated significantly to mean sagittal-plane pitching moments for each step was mean pro-retraction of the forelimb (R=−0.544, P=0.02), which was also moderately correlated to trunk inclination and peak hindlimb forces (P<0.05). **Conclusions:** Balance, quantified by mean pitching moments was principally adjusted by reducing the amount of forelimb retraction, which suggests that control of fore foot contact position
throughout stance is the most important balancing strategy when performing passage. The more protracted forelimb also provides greater vertical COM excursion and gives the impression of grandeur [2].

**Ethical Animal Research:** Study performed with approval from the Institutional Animal Care and Use Committee, Michigan State University, USA under protocol number 02/08-020-00. Owner consent was not stated.

**Sources of funding:** University of Central Lancashire and the McPhail endowment at Michigan State University.

**Competing interests:** None declared.


**KINEMATIC ANALYSIS OF THE A-FRAME IN CANINE AGILITY**


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**Reasons for performing the study:** Limited research has evaluated the kinematic demands of agility dogs despite the growing popularity of recreational and competitive agility. The A-frame is a common piece of equipment used within canine agility courses; consisting of two 9 foot ramps combining to a height of 5 foot 9 inches to give an ‘A’ shape and includes incline, apex and decline phases. To our knowledge, no research has evaluated canine A-frame kinematics. **Objectives:** To describe forelimb (FL) joint angles and spinal kinematics of dogs during the phases of A-frame completion. **Study design:** Observational, descriptive study. **Methods:** Eight agility dogs, all trained on the A-frame, of mixed breed, age and experience underwent 3 videoed runs over the A frame. Reflective markers were placed on each dog’s carpus, radiohumeral and scapulohumeral joints, Atlas, C3, T6, T13 and L3. Videos were transferred to Dartfish™ to facilitate kinematic analysis enabling carpal, radiohumeral and scapulohumeral angles for the approach (last stride), incline (FL contact), apex (FL over), decline (FL touchdown and FL departure) and range of movement (ROM) within the spinal markers to be calculated. **Results:** From the incline to the apex, dogs exhibited mean carpal flexion of 82.0±8.7°, mean radiohumeral flexion of 53.4±6.6° and mean scapulohumeral flexion of 14.9±1.6°. In contrast, from the apex to the decline, dogs displayed mean carpal extension of 85.9±4.8°, mean radiohumeral extension of 53.3±2.5° and mean scapulohumeral extension of 12.3±3.2°. ROM of spinal markers varied with the A-frame phases: approach-incline: atlas, T6, T13 and L3 extension; C3 increased flexion, incline-apex: atlas, C3, T13 and L3 increased flexion; T6 increased extension, and apex-decline: atlas, C3, T6, T13 and L3 increased extension. **Conclusions:** Agility dogs adapt their FL and spinal kinematics in a similar way when completing the A-frame; variation observed could be linked to individuals’ conformation or experience.

**Ethical Animal Research:** Ethical approval for the study was granted by the UWE (Hartpury) Ethics Committee. **Competing interests:** None declared. **Sources of funding:** This study was funded by R. Jackson and Hartpury College.

**KINETIC MEASURES OF POSTURAL SWAY IN HEALTHY MINIATURE DACHSHUND DOGS**


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**Reasons for performing study** Measures of postural sway have been used in humans to assess their stability. Miniature Dachshunds are at a high-risk of developing neurological problems including paresis and paraplegia, some of these dogs undergo spinal surgery and rehabilitation to regain normal function, but their functional improvement cannot be quantified before they can walk. **Objectives** The aim of the study was to obtain objective measures of postural stability during quiet standing in healthy Miniature Dachshunds. This assessment can be used in patients to objectively assess the efficacy of various treatments. **Study Design** Experimental study. **Methods** 43 healthy Miniature Dachshunds of different body conditions and breed variety were recruited. The dogs stood still on a planar pressure mat and a force plate. Data was collected using the two systems...
simultaneously. Trials of 10 second duration were collected, a minimum of 5 valid trials were used for analysis. Measures of Centre-of-Pressure (CoP) displacement, velocity, anterior-posterior range, medial-lateral range and areas of best-fit ellipsoid were computed with Matlab. ANOVA and Pearson’s correlation tests were used to examine differences between gender, breed variety, body condition and age. **Results** No statistical differences were found between gender and varieties groups. There was a negative correlation between medial-lateral range and age (normalised to body weight) and the CoP velocity was higher in dogs considered to be overweight. **Conclusions**: Posture sway may be affected in overweight dogs. Standing COP sway is an objective assessment tool that may be useful to evaluate the recovery of patients where their postural stability is affected.

**Ethical Animal Research**: Ethics and Animal Welfare Committee (NASPA) University of Surrey. **Competing Interests**: None declared. **Sources of Funding**: Science Without Borders, Brazil
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DIVERSITY OF LOCOMOTOR PATTERNS IN LARGE LAND MAMMALS

Professor John R. Hutchinson, The Royal Veterinary College, JHutchinson@rvc.ac.uk

Mammals evolved at a small body size (close to that of a mouse) over 200 million years ago, then gradually diverged into some of the lineages that still exist today, with a massive adaptive radiation beginning after the extinction of dinosaurs >65 million years ago. That ancestrally small body size, prolonged Mesozoic divergence in the shadow of dinosaurs, and the rapid explosion of post-Mesozoic speciation have left profound influences on the form, function and behaviour of modern mammals, including horses and dogs. Such a historical perspective on animal locomotion illuminates why animals are the way they are today (or at any past point in time) and can prompt novel questions, especially when combined with modern experimental and theoretical data on locomotor function.

I will briefly outline how mammals (and their locomotor patterns) evolved in conjunction with body size, with reviews of how dogs (and other carnivores including cats) and then horses (and other perissodactyls including rhinoceroses; as well as artiodactyls including camelids and giraffids) evolved their form and function. This review will feature some examples from my team’s research on general patterns in mammalian locomotion plus our recent focus on the cat lineage (large and small species) and unusual, very large species such as giraffes and elephants. The perspective that emerges is that a wide spectrum of locomotor mechanisms has evolved in concert with body size, ecology and other factors, leaving to groups of animals with distinct locomotor patterns even at the same body size. This diversity of locomotor mechanisms makes generalizations about locomotion in “normal” or even “cursorial” mammals difficult to formulate—evolution has repeatedly violated “rules” that seem to apply to some species, leading one to wonder what principles are truly universal.

For example, whilst mammals broadly tend to adopt more vertical limb postures as body size increases through evolution, helping to more effectively support themselves against gravity while standing or moving, beyond ~500kg body masses (e.g. horses) this general pattern no longer seems feasible, as limb postures become about as vertical as they seem able to be. Within some groups, such as cats, it appears that this general pattern of increasing limb extension is not used even across ~3-300kg body mass ranges. Mysteries remain regarding how much limb flexion is necessary to use bouncing gaits (horses and elephants use somewhat different limb postures at moderate “running” speeds, yet neither is fully columnar-limbed), or why some giant land mammals such as rhinoceroses seem more athletic than others such as elephants despite having the same body size. Even within groups with “cursorial” (elaborate) limb morphologies, such as horses and giraffes, athletic abilities and even gait usage can vary extensively, which remains inadequately explained.

On the other hand, generalizations about locomotor biomechanics are important hypotheses that can and do lead to valuable insights and applications. Broadly, across mammals, ratios of failure stresses to peak stresses (“safety factors”) during rapid locomotion or jumping are high enough for proximal limb bones that skeletal failure during normal movement seems of little concern. However, in the distal limbs the small areas and high forces may lead to large regional stresses, with hints of broad patterns of increasing levels of stress as animals become larger through evolution or growth. This seems to match other general patterns for the incidence of mechanically-related musculoskeletal pathologies such as osteoarthritis—are large mammals, then, more prone to pathologies in their feet because they are “living more dangerously” with lower safety factors in their distal limb structures, as opposed to more proximal ones? I explore this general speculation.

It is important to continue to test generalizations about mammalian locomotion and leave open the possibility that evolution has led to “exceptions” to general rules in biomechanics. Elephants pose one example of extreme specialization in size, anatomy and locomotion. I cover how my team has revealed many aspects of these extremes, from our initial studies of subtle gait transitions and <25kph maximal speeds in elephants of all species and sizes to our more recent examinations of the mechanics of elephant feet in comparison to the slender feet of horses or other mammals. In many ways, elephants are unlike “normal” mammals, which can in part be attributed to their large size but also to their unusual evolutionary history within the Afrotherian lineage of mammals, including their distant aquatic ancestry. How “normal”, then, are other large mammals such as horses (wild or domestic);
are all large-bodied mammals perhaps specialized in important, unique ways that generalizations sweep under the carpet?

Clearly, even at the size of elephants, numerous evolutionary pathways leading to disparate locomotor mechanisms exist, judging from the existence of giant rhinoceroses that surpassed any modern elephants in size and bipedal carnivorous dinosaurs as large as any living elephant. Giant land animals do face common and severe biomechanical constraints such as the dominant influence of gravity on their biology. Yet surprising flexibility remains for what kinds of forms, functions and behaviours can be produced by evolution, and the “evolutionary baggage” that animals carry with them from their ancestry may challenge the role of biomechanics itself in determining the diversity that exists or has existed. I conclude with a rumination on when and if we should assume that locomotor biomechanics is important.

A COMPUTATIONAL MODEL OF HOOF-GROUND DYNAMIC INTERACTION FOR EVALUATING MUSCLE AND JOINT REACTION FORCES DURING EQUINE LOCOMOTION

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Reasons for performing study: Injuries to the equine distal limb are common in racehorses and thought to be caused by very large forces generated during ground-hoof contact. Measurements of ground reaction forces at the hoof during racing are not practical with current technologies but computational modelling is able to predict these quantities. Objectives: To develop a computational model of the hoof-ground interaction using Smoothed Particle Hydrodynamics (SPH) to simulate the mechanical response of the track. Study Design: Observational. Methods: 3D computational models of a sand track and a synthetic track were calibrated using measurements of track surface elasticity and ductility. The SPH models use fundamental stress equations for elastic and plastic materials to predict the 3D physical response of the track surface during transient loading, such as by a hoof. 3D joint motion of a horse breezing on both track types was measured using video-based motion capture, and these data then used to prescribe hoof motion in the SPH model and predict ground reaction forces. The calculated values of ground reaction forces were used in conjunction with a validated distal forelimb model to determine muscle and joint reaction forces during galloping. Results: Forces were highly sensitive to the depth of surface penetration by the hoof into the track, stressing the need for accurate limb kinematic inputs. The dirt track was stiffer than the synthetic track, with bulk moduli of 4 MPa and 2 MPa, respectively, resulting in a more rapid rise in forces at initial hoof impact. Conclusions: SPH enables new insights to be gained into the differences in hoof-ground forces between track surfaces by allowing changes to synthetic track design to be evaluated quantitatively.

Ethical animal research: The use of animals was approved by approved by the University of California, Davis Institutional Animal Care and Use Committee. Owner consent was not stated. Sources of funding: Racing Victoria Limited and the Victorian State Government. Competing interests: None declared.

STIFFNESS AND SHOCK-ABSORBING ABILITY OF THIRD METACARPAL SUBCHONDRAL BONE IN THOROUGHBRED RACEHORSES UNDER SIMULATED GALLOPING LOADS

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Reasons for performing study: The distal palmar metacarpus is subjected to extreme loads in galloping horses. How these loads are absorbed or transferred through the subchondral bone (SB) is unknown, yet critical to understanding how injury at this site occurs. Objectives: To measure stiffness and shock-absorbing ability of distal metacarpal SB under high-rate compression similar to that experienced during galloping. Study Design: In vitro observational experiment. Methods: Cartilage-bone plugs (Ø6.5±0.2 mm) from the metacarpal condyles of n=8 racehorses were loaded while imaged with a high-speed camera attached to a stereomicroscope. Time to peak
strain was 0.05 sec and strains were 50–60% of the yield strain [1]. A digital image correlation technique calculated the average deformation of two ROI, the immediate SB (ISB, 0.5–2.5mm) and deep SB (DSB, 2.5–4.5mm). Data were analysed using Wilcoxon signed rank tests and Pearson correlations. Results: Overall applied strain of 2.6±0.3% (mean±SD) generated stress of 44.3±9.9MPa at the articular surface. In all specimens DSB was stiffer than ISB by a factor of 2.70±0.91. The shock-absorbing ability of ISB was significantly higher (P=0.006) than that of DSB by a factor of 3.1±0.8. ISB stiffness and normalised hysteresis were significantly correlated with ISB strain (r=0.8, P=0.02 and r=0.9, P=0.005, respectively). Conclusions: Distal metacarpal superficial SB is able to deform more and dissipate more energy under loads generated during galloping than its underlying SB, and the more compressible the superficial SB the greater the energy dissipated. Microcrack accumulation, commonly observed in the superficial SB in racehorses, is likely both a consequence of these high strains and a contributor to the loss of stiffness.

Ethical animal research: The use of animal tissues met the requirements of the University of Melbourne Animal Ethics Committee. Owners have been aware that their horses would undergo post-mortem examination and tissues would be retained for teaching or research purposes. Sources of funding: Racing Victoria Limited and the Victorian State Government. Competing interests: None declared.


THREE-DIMENSIONAL FINITE ELEMENT MODEL OF THE EQUINE CARPUS

1Olusa, T.A.O., 2Sun, Z., 3Nakarmi, T., 3Jiang, C., 2Burvill, C., 1Davies, H.M.S. and 1Murray, C.M.

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Reasons for performing study: A three dimensional (3D) finite element model of the carpus was desirable to provide an alternative means of investigation of the complex biomechanical functions of the carpus. Objectives: To provide a 3D solid surface model of the equine carpus. Study design: Computer software modelling. Methods: Laser scan images were generated from the bones from the left carpus of an adult thoroughbred horse with no apparent carpal pathology. These bones (distal end of the radius, radial carpal bone (Cr), intermediate carpal bone (Ci), ulna carpal bone (Cu), accessory carpal bone (Ca), second carpal bone (C2), third carpal bone (C3), fourth carpal bone (C4) and the proximal end of the second, third and fourth metacarpals) were individually scanned and those images were trimmed, aligned, fused and polished using ScanStudio HD PRO software to generate mesh data which were later exported to Solidworks® computer software to be modelled and then assembled to their normal anatomical position to resemble the configuration of the carpal joint in a live horse. Results: The model contained 1,591,398 quadratic tetrahedral elements of type C3D10H. The joint’s motion (flexion and extension) was simulated and a range of angular motion from 0-45 and 0-15 degrees for antebrachio carpal and middle carpal joints respectively was achieved. Further flexion beyond these points was limited or prevented by Ca during simulation. Conclusion: The created model provided a 3D solid surface representation of the equine carpus. This model will be useful in further studies on conformation, contact and stress distribution pattern within the carpal joint as the individual assembled parts would interact similarly to what occurs in the live animal. This is expected to give a better result than if the whole carpus had been scanned and modelled as one single block or unit.

Ethical Animal Research: Material (bones) was collected from a horse euthanized for reasons not associated with the study and owner’s consent was obtained. Sources of Funding: None. Competing interests: None declared.

QUANTITATIVE ASSESSMENT OF EQUINE CARPAL ANGLES IN THOROUGHBRED RACEHORSES

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Reasons for performing study: A lack of objective quantitative assessment of carpal conformation despite a perceived influence of conformational deviations on performance and lameness. Objectives: To provide an objective measurement protocol for quantitative assessment of carpal conformation in thoroughbred racehorses.
Study design: Pilot study. Methods: Conformational measurements (carpal circumference and angles) were taken from 20 two-year old thoroughbred racehorses in training. The circumference was measured using flexible calibrated tape while all the carpal angles were measured from standing lateromedial/mediolateral and dorsopalmar radiographs except 2 (medial and dorsal carpal angles) which were also measured on standing horses using a goniometer. Consistent anatomical landmarks were used for each of the defined conformational parameters based on the ease of identification of particular bony features such as physes, facets and tuberosities. Results: 5 correlated carpal angles and 8 wedge angles were identified and defined to assess carpal conformation. Mean carpal circumference was 32.95±0.83cm and 33.07±0.82cm for left and right carpi respectively. The larger third Carpal bone Palmar Facet Angle (C3PalFCA) and smaller Dorsal Carpal Angle (DCA) contributed to a more significantly extended (P<0.05) right carpus than left. There was no significant difference between the DCA measured on radiographs and on live horses, suggesting that a goniometer can be used to accurately measure the DCA in a live horse. Conclusion: Geometric data obtainable from carpal radiographs and goniometry in live horses allows for an objective quantitative assessment of carpal conformation. This approach would eliminate judgemental errors or variation between observers using subjective visual assessment for the carpus.

Ethical Animal Research: Study protocol was part of an approved study by the University of Melbourne Research ethics committee. Owners provided informed consent. Sources of Funding: None. Competing interests: None declared.

COMPARISON OF METHODS TO SIMULATE GROUND REACTION FORCES IN TROTTING HORSES
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Reasons for performing study: Ground reaction forces (GRF) in trotting horses are determined by leg and surface properties. Simulation models use mass-spring-damper arrangements to approximate the characteristic force-time curve obtained with force plates or dynamometric horseshoes. Simulation enables quick assessment of the influence of surface stiffness and energy restitution (rebound, damping) on GRF in vertical and horizontal directions. Objectives: To compare simulation approaches with respect to results, adaptability and effort. Study design: Modelling study. Methods: The model specifies the surface as a nonlinear spring parallel with a viscous damper. The leg consists of a small mass (1kg-4kg) representing the hoof and lower limb and a large mass of 275kg (half of the body mass due to two leg stance in trotting) linked via spring and damper elements. The latter is moved with an additional sinusoidal force. Three unidimensional simulation models were applied and analysed with SimulinkV8.6 (MathWorks, Inc., USA). The mathematical model (A) was based on differential equations of motion. The mechanical model (B) was developed in SimMechanics™ as a multibody system. The electrical model (C) used equivalent electrical elements (mechanical-electrical analogies: force-current, velocity-voltage, spring-inductivity, damper-resistor, mass-capacitor). Initial boundary conditions and parameters follow the literature and were all the same. Results: Simulated GRF curves from models A-C were identical and close to the reported shape in trotting horses. Model B and C proved to be less difficult than model A, because differential equations are complex to model. Model B allows a real time visualisation of the movement of elements appropriate for teaching and better understanding. Model C allows easier implementation of complex structures. With increasing numbers of elements this advantage becomes more evident. Conclusions: Simulating of the GRF can be done with different methods. The adequate selection of a method may simplify the structure and increase efficacy and flexibility.

Ethical Animal Research: Not applicable. Sources of funding: None. Competing interests: None declared.
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<td>REPEATABILITY OF THE COP PATH DETERMINED BY AN INDIVIDUAL LIMB IN HORSES WITH SYMMETRIC AND ASYMMETRIC DORSAL WALL ANGLES</td>
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VALIDATION OF THE ACCURACY OF NON-INVASIVE TRACKING TECHNIQUES IN BIPLANE HIGH-SPEED FLUOROSCOPY FOR THE EQUINE DISTAL EXTREMITY

1Geiger, S.M., 1Reich, E., 2Böttcher, P., 1Hagen, J.

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Reasons for performing study: Biplane high-speed fluoroscopy is a new method for gait analysis of the equine distal extremity. So far there is no study assessing the accuracy of the non-invasive tracking possibilities (automated shape-based and manual image registration) taking the peculiarities of equine anatomy into account.

Objectives: The aim of this study was to determine the accuracy with which these two tracking methods work in comparison to the invasive gold standard marker-based image registration as a basis for future research on the equine distal limb. Study design: Comparative, in-vitro study. Methods: Five distal extremities of ponies were implanted with three to four tantalum beads with 1mm diameter per bone (proximal, middle and distal phalanx). 3D models of the bones were reconstructed using computer tomographic data (120kV, 50mA, slice thickness 1mm, increment 0.5). The beads were digitally removed from the bone models. Biplane fluoroscopic videos were taken at 69.5±3.5kV, 102.5±22.5mA, 500fps and 0.5ms shutter speed. The five specimen were moved in the trial field of the biplane fluoroscopic setup in a step-like (simulation of landing, main stance phase, lift-off) motion. Videos were recorded at a resolution of 1280x1024 pixels and were 938±206 frames long. Marker-based, shape-based and manual image registration was carried out and agreement computed as bias (average Euclidean difference in translation of model’s center point in 3D space) and precision (standard deviation of differences).

Results: Bias and precision for automated shape based image registration for the proximal, middle and distal phalanx were 1.06±0.87mm, 0.79±0.38mm and 0.54±0.21mm respectively. The results for manual tracking in the same order were 0.49±0.19mm, 0.73±0.37mm and 0.63±0.23mm. Conclusions: Non-invasive biplane high-speed fluoroscopy allows measurements of equine distal extremities bone positions during movement to a submillimeter accuracy. However, which tracking method to choose for lowest bias depends on the bone in question.

Ethical Animal Research: The animals were derived from an abattoir and the abattoir gave consent. Competing Interests: None declared. Sources of Funding: None

REPEATABILITY OF THE COP PATH DETERMINED BY AN INDIVIDUAL LIMB IN HORSES WITH SYMMETRIC AND ASYMMETRIC DORSAL WALL ANGLES

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Reasons for performing study: The centre of pressure (COP) path quantifies the dynamic load distribution under the hoof. Hoof shape and position with respect to the limb would alter this path. Ground reaction forces in sound horses with left-right asymmetric hooves show systematic differences in the horizontal braking force and relative timing of break-over. Objectives: To test whether anatomical asymmetry, quantified by the difference in dorsal hoof wall angle between the left and right forelimbs, correlates with asymmetry in the COP path between these limbs. Study design: Observational. Methods: Thirty one sound horses with various degree of hoof asymmetry trotted six times (3 left and 3 right foot landings) over a force/pressure combination recording mat. The COP path was determined in a hoof-bound coordinate system. Repeatability of path shape and path size was determined using an ANOVA in MorphoJ. Differences between individuals and sides were tested in a MANOVA design. The relationship between left and right COP paths and the degree of asymmetry in dorsal hoof wall angle was investigated through correlations. Results: The COP path was repeatable (r for shape 0.35, r for size 0.79), horse and limb specific (P<0.05). For 23/31 horses the craniocaudal patterns were highly correlated (r>0.9) between left and right limbs, but the mediolateral patterns were unique for each limb (r variable). Although some relationships were found between COP path and dorsal hoof wall angle, anatomical asymmetry in this variable did not automatically result in COP path asymmetry. Conclusions: Functional asymmetry is not always linked to dorsal hoof wall angle asymmetry only. Since each limb demonstrated a specific COP path, we believe this is a
promising result and can potentially be used in a longitudinal study as an early detection method for changes in the horse’s locomotor pattern.

Ethical Animal Research: The study was approved by the local ethics committee in compliance with the Dutch Act on Animal Experimentation. Owners provided informed consent. Sources of funding: FWO grant to SN; travel costs by Qualysis, Sweden to SJH. Competing Interests: None declared.

EFFECTS OF A DYNAMOMETRIC HORSESHOE ON STRIDE VARIABLES AND IMPACT SHOCK AT THE CANTER.

1,2Château, H., 1,2van Hamme, A., 1,2Munoz-Nates, F., 1,2Camus, M., 1,2Ravary, B., 1,2Pourcelot, P., 1,2Crevier-Denoix, N.

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Reasons for performing study: A dynamometric horseshoe (DHS) is a helpful tool to measure ground reaction force in the field. However weight and height increases of the shoe due to the sensors may modify stride variables and impact shock. Objectives: To quantify the effects of a DHS, compared to standard shoes (SS), on the stride variables and impact shock at the canter. Study design: In vivo experiment. Methods: Three sound French Saddle horses (556±55kg) were equipped with a miniature accelerometer (356B20, PCB, 7.8 kHz) on their right front hoof and a GPS (RLVBSS100, Racelogic). Each horse was first tested with its usual shoe (SS: 408±24g, 9.3±3.2mm height) and then with a DHS (520g, protection+connectors: 160g, 22mm height). Trials (10 stabilized strides) at the canter (both leads) were repeated at three different speeds (15, 25 and 35 km/h). Stance duration, duty factor, stride frequency, stride length and maximal vertical hoof deceleration (MaZ) were calculated. Linear mixed-effects regression models were used (SAS Software). Coefficients estimated values were calculated and statistically tested for different speeds (P<0.05). Results: For the trailing limb, there was no statistical difference between SS and DHS for duty factor, stride frequency and stride length regardless the speed but, with DHS, stance duration was slightly increased (+3.6%) at slow speed (15-18 km/h) and MaZ was higher. For the leading limb, there was no statistical difference between SS and DHS for duty factor, stance duration and MaZ regardless the speed but, with DHS, stride length was increased (+4%), as well as swing duration (+4.8%), and stride frequency was lower (-3.7%). Conclusions: As expected, slightly larger stride length and lower stride frequency were observed with a heavier shoe (DHS) compared to SS. Interestingly, these stride variables were however mostly modified for the leading limb but not for the trailing limb at canter.

Ethical Animal Research: Owner informed consent was obtained. Sources of funding: Feder (Fonds Européen de Développement Régional), the Conseil Régional de Basse-Normandie, the Institut Français du Cheval et de l’Equitation (IFCE), the Fonds Eperon. Competing interests: None declared.

VALIDATION OF DISTAL LIMB MOUNTED IMU SENSORS FOR STRIDE DETECTION AND LOCOMOTOR QUANTIFICATION IN WARMBLOOD HORSES AT WALK AND TROT

1Bragança, F.M., 2Bosch, S., 3Voskamp, J., 5Marin-Perianu, M., 5Van der Zwaag, B.J., 1Van Weeren, P.R., and 1,4Back, W.

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Reasons for performing study: IMU-sensor based techniques are becoming more popular in horses as a tool for objective locomotor assessment. Using currently proposed methods only limited information about stride variables can be obtained for walk and trot. Objectives: To describe, evaluate and validate a method of stride detection and quantification (i.e hoof-on/off detection and stance duration calculation) at walk and trot using distal limb mounted IMU-sensors. Study design: Validation study. Methods: To compare IMU-sensors and motion capture (MoCap) with force plate data as the gold standard, 7 warmblood horses equipped with metacarpal/metatarsal IMU-sensors (range: low-g accelerometer ±16g; high-g accelerometer ±200g) and reflective markers for MoCap were hand walked and trotted over a force plate. All instruments were frame
synchronized and data were collected at 200Hz. Using four custom-built algorithms hoof-on/off timing over the force plate and stance duration were calculated for each trial from the IMU data. Accuracy of the computed parameters was calculated as the mean difference in milliseconds between the IMU/MoCap generated data and the data from the force plate (bias) and precision as the standard deviation of these differences. **Results:** The best performing IMU algorithm achieved for stance duration at walk an accuracy, precision and percentage of error of 28.5 ms/31.6 ms/3.7% for the forelimbs and -5.5ms/20.1ms/2.2 % for the hind limbs respectively. At trot the best performing algorithm achieved an accuracy, precision and percentage of error of -27.6 ms/8.8 ms/8.4% for the forelimbs and -6.3 ms/33.5ms/9.1% for the hind limbs. Using IMU algorithms for hoof-off detection a better overall accuracy and precision was obtained, than when using MoCap. **Conclusions:** The observed IMU validation performance appears very promising, and seems ready to practically and accurately determine important stride variables at walk and also at trot, being the key gait for lameness assessment and training evaluation.

**Ethical Animal Research:** This study was approved by the local ethics committee. Owner consent was not stated. **Sources of funding:** This study was funded by STW Valorisation Grant 13448. **Competing Interests:** None declared.

**EFFECT OF HOOF PACKERS ON 3D HOOF DEFORMATION AND DISTAL PHALANX DISPLACEMENT IN VITRO USING A NOVEL COMPUTED TOMOGRAPHY BASED METHOD**


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**Reasons for performing study:** Using packing material to fill in the area under the sole is common practice with farriers and alters pressure distribution in the standing horse1. Shoes alter heel expansion2, however little is known how packing feet influences hoof deformation and hence shock absorption under load. **Objectives:** To determine the effect of two packing materials on 3D hoof deformation and distal phalanx displacement using a computed tomographic (CT) method. **Study design:** Experimental, cadaver study. **Material and methods:** Six cadaver Warmblood forelegs were loaded in a custom-made hydraulic jig and CT images were acquired in the unloaded leg and under load with four shoeing conditions: unshod, shod with standard steel concave shoe, shod with a soft packer and shod with a harder packer. Sixteen measurements quantified distal phalanx displacement, navicular bone displacement, frog deformation, and hoof capsule deformation after the reliability of the measurements was determined. **Results:** There were no statistically significant differences between shoeing conditions in the unloaded limbs. In the loaded limbs, there was a significant difference between shoeing conditions in the height of the frog central sulcus (P=0.009), the width of the foot at the palmar part of the coronet (P=0.04) and the width of the foot at the heels (P=0.05). **Conclusions:** Results indicate that sole packing materials restrict frog movement and heel expansion on hard surfaces and that the effect increases with increasing packer hardness. Further research using a bigger sample size, different surface materials and pressure data is warranted to better understand the effect on hoof dynamics.

**Ethical Animal Research:** This project was approved by the Royal Veterinary College’s Ethics and Welfare Committee. The animals were derived from an abattoir and the abattoir gave consent. **Sources of funding:** World Class Equestrian Program Competing interests: None declared.


**CALCULATION OF MUSCLES FORCES IN THE LABRADOR RETRIEVER HIND LEGS DURING STANCE.**

1Dingemanse, W., 2Jonkers, I., 3Müller-Gerbl, M., 2Bosmans, L., 4Vander Sloten, J., 1Gielen, I.

1Department of Medical Imaging and Small Animal Orthopaedics, Faculty of Veterinary Medicine, Ghent University, Belgium, 2Human Movement Biomechanics Research Group, Faculty of Kinesiology and Rehabilitation Sciences, KU Leuven, Belgium, 3Institute of Anatomy, Basel University, Switzerland,
Reasons for performing the study: In dogs, osteochondrosis is a multifactorial disease with a poorly understood pathophysiology. Joint biomechanics and joint loading are likely to be one of the contributing factors to the development of osteochondral lesions. The study presented is part of a research project investigating the role of biomechanics and joint loading on the development of osteochondral lesions in the tarsal joint in dogs. Objectives: Calculate muscle forces generated by the hind limb muscles during stance phase of gait in the Labrador Retriever.

Study design: In silico evaluation based on integrated 3D motion capture data. Methods: Integrated 3D gait analysis was conducted in eight dogs. These data served as input to a breed-specific musculoskeletal model, defined in OpenSim, based on CT. The muscle-tendon units were represented by path-actuators with force generating capacities based on the muscle physiological cross sectional area (PSCA). Inverse kinematics and inverse dynamics workflows, based on integrated 3D mocap data were used to calculate joint kinematics and kinetics. These served as input for a static optimization workflow. Results: The glutei, semimembranosus, semitendinosus, adductor, and gracilis muscles are contributing the most to the external flexion moment of the hip present at the first two-third of the stance phase. At the knee, the biceps, semimembranosus, rectus femoris, vasti, and gastrocnemius muscles contribute to the external flexion moment. The gastrocnemius and superficial digital flexor play a similar role at the level of the ankle joint. Conclusions: The muscle recruitment during the stance phase aims at supporting the bodyweight after the swing phase and propelling of the body in the late stance phase. The muscle recruitment shows similarities with previously reported EMG data in dogs. There is some co-activity of flexor and extensor muscles especially at the level of the hip and knee, which most likely has a stabilizing function.

Ethical Animal Research: Informed owner consent was obtained in all cases. Sources of funding: Research was funded by agency for Innovation by Science and Technology (IWT). Competing interests: None declared.

DEVELOPMENT OF A MEASUREMENT TOOL FOR GUARD DOGS’ FUNCTIONAL BITE FORCE

Reasons for performing the study: Breed and sport specific information of dogs’ functional bite force would be important in preventing, diagnosing and treating temporomandibular related dysfunction in guard dogs. Before the forces can be measured, a reliable measurement tool has to be developed. Objectives: The aim of the study was to generate and reliability test a measurement method for guard dogs’ functional bite force, and to report the forces for two breeds. Study design: Prospective clinical study. Methods: Twenty Finnish male police dogs, 6 German Shepherd Dogs (GSD) and 12 Belgian Shepherd Dog Malinois (BSDM), were included in the study. A helper sleeve was fitted with three force sensors (FC23 Series, Measurement Specialities, Hampton, USA) and the sleeve was rebuilt to maintain original size, shape and bite feel. Data was collected using a LabQuest 2 (Vernier Software & Technology, Oregon, USA) data collector. On command, dogs accelerated 25m and bit the sleeve. Each dog repeated the attack three times. Reliability was studied through Cronbach’s Alpha and Intraclass Correlation. Mann-Whitney U and Kruskal-Wallis tests were used to analyze the age, weight, height and bite force differences between the two breeds. Results: Cronbach’s alpha 0.75 suggested relatively high internal consistency. Test-retest reliability was substantial with Intraclass Correlation of 0.75. The two groups differed significantly only in their weight (p= 0.001). The mean bite force of the GSDs was 503N (±319) and BSDMs 329N (±250). Conclusions: The measurement sleeve developed in this study is a reliable tool for measuring guard dogs’ functional bite force. Preliminary values for functional bite force for two breeds were accomplished.

Ethical Animal Research: The study protocol was approved by the University of Helsinki Ethics Review Board at Viikki Campus. Competing interests: None declared. Sources of funding: None.
### Session ID: POSTER2

### Session Title: Anatomy / Lameness/ Techniques

### Session Date/Time: Thursday, August 18th, 15:00-17:30

### Session Location: RVC Hawkshead, Structure and Motion Lab

### Session Chair: John Bertram + Maarten Oosterlinck

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### IS SIDE-TO-SIDE OSCILLATION OF THE HOCK AN INDICATOR OF POOR MUSCLE STRENGTH AND/OR PAIN-RELATED GAIT ABNORMALITY IN 10 SHOWJUMPING HORSES? A PILOT INVESTIGATION.

Dyson, S., Tranquille, C., Murray, R.

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**Reasons for performing the study:** Clinical experience suggests that side-to-side oscillation (wobbling) of the hock may be an indicator of poor muscle strength. **Objectives:** Describe frequency and magnitude of hock wobble (HW) in a group of showjumpers. **Study design:** Cohort study. **Methods:** Ten warmblood horses (mean age=8 years) in active showjumping training/competition were evaluated in-hand and ridden. Each horse jumped an upright fence (1.2m high) four times, twice off each rein, and a parallel fence (1.2m high, 0.6m wide), four times, twice off each rein i.e. eight jumping efforts. Horse features were subjectively assessed on videos acquired from nine high-speed cameras. HW was defined as the mid-line of the hock moving medially/laterally/both directions when the feet were in contact with the ground. Descriptive statistics were performed. Chi-squared tests were used to determine associations between features (P≤0.05). **Results:** In-hand, HW was observed in two horses. Ridden, there was HW of one or both hocks during stance on the turn, the approach or during take-off in all horses. HW did not alter with repeated jumping efforts in five horses, but increased in magnitude in five horses. HW magnitude was greater in the inside hindlimb on a turn compared with the outside hindlimb. The foot rotating laterally during stance was associated with HW on the turn (left-hind P=0.05), on the approach (left-hind P<0.01), and at take-off (left-hind P<0.01, right-hind P=0.02). There was no association between either advanced diagonal placement of a hindlimb during the turn, or approach, or hind foot separation at take-off and HW. One horse exhibited consistent severe left HW on landing. **Conclusions:** HW magnitude was greater with increased work in

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<td>THE EFFECT OF TWO NUTRACEUTICALS ON INFLAMMATION AND BIOMARKERS OF CARTILAGE METABOLISM IN EQUINE SYNOVIAL FLUID AFTER EXPERIMENTALLY INDUCED ACUTE SYNOVITIS</td>
<td>Van de Water, E., Oosterlinck, M., van Weeren, P.R., Korthagen, N.M., van Doorn, D.A., Pille, F.</td>
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<td>16:30-17:30</td>
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<td>IN VIVO EFFECTS OF INTRA-ARTICULAR ANTI-NERVE GROWTH FACTOR ON ARTICULAR CARTILAGE AND BIOMECHANICAL GAIT PARAMETERS IN AN EQUINE IL-1B SYNOVITIS MODEL</td>
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<td><a href="mailto:Eline.VandeWater@ugent.be">Eline.VandeWater@ugent.be</a></td>
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certain horses, suggesting that muscle control was reducing through fatigue. Altered limb loading due to HW may place altered strain on the structures of the hindlimbs and potentially predispose to injury.

**Ethical Animal Research:** Approved by the Ethical Review Committee of the Animal Health Trust (project number: AHT 32-2014) and all owners gave informed consent. **Sources of Funding:** The Peter Harrison Foundation. **Competing interests:** None declared. **Acknowledgements:** We thank the riders and Vicki Walker, Russell Guire, Mark Fisher, Diana Fisher, Charlotte Bullard, Jessica Cooke, Teresa Cordovil, Siobhan Gilligan and Isabelle Pettit.

**FINE-TUNING THE LPS-MODEL FOR INDUCTION OF TEMPORARY LAMENESS IN STANDARDBRED HORSES: PRELIMINARY RESULTS**

1Van de Water, E., 1Oosterlinck, M., 2,3,4van Doorn, D.A., 1Pille, F.

1Department of Surgery and Anaesthesiology, Faculty of Veterinary Medicine, Ghent University, Belgium; 2Department of Farm Animal Health, Faculty of Veterinary Medicine, Utrecht University, The Netherlands; 3Equivado, Equine Nutrition Consultancy, Utrecht, The Netherlands; 4Department of Equine Sciences, Faculty of Veterinary Medicine, Utrecht University, The Netherlands. Email: Eline.VandeWater@ugent.be

**Reasons for performing study:** A recent experiment in Standardbred horses using exactly the same LPS-model as described in Warmblood horses [1] did not result in detectable lameness, despite the presence of a clear synovitis. **Objectives:** To quantitatively evaluate lameness over time after intrasynovial injection of 10 Endotoxin Units (EU) LPS of E. coli O55:B5 in 1 ml saline in the intercarpal joint of Standardbred horses. **Study Design:** Experimental study. **Methods:** Eight healthy and clinically sound Standardbred horses were injected with 10 EU of LPS of E. coli O55:B5 in 1 ml saline in the right intercarpal joint. At 12 selected time points (pre-injection baseline measurement, and subsequent 2-hour intervals for 12 hours, 4-hour intervals for the next 12 hours and 8-hour intervals for the next 24 hours), horses were trotted in a straight line and lameness was scored visually from zero (sound) to 5 (non-weight-bearing), and was quantified (Vector Sum, VS) using an inertial-sensor system (Equinosis Lameness Locator, Missouri, USA). A mixed model with repeated measures and post-hoc pairwise comparisons was used for statistical analysis (P<0.05). **Results:** Compared to baseline measurements, the mean visual score (3±1; P<0.001) and VS (38.7±20.0; P=0.003) were significantly increased at 4 hours after injection and gradually decreased afterwards. From 20 and 24 hours post-injection onwards, the visual score and VS, respectively, did not present a significant difference with baseline measurements anymore. **Conclusions:** Injection of 10 EU LPS in the intercarpal joint consistently induced temporary mild to moderate forelimb lameness in Standardbred horses. Lameness peaked at 4 hours after injection, which is earlier than described in Warmblood horses [1].

**Ethical Animal Research:** Data presented are part of a larger protocol approved by the ethical committee of the Faculty of Veterinary Medicine of Ghent University (nº2015/52). **Sources of funding:** Sonac, a Darling Ingredients brand (Son, The Netherlands). **Competing interests:** The funding company did no participate in analysis and decision to publish. All authors declare that they had full autonomy and independency in research and publishing.


**COMPENSATORY MECHANISM OF GAIT ADAPTATION TO BILATERAL STIFLE JOINT INJURIES IN SHETLAND PONIES AT TROT.**

1Bragança, F.M., 1Mancini, I., 1Brommer, H., 2Malda, J., 2Visser, J., and 2van Weeren, P.R

1Department of Equine Sciences, Faculty of Veterinary Medicine, Utrecht University, Yalelaan 112, NL-3584 CM Utrecht, The Netherlands; 2Department of Orthopaedics, University Medical Center Utrecht, Heidelberglaan 100, 3508 GA Utrecht, The Netherlands, Email: f.m.serrabraganca@uu.nl

**Reasons for performing the study:** Injuries of the locomotor system of horses are the main reason for veterinary consultation worldwide. Little information is known about the mechanism by which horses adapt to bilateral joint lesions. **Objectives:** To evaluate and describe the kinetic and kinematic mechanisms of gait adaptation to induced
bilateral joint lesions. **Study design:** *In vivo* experiment. **Methods:** Eight healthy Shetland ponies were used, which were deemed sound at subjective lameness examination prior to study. Ultrasound and radiographic examination of both stifles excluded any signs of joint disease. Kinetic and kinematic data was collected two weeks (T0) and one week (T1) before lesion induction and two (T3) and six months (T4) after lesion induction. A linear mixed model compared the measured kinetic and kinematic parameters for each horse between the different time points and between limbs. **Results:** No significant differences (p>0.05) were observed in the stifle range of motion between time points. No significant differences were observed in all calculated variables between T0 and T1 and during these time points, and no significant differences were found between left and right hind limbs, except for vertical Impulse (VI) (P=0.03). After lesion induction normalised peak vertical force (nPVF) increased significantly compared to T1 (P=0.005) and stance duration (SD) decreased (P=0.004) in both hind limbs with no significant difference between left and right. **Conclusion:** The compensatory mechanisms of gait adaptation to bilateral lesions in the stifle joint are subtle and differ from the response to unilateral hind limb lameness, where a decrease in nPVF and a prolongation of SD is reported. Relatively severe joint disorders may thus be masked.

**Ethical Animal Research:** The study was approved by the local ethics committee (DEC protocol 10801). **Sources of funding:** partially funded by a grant from the Dutch Arthritis Foundation. **Competing Interests:** None declared.

**HEAD AND PELVIC VERTICAL DISPLACEMENT IN INDUCED SWINGING LIMB LAMENESS IN DOGS**

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**Reasons for performing study:** Head and pelvic motion are commonly used parameters of a visual lameness examination in dogs. Yet, there is a lack of studies describing their motion pattern during swinging limb lameness. **Objectives:** The aim was to describe the vertical head and pelvic motion in dogs with and without an induced swinging limb lameness. **Study Design:** Experimental study. **Methods:** Swinging limb lameness was induced in ten sound medium-size dogs by placing a custom made weight (200g) proximal to the carpus and tarsus, respectively. The position of reflective markers, placed on the head and pelvis, was captured by eight infrared-based video cameras (240 Hz) while dogs were trotting on a treadmill before and after lameness induction. For each stride cycle, the differences in displacement between the two highest (HDmax, PDmax) and the two lowest (HDmin, PDmin) values of the head and pelvis were calculated, respectively. Pair-wise comparisons for each lameness induction compared to the sound measurement were performed using Wilcoxon signed rank test. **Results:** HDmax was increased in dogs with induced swinging fore limb lameness and PDmax was increased in induced swinging hind limb lameness (p<0.05). Induction of swinging hind limb lameness also increased both HDmax and HDmin, mimicking the pattern of a compensatory fore limb lameness (p<0.005). **Conclusions:** The study showed that differences in the maximal vertical head and pelvic displacements occur in induced swinging limb lameness in single fore- and hind limbs, respectively, and that vertical head motion symmetry is affected by both fore and hind swing limb lameness.

**Ethical Animal Research:** The study design was approved by the local Ethical Committee on Animal Experiments. **Sources of funding:** AGRIA animal insurances. **Competing interests:** None declared

**COMPARING INERTIAL SENSORS TO FORCE PLATES FOR DETECTION OF MILD, EXPERIMENTALLY-INDUCED LAMENESS IN HEALTHY DOGS**

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Reasons for performing study: Assessing canine lameness is a clinically important aspect of small animal veterinary practice. Currently, force plate gait analysis is the most sensitive and objective measurement to evaluate limb loading and gait in dogs, but is not feasible in the clinic or home setting. Due to their convenience and affordability, inertial sensors are growing in popularity. Objectives: To assess the utility of inertial sensors (©Xsens) to detect a mild, experimentally-induced lameness in healthy canines. Study Design: Method comparison between force plate and inertial sensors for detection of lameness. Methods: Nine healthy, skeletally mature dogs were enrolled in the study. Experimental lameness was induced with a plastic marble taped to the bottom of the right hind foot. Impulse ratio (i.e. the proportion of total vertical impulse that is contributed by each individual limb over a complete stride) was quantified using the force plate and was compared to displacement of the inertial sensors in all three planes. Wilcoxon signed-rank test and Spearman’s rank-order correlation were used for statistical analyses and significance was set at \( p \leq 0.05 \). Results: Data obtained from an inertial sensor placed on the sternum was analyzed. Following lameness induction, impulse ratio of the right hind limb was significantly decreased in all subjects and the left hind limb was significantly increased in 7/9 subjects. Changes in left and right front limb impulse ratio were nonsignificant in all but one dog. Of the displacement data, post-left footfall displacement appeared most relevant with an increase in 8/9 dogs. There was a significant negative correlation between force plate right hind impulse ratio and inertial sensor post-left footfall displacement in lameness trials (\( p = -0.733 \)). Conclusions: The current study suggests that inertial sensors may be an effective and practical tool for the detection of subtle lameness in canine patients.

Ethical Animal Research: This study was approved by the University of Calgary Animal Care Committee and was carried out according to the guidelines of the Canadian Council of Animal Care under the supervision of a licensed veterinarian. Animals involved in this study were client owned animals and informed client consent was obtained in all cases. Competing interests: None declared. Sources of funding: Funding was provided by the University of Calgary and an unrestricted research grant from Zoetis Canada.

FASCIAL PATTERNS IN THE EQUINE DISTAL FORELIMB

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Reasons for performing study: Fascial organization and fiber arrangement in the equine distal limb indicate possible tension distribution paths and may help elucidate forelimb loading patterns and functional relationships. Objectives: To investigate the fascial anatomy of the equine metacarpus, fetlock and proximal digit. Study design: Observational study. Methods: Nine pairs of cadaveric distal forelimbs were dissected using photography to document consistent fascial connections. The ergot tissue was also investigated via immunohistochemistry. Results: The deep fascia formed tendon-like expansions over the fetlock joint between the extensor tendons and the interosseous ligament extensor branches. These expansions were no discrete structures but were instead continuous with the tendons and ligament branches. Medially, the expansion formed a ligamentous connection to the proximal extremity of the proximal phalanx. Either side, the common digital extensor tendon had an additional connection to the hoof cartilage and digital cushion above the hoof capsule via a prominent fascial band (pastern band) which is not illustrated in the common literature. This band was continuous with the ergot ligament. The ergot cushion had a single strong point of attachment to the fetlock annular ligament and was continuous with fascia over the flexor tendons in the metacarpus. Nerve bundles were present in the ergot connective tissue between the dermis and fetlock annular ligament. Conclusions: Distal forelimb structures are functionally and mechanically integrated through fascial expansions on the dorsal aspect of the fetlock joint, and through the pastern band. The ergot and its ligaments appear to be functionally significant in the coordination of distal forelimb structures, as well as in directing load through and between these structures. Further histological investigations of the fascial expansions described may help further elucidate joint function and proprioceptive ability.

Ethical Animal Research: Research ethics committee oversight not required. All animals were derived from an abattoir and the abattoir gave consent. Sources of Funding: None. Competing interests: None declared.

Osseous lesions of the equine thoracolumbar synovial intervertebral articulations

1Clayton, H.M., 2VanderBroek, A., and 3Stubbs, N.C.
Three-dimensional architecture of the equine musculus longissimus lumborum et thoracis

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Reasons for performing study: As the longissimus muscle is the largest muscle in the equine back, it has a great influence on the stability of the spine, locomotion ability and performance in the horse [1]. In general, muscle function is determined by specific intramuscular architecture. However, only limited three-dimensional data is available for the inner organization of the equine longissimus muscle. Objectives: To digitally reconstruct the three-dimensional architecture of the equine long back muscle and describe its generally valid muscle parameters independent of body type or size of the horse. Study design: Descriptive cadaver study. Methods: The thoracic and lumbar longissimus muscles of six formalin-fixed cadaveric horse backs of different ages and body types were dissected layerwise. Three-dimensional coordinates along individual muscle fiber bundles were recorded using a digitization tool (Microscribe), to capture their origin, insertion and general orientation. Together with skeletal data from CT-scans, 3D models were created. Morphometric parameters such as the fascicle length, fascicle angles to the sagittal and frontal planes and muscle volume were determined. Result: Independent of the muscle volume (range 1.35-4.7 liter) fiber bundle length showed highest values in the thoracic region. In the multipennate, lumbar region, fiber bundle length was reduced while muscle cross-sectional area was largest. Fascicle angles (to the horizontal plane) were found to be steeper compared to those in more cranial parts. Conclusions: The data provide the basis for specific biomechanical models for simulating longissimus muscle function under various conditions.

Ethical Animal Research: The owners have been aware that their horses would undergo post-mortem examination and tissues would be retained for teaching or research purposes. Sources of funding: This study was funded by the Austrian Science Fund. Competing interests: None declared.

RANGE OF MOTION: FINDING THE JOINT CONSTRAINTS OF THE FORELIMB JOINTS OF THE HORSE

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Reasons for performing study: The evolution of monodactyly occurred independently in four different lineages; Equus is the only remaining lineage. This study is part of a larger research project that will test hypotheses on the disappearance of the three extinct lineages by creating a forward dynamic model of these species. Objectives: In this first step, we focussed on finding joint constraints of our model species (Equus ferus caballus). Study design: Literature study combined with cadaver experiments (N=6). Methods: We identified the range of motion (ROM) of the forelimb at different levels: 1) ROM in horses moving at different gaits, 2) ROM of intact fresh cadaver forelimbs, 3) ROM of skeletal forelimbs including ligaments, but without muscles and 4) ROM based on joint surfaces of the forelimb bones. A literature study provided information for level 1. A cadaver study was performed by tracking bone pins with reflective marker triads using a 6 camera system (Vicon) to calculate 3-D ROM for levels 2 and 3. Surface scans of the bones, made with a laser surface scanner (Faro), together with Software for Interactive Musculoskeletal Modelling gave the insight necessary for level 4. The ROM was determined for flexion-extension, abduction-adduction and internal-external-rotation. The ROM values were compared between levels as well as between individual joints using ANOVA. Results: The largest variation in the reported values of the joint ROM of moving horses was observed in the fetlock. The ROM comparison between the levels showed that the ligamentous constraints resulted in the largest decreasing effect on the ROM per joint. The ROM and its increase varied between the individual levels and joints. Conclusion: The present study provided information about the ROM constraints which will be used in combination with additional extant and extinct data in our future research concerning the locomotor performances of the four monodactyl lineages.

Ethical animal research: Not applicable in research on cadavers. The horses were euthanatized for reasons unrelated to this study. The owners have been aware that their horses would undergo post-mortem examination and tissues would be retained for teaching or research purposes. Competing interests: None declared. Source of funding: This study was funded by the Bijzonder Onderzoeksfonds (BOF) and the University of Antwerp, Belgium.

A PRELIMINARY INVESTIGATION OF HOOF CIRCUMFERENTIAL CHANGES OF RIDING SCHOOL HORSES WITH AN INCREASE IN WORKLOAD

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Reasons for performing study: Hoof conformation responds to mechanical demands; the impact of these are not well documented, especially for horses in a non-competitive but high workload environment. Objectives: To investigate changes in circumferential hoof variables of riding school horses. Study design: Observational, cohort study. Methods: Repeated hoof base (HB) and coronet band (CB) measures were collected via tape measure at three 5 week intervals (DC1-3), from September, from 32 shod (all, n=17; shod front only, n=12) and unshod (n=3) riding school horses. Shod forefeet were sub-grouped into toe-clips (n=16) and side-clips (n=9). Workload increased from low to medium-high intensity across the study. Wilcoxon’s matched-pairs determined circumferential differences between left-right hooves for each DC (P<0.05); Kruskal-wallis analyses with post-hoc and Bonferroni adjustment (P≤0.02) examined differences between DC. Results: Right forelimb was significantly larger than left at DC3 for CB (P≤0.05) and for HB and CB in the hind-limb (DC1 P≤0.05; DC2 P≤0.05; DC3 P≤0.001). CB differed significantly between DC1 (389.8mm) and DC2 (392.1mm) (P=0.02). All variables, except asymmetry, differed between forelimb subgroups; CB asymmetry at DC1 was significantly lower (P≤0.02) for horses with toe-clips compared to side-clips. Mean hind CB in shod feet increased significantly (P≤0.02) between DC1-DC2. Routine management meant some horses had hind shoes removed between DC2-DC3; these demonstrated right CB increase at DC3 reflected by a significant increase (P≤0.02) in mean CB between DC1-DC3. Conclusions: CB decrease has been associated with increased workload in racehorses [1];
for riding school horses, significant changes in hoof circumference were related to CB increase. Significant differences between values for shod and unshod hooves indicate variation in foot conformation associated with the use of shoes.

**Ethical Animal Research:** Ethical approval for the study was granted by the UWE (Hartpury) Ethics Committee. Owner consent was not stated. **Sources of funding:** Hartpury College. **Competing interests:** None declared.


**SUBCHONDRAL DENSITY AND ARTICULAR CARTILAGE THICKNESS IN THE FETLOCK JOINTS OF THOROUGHBRED RACEHORSES**

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**Reasons for performing study:** Osteoarthritis (OA) of the metacarpophalangeal (MCP) and metatarsophalangeal (MTP) joints are one of the most common causes of lameness in racehorses. The aetiology of OA is multifactorial but subchondral bone sclerosis and thinning of articular cartilage is observed in the progression of the disease. **Objectives:** The aim of this study was to characterise subchondral bone density and articular cartilage thickness in the MCP and MTP joints. We hypothesised that there would be articular cartilage thinning overlying areas of dense subchondral bone in the fore and hind legs, and that this relationship would be exaggerated in the MCP joint. **Study design:** Experimental, cadaver study.

**Methods:** Twenty-eight MCP and MTP joints from fourteen racehorses (2-9 years) were used. Articular cartilage thickness was measured using magnetic resonance imaging (MRI) and specialised software (KneeSeg2_32). Computed tomography (CT) was used to evaluate the subchondral bone and density measurements were obtained using dedicated software (Mimics v14). **Results:** The articular cartilage in the MCP was significantly thicker than in the MTP (P=0.0007). The subchondral bone of the distal third metacarpal bone was significantly denser than that of the proximal phalanx in the fore (P=0.0004) and hind (P=0.003) legs. No significant correlation between subchondral bone density and articular cartilage thickness in either the fore or hind limbs was observed. **Conclusions:** This study shows differences in cartilage thickness and subchondral bones density between MCP and MTP joints, which may reflect the differences in loading between front and hind limbs. Practical significance: the results of this study give an insight in the effect of loading on cartilage thickness and subchondral bone density, which provides a reference for future comparison in live horses.

**Ethical Animal Research:** This project was approved by the Royal Veterinary College’s Ethics and Welfare Committee. The animals were derived from an abattoir and the abattoir gave consent. **Sources of funding:** Royal Veterinary College. **Competing interests:** None declared.

**MORPHOMETRY OF THE GREYHOUND NUCHAL LIGAMENT IN VARIOUS BODY POSITIONS.**

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**Reasons for performing study:** The literature lacks studies on the functional morphology of the greyhound nuchal ligament (NL) despite its probable role in locomotion. **Objectives:** To describe the effect of some neck and body positions on the greyhound NL length and width. **Study Design:** Observational study. **Methods:** NL length and width were measured using Image Pro from standardised photographs of 9 adult Greyhound cadavers wired into 7 different standardised (P1 to P7) body positions taken from high speed film of racing greyhounds. P4 and P7 included cervicothoracic spinal flexion; all other positions included varying degrees of cervicothoracic extension. Cadavers were dissected through the neck musculature on one side (left side) to expose the nuchal ligament; this included removing the rhomboideus, trapezius, splenius, serratus dorsalis cranialis, and the cranial part of the longissimus thoracis, multifidus cervicis, serratus ventralis cervicis, longissimus thoracis, and cervicis muscles. Three pins were placed to mark regions of interest on the NL; at one cm cranial to the site of origin (the most dorsal point of the 1st spinous process of the 1st thoracic vertebra), at the midpoint of the NL, and one cm caudal to the NL site of insertion (close to the axis). **Results:** NL length in relation to the standard position (P1)
was significantly (P < 0.05) less (-7%) in P6 (neck elevated) and increased in all other positions (+1% for P2, +19% P3, +37% P4, +1% P5, +40% P7). NL width at the middle decreased significantly (P < 0.05) with P4 (-26%), and P7 (-32%). NL width at the site of origin decreased significantly (P < 0.05) with P4 (-24%) and P7 (-35%).

**Conclusions:** Neck angles including cervicothoracic spinal flexion may limit NL elastic recoil from head and neck movements during locomotion. These body postures may increase the chance of NL damage.

**Ethical Animal Research:** These dogs were euthanized for reasons not associated with the study. For client owned animals, the informed consent of the owner was obtained. **Sources of funding:** Departmental funding. **Competing interests:** None declared.

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**WHAT SCALED CANINE MUSCLE PARAMETERS CAN TELL ABOUT THEIR FUNCTIONAL PROPERTIES.**

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**Reasons for performing the study:** As part of a musculoskeletal modeling effort, fiber length and physical cross-sectional area (PCSA) of muscles of the canine hind limb were determined. **Objectives:** The ratio of PCSA to fiber length was examined to identify the muscle specialization towards muscle force production or contraction speed. **Study Design:** In vitro study of six canine hind limbs. **Methods:** All twenty-four right hind limb muscles inserting into femur or tibia/fibula (excluding the psoas) were dissected from six dogs weighing between 28 and 52 kg. Immediately afterwards the muscles were weighed and treated with 3.8% formaldehyde solution for 48-72h, 0.4M phosphate-buffered saline solution (pH 7.2) for 24-48h, and subsequently 20% sulphuric acid solution for 3-7 days. After muscle fiber loosening, 3-8 individual muscle fibers, depending on the size of the muscle, were removed from different muscle sites to obtain a representative sample. Muscle fibers were then measured based on photographs taken on grid paper. Fiber length was normalized to limb length (L_Mnorm), being the summed length of femur, tibia and foot. Muscle volume was calculated as muscle weight / density. PCSA was calculated as muscle volume divided by fiber length as no pennation angle exceeded 20° (1) and thus would not significantly affect PCSA calculation. PCSA was normalized by dog weight (PCSA_norn). **Results:** Our results show muscles associated with muscle force production, i.e. presenting a high PCSA_norn/L_Mnorm_ratio are gastrocnemius, deep and superficial digital flexors and quadriceps. Muscles associated with high contraction velocity, i.e. a low PCSA_norn/L_Mnorm_ratio, include the cranial & caudal sartorius, cranial tibial, semimembranosus and semitendinosus muscles. **Conclusions:** The PCSA_norn/L_Mnorm_ratio is a valuable tool to classify muscles by function and is further explored in ongoing experimental work.

**Ethical Animal Research:** not applicable. **Sources of funding:** Scholarship, PhD studentship. **Competing interests:** None declared.


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**SACROCAUDAL FUSION IN THE GREYHOUND: A QUANTITATIVE STUDY OF STRUCTURAL RELATIONSHIPS IN THE HINDLIMB**

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**Reasons for performing study:** A recent study reported a 33% incidence of complete sacrocaudal fusion in greyhounds compared to a 3% incidence in other dogs (1) but lacked data on associations with other parameters. **Objectives:** To provide quantitative data on the greyhound sacrum and sacrocaudal fusion. **Study Design:** Observational study. **Methods:** 290 racing greyhound (2-5 years old) cadaver sacra were grouped based on the occurrence and types of fusion (1). Sacra and related bones were weighed; and their length and width measured. **Results:** Dog weight had no effect on the occurrence of sacrocaudal fusion. Sacrocaudal fusion was found in
119/290 (41%) of the greyhounds. Mean weight, length, and average width of sacra with sacrocaudal fusion was higher (27.50 g, SD = 6.53, n = 114; 58.97 mm, SD = 4.41, n = 117; 59.38 mm, SD = 4.15, n = 114) than standard sacra (23.16 g, SD = 5.70, n = 159; 46.06 mm, SD = 2.98, n = 162; 56.25 mm, SD = 7.58, n = 159). Average length of the 7th lumbar vertebra of greyhounds with sacrocaudal fusion was higher (28.43 mm, SD = 1.76, n = 92) than in those with standard sacra (27.02 mm, SD = 2.14, n = 100). All measurements were higher in males than females. Among 100 Greyhounds with standard sacra, 56 were male (56%) and 44 female (44%). In 71 Greyhounds with fused sacra, 37 were male (52%), and 34 were female (48%). Percentages of sacrocaudal fusion type: A, C and D were: 14.8%, 20.3% and 5.9% respectively. **Conclusions:** The occurrence of sacrocaudal fusion in greyhounds was not associated with dog weight.

**Ethical Animal Research:** These dogs were euthanized for reasons not associated with the study. For client owned animals, the informed consent of the owner was obtained. **Sources of funding:** Departmental funding. **Competing interests:** None declared.


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### THE FUNCTIONAL ANATOMY OF THE CANINE PECTINEUS MUSCLE

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**Reasons for performing study:** Pectineus muscle functional anatomy was investigated to complement existing literature, and better understand its biomechanical function in cursorial quadrupeds. **Objectives:** To measure muscular morphology, describe fascial connections, and the incidence and distribution of muscle spindles and Golgi tendon organs in athletic canines’ pectineus. **Study design:** Observational study. **Methods:** Morphological measurements including mass, length and circumference of isolated, relaxed, pectineus muscles were investigated by dissection of twelve defrosted greyhound cadavers previously frozen in a neutral position. Post mortem samples of proximal, middle and distal muscle sections from three greyhounds, euthanized for unrelated reasons, were examined histologically. **Results:** Mean muscle mass was 16.19 ± SEM 0.92 g. Pectineus was the smallest adductor muscle and smallest proximal hind limb muscle in the greyhound compared to other Greyhound hindlimb muscles in a recent study that omitted pectineus. The left pectineus muscles had a significantly longer mean length of 9.78 ± 0.25 cm in comparison to 9.24 ± 0.25 cm for the right pectineus (p=0.01). Mean maximum circumference was 7.12 ± 0.15 cm. Fascial connections surrounding the muscle were extensive and included a consistent perpendicular band of fascia at the proximal end of the muscle, which intersected at the midline and connected contralateral limbs. The histological samples contained no Golgi tendon organs, but there was a high concentration of muscle spindles (0.16 per mm² on the right and 0.097 per mm² on the left), distributed towards the proximal end of the muscle (p=0.03). **Conclusions:** Despite the small sample size, there is convincing evidence that pectineus is important for hind limb coordination and proprioception and is less adapted for locomotory behaviours such as addiction and flexion.

**Ethical Animal Research:** These dogs were euthanized for reasons not associated with the study. For client owned animals, the informed consent of the owner was obtained. **Sources of funding:** Departmental funding. **Competing interests:** None declared.

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### INERTIAL PROPERTIES OF THE GERMAN SHEPHERD

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**Reasons for performing study:** The German Shepherd, a dog breed commonly deployed by police and military, is exposed to all manner of injury while on the job. It costs an estimated $60,000 CAD to train a police canine team, an expense which can substantially increase when a dog becomes injured. Biomechanical analyses can assist in training, injury prevention and treatment, however such analyses require a priori inertial data, currently
unavailable for this breed. **Objectives:** To provide 3-dimensional segment inertial properties of the German Shepherd to construct an inverse dynamic model for investigating internal joint forces, moments and powers in living dogs. **Study design:** Single/multiple linear regression. **Methods:** 6 male German Shepherd police dog cadavers (aged 2-8.5 yrs, $x=4.75$; mass 34.29-39.41 kg, $x=36.8$ kg) were frozen and dissected into 17 segments. Morphometry, mass, volume (immersion method), and 3D inertial tensor (pendulum method) were collected for each segment. Using segment dimensions, geometric modelling and whole body mass, regression analyses were performed to generate equations for predicting segment masses and moments of inertia. **Results:** Tissue loss was minimal ($x=0.49\%$ of whole body mass). 33 dimensional measures were used in 11 equations for predicting segment mass, 33 equations for predicting moment of inertia and 17 joint centre estimations. Regression equations correlated well, with estimations of segment mass ranging from $r=.994$ for the thorax to $r=.808$ ($p<.05$) for the crus; estimations of inertial tensor about the flex/ext axis ranged from $r=.996$ for the crus to $r=.747$ for the antebrachium. **Conclusions:** Regression correlations have been successfully established for segmental masses, centres of mass, radii of gyration and densities, data essential for the biomechanical understanding of these dogs. The data will be used in evaluating inertial properties in live dogs for purposes of enhancing injury treatment and training methods.

**Ethical Animal Research:** Research ethics committee oversight not currently required by this conference: cadaveric study using donor animals. **Sources of funding:** This study was funded by the Vancouver Police Foundation and the British Columbia Institute of Technology. **Competing interests:** None declared.

A HORSE HOOF-MOUNTED INERTIAL MEASUREMENT UNIT, HOOFIMU(V3)

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**Reasons for performing study:** Existing measurement systems for investigating hoof kinematics and surface interaction simulate hoof/surface interaction, use relatively bulky sensor platforms, or elaborate photographic systems, which limit their application. **Objectives:** To develop and validate a light-weight inertial measurement unit which can be readily attached to a horses hoof for hoof/surface interaction studies at all gaits and speeds, on any surface. **Study design:** Equipment and method development. **Methods:** The Hoof Inertial Measurement Unit, HoofIMU(v3), is a self-contained inertial sensor and data acquisition package which mounts on a horse’s hoof, and represents further development of a novel instrumented horseshoe where inertial and strain sensors were mounted in a standard horseshoe. It has a mass of 14gm, incorporates MEMS-technology sensors for measuring triaxial orthogonal ±200g accelerations and ±4000°/s rotational speeds, recorded at scan rates up to 2000Hz for up to 1 hour, and is readily attached to the hoof wall using farriery adhesive. It can be connected to a strain-gauged horseshoe providing an indication of limb load, function as a data recorder for other sensors, or be attached at other positions of inertial interest. **Results:** HoofIMU function has been verified during a separate, on-going study which determines hoof penetration, and forward and lateral slip on track surfaces for the purposes of track rating. Preliminary study results from multiple tests of 10 horses on 6 different grass and synthetic thoroughbred horse racing tracks at speeds up to 60km/h, have recorded typical hoof penetrations of 50mm-60mm on synthetic, and 30mm on grass tracks. Comparing HoofIMU with instrumented horseshoe data indicate maximum 5% signal attenuation with higher frequency components arising from the HoofIMU attachment method or hoof wall compliance. **Conclusions:** The HoofMIU’s light-weight design, ease of mounting and autonomous operation permits a wide range of potential applications, with preliminary studies verifying its function.

**Ethical Animal Research:** HoofIMU hoof mounting and study protocol was approved by The Animal Experimentation Ethics Committee of the University of Melbourne project number 1212461.1. For client-owned animals, the informed consent of the owner was obtained. **Sources of funding:** HoofIMU development and Track Rating study funded by Racing Victoria Limited (RVL), Australia. **Competing interests:** None declared.

VALIDATION OF AN INERTIAL MEASUREMENT SYSTEM TO ANALYZE JUMPING MOVEMENTS OF EXPERIENCED ELITE SHOW JUMPING HORSES USING A THREE-DIMENSIONAL MOTION CAPTURE SYSTEM

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Thursday, August 18th

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**Reasons for performing the study:** In order to gain objective measurements of the position and velocity of relevant body parts of horse and rider in show jumping, a large measurement volume needs to be covered. Therefore, existing video-based measuring systems allow 3D-movement recordings only in controlled situations but not under realistic conditions in training and competition. **Objectives:** A specifically tailored measurement system (based on accelerometers and gyroscopes) has recently been developed (Four Sense, Muenster). Embedded in a girth, this light-weight system (5g) can be used in training and competition. Our aim was to evaluate the precision and accuracy of the measurements by comparing the results to a VICON system. As a reference, 3 motion capture markers were fixed on the girth and at the lowest point of the horses’ abdomen. **Study design:** Observational. **Methods:** In an indoor riding hall of the German Military Sport School, 7 experienced show jumping horses (6 to 14 years of age) performed 12 jumps each. All riders were top national level. Velocity and acceleration was computed from 3D position-data recorded by a VICON system (14 cameras, covering 10x4x4m volume, 100Hz) and compared to the girth measurements. Each horse performed 12 jumps over a 1.3m fence. Six of these were approached in canter, the other six out of a series of gymnastic jumps. All trials were simultaneously recorded by VICON (33 markers on the horses, 39 on the riders) and girth. **Results:** The orientation of the measurement device in the sagittal plane derived from the gyroscope data show a high correlation to the reference data ($r^2=0.95$, $P<0.001$). **Conclusion:** Relevant parameters of the jumping movements can be described sufficiently accurately by the measurement system. To determine absolute angle data it is, however, necessary to scale the gyroscope data and to use a baseline correction.

**Ethical Animal Research:** Owner and rider consent was obtained. **Sources of funding:** Deutsche Reiterliche Vereinigung / Private donor. **Competing interests:** None declared.

**EQUINE LOCOMOTOR SPORTS: WHERE IS YOUR SMART, WEARABLE, REAL-TIME FEEDBACK: A PILOT STUDY?**

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**Reasons for performing the study:** To date movements of horses are only evaluated visually and thus become subjectively judged, even in elite sport horses. The human eye is capable of tracking individual images at a frequency of only 20 Hz. **Objectives:** Therefore, the goal of this pilot project was to develop an on location applicable (‘field’) locomotor analysis system for horses using an inertial measurement unit (IMU) device, which refreshes faster than the human eye (50 Hz). **Study design:** Prospective qualitative pilot validation study comparing a mobile IMU sensor with visual inspection as the gold standard. **Methods:** An adult sport horse (n=1) representative from the universities teaching herd was saddled and an inertial measurement unit (IMU) in the form of a smartphone (Android®) was put in the pocket of the coat of a student rider. The rider (n=1) was also equipped with a HeadUpDisplay device (Google Glass®) and started a voice responded custom made ‘app’ (EquiCoach®, www.rhaebus.com) running on the smartphone to collect data at a measuring frequency up to 50 Hz when riding the horse at a 2-minute walk, trot and canter. **Results:** The different sinusoidal locomotor patterns collected at walk, trot and canter were displayed in real-time as text items visible for the rider on the HUD. From a retrospective analysis of the stored data the locomotor asymmetry of the different gait could be quantitatively evaluated. **Conclusions:** We developed and tested a simple prototype for a voice operated, mobile, locomotor analysis system for horses on the basis of an Android smartphone and a Google Glass display, thus providing real-time feedback to the rider needing further quantitative validation studies. This would also open perspectives for objectively evaluating rehabilitation and training effects for a team of sports horses preparing for a major event.

**Ethical Animal Research:** The study was approved by the local ethics committee in compliance with the Dutch Act on Animal Experimentation. **Sources of funding:** STW Demonstrator Grant 14026. **Competing Interests:** None declared.

**AN EX-VIVO COMPARISON OF SKIN AND BONE MOUNTED DISTAL LIMB ACCELEROMETERS TO MEASURE IMPACT VIBRATIONS**

50

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Reasons for performing study: Bone mounted accelerometers have been used previously to quantify distal limb accelerations [1]. Skin mounted accelerometers could be a non-invasive alternative. Objectives: To determine the difference in impact vibrations measured directly at the third metacarpal bone (MCIII) and at the overlying skin.

Study design: Ex-vivo impact simulation with novel experimental method. Methods: Four equine cadaver forelimbs were instrumented with two high range (1000x gravity, 5000 samples/s,) 3D accelerometers (weight: 8 grams) mounted directly to the dorsal surface of the third metacarpal bone (MCIII) and immediately distal, on the skin overlying the dorsal aspect of MCIII. Limbs were fresh frozen and thawed fully prior to use. Limbs were attached to a custom made device which enables a lightly loaded limb to impact the ground mimicking the impact phase of a horse trotting at 3m/s. Total (TOTAL) and maximum signal power (MAX), up to 1503Hz, and frequency of maximum power (FMAX) were calculated from FFT of acceleration signals from impact to 20ms after to characterize impact vibrations. Parameters were assessed using descriptive methods and Wilcoxon signed rank test in SPSS. Results: Preliminary results show that in the proximodistal direction, median (IQR) TOTAL is 5851G² (2733G²) at the bone but significantly (P<0.001) greater 21082G² (36502G²) at the skin. In the craniocaudal direction TOTAL is 63964G² (83743G²) at the bone but significantly (P<0.001) lower 6824G² (4367G²) at the skin. This is similar for MAX. Conclusions: There is a significant difference between impact vibrations at the bone and skin. This could reflect different tissue dampening properties and different accelerometer attachment methods, this requires further investigation before skin mounted accelerometers can be used to estimate bone impact vibrations.

Ethical Animal Research: Cadaver studies conducted with approval of the Royal Veterinary College’s Ethics and Welfare Committee. The animals were derived from an abattoir and the abattoir gave consent. Sources of funding: RVC. Competing interests: None declared.


AUTOMATED DETECTION OF BASIC EQUESTRIAN EXERCISES BASED ON SMARTPHONE ACCELEROMETER DATA

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Reasons for performing study: Automatically documenting riding activities may contribute to evidence based training regimens optimizing performance and minimizing injuries. Suitable sensors are found in SmartPhones enabling classification of non-equestrian human activities and calculating equine movement symmetry [1]. Here we explore automated classification for basic equestrian activities using sensors embedded in a SmartPhone.

Objectives: To test a simple automated classification approach discriminating between gaits and riding techniques (walk, sitting trot, rising trot, canter) using SmartPhone accelerometer data. Study design: Proof of concept study.

Methods: One rider was equipped with a SmartPhone (iPhone6+, Apple) with datalogging App SensorLog (www.berndthomas.net) mounted strapped to the rider’s thigh. The rider was asked to perform 2-minute bouts in each the four gaits/riding techniques logging tri-axial accelerometer data at 50Hz sample rate. Data were highpass filtered (cutoff 0.25Hz) and the vector sum calculated providing orientation-independent output. Then a spectrogram was calculated (sliding windows: 2.56s length, 512 point fast Fourier transformation). Finally, power spectral density was summarized into 16 bands (band width: 0.25Hz up to 1Hz, 0.5Hz up to 5Hz, 1Hz up to 10Hz) providing frequency features. Frequency band means were calculated from 30 seconds of data (from 15s to 45s into the trial) per gait/riding technique and nearest neighbor classification (Euclidian distance) classified 45s of unseen data (from 45s to 90s). Results: Frame-by-frame classification accuracy was high: overall 99.8%; walk: 100%; sitting trot: 100%; rising trot: 99.5%; canter: 99.6%. Conclusions: Rider specific classification of basic equestrian activities performs well with very little training data using frequency based features from accelerometers embedded into a SmartPhone and employing simple nearest neighbor classification.

Ethical Animal Research: Informed owner consent was obtained. Sources of funding: None. Competing interests: None declared.
**Thursday, August 18th**


**COMPARISON OF STRIDE SPLIT BASED ON MINIMUM POSITION OF WITHERS/SACRUM AND FETLOCK OPTICAL MARKERS IN HORSES WITH VARYING DEGREE OF LAMENESS**


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**Reasons for performing study:** Stride split is a common method used in biomechanics. A stride-split method must be validated for temporal characteristics. Comparisons among split methods could be made and results evaluated relative to speed, gait, lameness, surface, circles and other factors. Stride-split is often based on limb position e.g. impact, toe off, maximal pro/retraction and mid stance. Less commonly used is the lowest position of the fetlock that is however closely related to peak vertical GRF. **Objectives:** To study the association between stride-split based on fetlock and sacrum/wITHERS minimum vertical position during the stride cycle, including influence of induced forelimb/hindlimb lameness. **Study design:** Experimental study. **Methods:** Lameness was induced (sole pressure model, AAEP lameness grade 0.5-3/5) in all limbs sequentially in 10 sound Warmblood horses. The horses trotted at straight-line on a hard surface and on a treadmill. Using spherical reflective markers at anatomical landmarks, kinematic analysis was performed using high-speed motion capture (Qualisys AB, Sweden). Stride data were analysed with mixed models technique. **Results:** Sacrum vs fetlock minimum position were delayed 6.35% +/-0.41 of stride duration (mean and std, n=801 steps). Withers vs fetlocks fore were delayed 2.69% +/-0.63 (n=784) and fore- and hindquarters were significantly different (P<0.001). Differences between proximal and distal markers were also slightly but significantly affected by horse, stride duration and degree of lameness (differences <0.5%, P=0.05-0.01). **Conclusions:** Precision in using sacrum compared to fetlock minimum vertical position is good (around 0.5% std of stride duration). The different bias of 3% and 6% in fore and hindlimb respectively should be taking into account when performing stride split. We hypothesize that the difference was related to higher vertical stiffness in fore compared to hindquarters. Other factors also influenced the bias, which has to be further investigated together with factors not assessed in this study.

**Ethical animal research:** The study protocol was approved by the Animal Health and Welfare Commission of the canton of Zurich (permission number 51/2013). Informed consent of the horse owners was obtained. **Source of funding:** The Swedish-Norwegian Foundation for Equine Research. **Competing interests:** C. Roepstorff is an employee of Qualisys AB.

**VALIDATION OF A TRANSLATED VERSION OF THE CANINE BRIEF PAIN INVENTORY FOR THE MEASURE OF PAIN SEVERITY AND FUNCTIONAL MOVEMENTS IN CANINE OSTEARTHRITIS**


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**Reasons for performing study:** The Canine Brief Pain Inventory (CBPI) is a caregiver-reported questionnaire designed to assess pain severity and the impact of pain on activities, such as functional movements, in canine osteoarthritis (OA). The English version of CBPI has displayed satisfactory psychometric properties, in canine OA. To be used in another language the CBPI has to be properly translated and tested. **Objectives:** To report some psychometric properties of a translated version of the CBPI (CBPI-S), in a group of dogs diagnosed with OA. **Study design:** Observational, cross-sectional. **Methods:** Twenty-one caregivers of clinically sound dogs and 61 caregivers of dogs with OA were prospectively included in this study. After being translated, according to recommendations for patient-reported outcome measures, the CBPI-S was completed by the caregivers. Construct
validity (the ability to measure what it is supposed to measure) was assessed by repeating the principal component analysis and by assessing for differences between sound dogs and dogs with OA using Mann-Whitney U test. Internal consistency (the correlation among items) was estimated by Cronbach’s α. **Results:** Principal component analysis showed a two-component structure (pain severity and impact of pain). Two components accounted for 76.8% of the total variance, suggesting an acceptable fit of a two-component structure. Inter-item correlations were good (overall > 0.39) and mean inter-item correlation was 0.79 for severity items and 0.62 for impact items. Clinically sound dogs differed from OA dogs and showed significantly lower CBPI-S total score. Cronbach’s α was 0.94 for the total CBPI-S, 0.91 for the pain severity and 0.91 for the impact of pain. **Conclusion:** Our results supplement the knowledge with the CBPI by verifying the easy to use utility. Also, by repeating satisfying construct validity and high internal consistency of CBPI-S our results indicate that the translated version seems valid for use in another language.

**Ethical Animal Research:** The study was approved by the Local Animal Ethics Committee in Uppsala. Informed client consent was obtained for all animals used in the study. **Sources of funding:** This study was funded by Evidensia Djursjukvård, Sveland Stiftelse, Jan Skogsborgs Stiftelse and Agria & Svenska Kennelklubbens Forskningsfond. **Competing interests:** None declared.

**THE EFFECT OF TWO NUTRACEUTICALS ON INFLAMMATION AND BIOMARKERS OF CARTILAGE METABOLISM IN EQUINE SYNOVIAL FLUID AFTER EXPERIMENTALLY INDUCED ACUTE SYNOVITIS**

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**Reasons for performing study:** Scientific evidence of the efficacy of nutraceuticals for equine osteoarthritis is lacking. **Objectives:** To study the effects of two specific nutraceuticals on inflammation and biomarkers of cartilage metabolism in synovial fluid after experimentally induced acute synovitis. **Study design:** Blinded, controlled, randomized experimental study. **Methods:** Twenty-four healthy Standardbreds were randomly allocated to supplement AT (Cavalor ArtiTec (Liquid)®, Nutriquine N.V., Drongen, Belgium) for 28 days, supplement HP (Hydro-P®, Sonac, Son, The Netherlands) for 60 days, meloxicam (Metacam®, Boehringer Ingelheim Vetmedica, Ingelheim/Rhein, Germany) 0.6 mg/kg for 4 days or placebo for 60 days. Synovitis was induced in the right intercarpal joint by injection of 0.5 ng lipopolysaccharide (LPS) of E. Coli [1] while treatments were continued for another 3 days. Synovial fluid analysis, blood hematology and biochemistry were performed before treatment, prior to LPS-injection, and 8, 24 and 48 hours post-injection. Synovial fluid samples were analyzed for total nucleated cell counts (TNCC), total protein (TP), and a comprehensive set of biomarkers (PGE₂, IL-6, MMPs, CP-II, GAG). A linear model with random horse effects and fixed time and treatment effects and their interaction was used for statistical analysis. **Results:** Before treatment and LPS-injection, there were no significant differences between groups for cytology and biomarkers. After LPS-injection, the placebo group showed significantly higher TP, TNCC, and PGE₂ compared to meloxicam. Both nutraceuticals resulted in significantly lower TP, TNCC and PGE₂ compared to placebo; no other significant differences between groups were observed. No adverse systemic effects were observed in any of the groups. **Conclusion:** These specific nutraceuticals decreased joint inflammation in a validated synovitis model.

**Ethical animal research:** The study protocol was approved by the ethical committee of the Faculty of Veterinary Medicine of Ghent University (n°2013/165). **Sources of funding:** Nutriquine N.V. (Drongen, Belgium) and Sonac, a Darling Ingredients brand (Son, The Netherlands). Data analysis was partially funded by the Dutch Arthritis Foundation (project LLP22). **Competing interests:**.


**IN VIVO EFFECTS OF INTRA-ARTICULAR ANTI-NERVE GROWTH FACTOR ON ARTICULAR CARTILAGE AND BIOMECHANICAL GAIT PARAMETERS IN AN EQUINE IL-1Β SYNOVITIS MODEL**
Reasons for performing the study: Equine pain management is one of the most challenging issues for veterinarians. With increased understanding of the underlying mechanisms causing various types of pain comes a need to develop more directed multimodal pain management protocols. The administration of anti-nerve growth factor (anti-NGF) in non-equine species has a significant anti-inflammatory and analgesic effect. Objectives: 1) to determine the \textit{in vivo} analgesic efficacy of anti-NGF administered intra-articularly on objective lameness parameters at three different doses; and 2) to determine the direct effect on articular cartilage and synovial membrane. Study Design: \textit{In vivo} (non-terminal) experiment. Methods: A transient mild synovitis was created in one randomly selected tarsocrural joint in 24 horses. Each horse received a single intra-articular injection of reIL-1β, while an equivalent amount of sterile phosphate buffered saline solution was injected into the contralateral joint. Anti-NGF was administered intra-articularly 4-hours after induction of synovitis into the reIL-1β and PBS treated tarsocrural joints. Treatment groups consisted of anti-NGF Dose 1(0.1mg), 2(1mg), 3(10mg) or placebo. Synovial fluid, lameness evaluation and ground reaction forces were collected at three different time points. Ten hours after induction of synovitis, synovial membrane and articular cartilage biopsies of the lateral trochlear ridge of the talus were taken by standing arthroscopy. Results: Compared with the placebo control, 1mg produced significant disease-modifying effects with a reduction in synovial membrane intimal hyperplasia and PGE$_2$ in synovial fluid. Similarly, the 10mg dose demonstrated disease-modifying effects with improvements in synovial fluid PGE$_2$ and GAG concentrations compared to reIL-1β placebo treatment. Significant clinical improvements with less pain demonstrated during hock flexion and a symmetrical loading of the limb were produced at the 10mg dose. Conclusions: The results of this study demonstrate an effective suppression of inflammation, pain and catabolic activity in horses in which reIL-1β induced inflammatory responses were treated with intra-articular anti-NGF.

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MYOLOGICAL CAUSES AND CONSEQUENCES OF MOVEMENT PROBLEMS IN CHILDREN WITH SPASTIC CEREBRAL PALSY

Shortland, A.

One Small Step Gait Laboratory, Guy’s and St Thomas’ Foundation Trust and King’s College London.

Cerebral palsy is an umbrella term for a number of conditions in which an injury to the developing brain causes a developing problem of posture and movement. The term "spastic" loosely describes those children with an injury that affects cortico-spinal tract function. Cerebral palsy is a common problem with a prevalence of 2 in 1000 of which the majority of individuals have the "spastic" form. The neurological injuries lead to inadequate muscle growth and function. Muscle impairments are prevalent in these children and are associated with a decline in motor function in adolescence and in adulthood.

Children with spastic cerebral palsy often walk on their toes (in equinus). This has been attributed to heightened reflexes and/or a failure in the development of central programming. In other words, it has been considered to be a wholly neurological phenomenon. However, recent evidence suggests that changes in the properties of muscle may contribute to dynamic equinus, particularly, the altered resting length of sarcomeres in the affected muscles of children with spastic cerebral palsy.

The most important muscle group to support and advance the body in walking is the plantarflexors. When typically developing individuals walk, they demonstrate an exquisite interaction between muscle belly and tendon which limits eccentric action of the muscle belly and maximises efficiency. However, in children with spastic cerebral palsy this mechanical interaction is disturbed, potentially leading to muscle damage, further development of muscle deformity and pain.

The effect of a cerebral injury on the development of muscle in childhood will be reviewed and supported by data at the molecular, cellular and organ levels. In this talk, we will try to pool the available evidence and develop a theory of muscular deformity in children with spastic cerebral palsy.

THE ASSOCIATION BETWEEN FOOT PRONATION AND ACTIVE CONTROL OF PELVIC MOVEMENT DURING SITTING WITHOUT FOOT-FLOOR CONTACT

Engell, M.T., Hernlund, E., Bergh, A., Egenvall, A., Clayton, H.M., Roepstorff, L.

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Reasons for performing study: To develop movement symmetry in the horse, the rider should move symmetrically. We have shown that riders with greater pronation of one foot walk with increased contralateral pelvic drop when the more pronated foot is in early stance. This could affect the riders’ athletic abilities if pelvic asymmetry remains present when the rider is actively moving the pelvis in sitting position. Objectives: Firstly, to seek an association between greater pronation of one foot and pelvic movement asymmetry while sitting on a balance chair without foot support. Secondly to study trunk movement in connection to pelvic movement while sitting. Study design: Experimental study. Methods: Kinematic 3-D data were recorded from 18 female advanced riders using a full-body set of reflective markers and eight motion capture cameras (250 Hz). Riders a) walked barefoot and b) sat on a balance chair with a movable seat without foot support and were instructed to move the chair from side to side. Foot pronation was calculated in early stance during walking. Maximum roll when moving the chair from side-to-side was averaged over 2-5 movement cycles for pelvis and trunk respectively. McNemars test was used to investigate the association between the side of greater foot pronation and the side of greater pelvic roll on the chair (P<0.05). Results: Thirteen riders had greater right foot pronation, 11 of those displayed greater roll towards the left side while sitting. Five riders had greater left foot pronation, three of whom displayed greater roll towards the right (P=0.03). All 21 riders used the trunk to compensate for the pelvic movement. Conclusions: Greater pronation of one foot is associated with asymmetries in active control of pelvic roll in riders seated on a balance chair. This pelvic asymmetry is similar to the increased contralateral pelvic drop seen in walking.
**Ethical Animal Research:** Informed consent was obtained for all participants. **Sources of funding:** Ulla Håkanson’s foundation. **Competing interests:** None declared.

**RIDERS’ PERCEPTION OF SYMMETRICAL PRESSURE ON THE ISCHIAL TUBEROSITIES AND REIN CONTACT WHILST SITTING ON A STATIC OBJECT.**

1,2 Guire, R., 3Fisher, D., 3Fisher, M., 3Mathie, H.

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**Reasons for performing the study:** The pelvis is key in providing stability for the rider and transmitting discrete movement patterns in order to control the horse’s locomotion. Understanding the importance of the rider’s seat and rein contact is vital in optimizing horse and rider interaction. **Objectives:** To compare perceived seat and rein pressure symmetry with measured seat and rein pressures of a cohort of riders whilst sitting on a static object. **Study design:** Quantitative measurements in random sample of riders. **Methods:** 30 riders, (4 male and 26 female), mean age 41 years were asked to sit on a pressure mapping mat (Novel Pliance) positioned on a static platform 46 cm high and 40 cm wide with a seat depth of 26 cm and asked to mimic even contact using two reins attached to rein gauges (Centaur) both attached to a solid wall, 25 cm from the seating platform. Riders were given two cues within the same condition, “sit equal on both SEAT BONES” and “take an EVEN contact”. When the rider perceived to have equal weighting and equal rein tension, pressure mat and rein tension measurements for left and right sides were recorded and compared (mean of 3 repeats of 5 seconds with a paired T-test (P<0.05). **Results:** A significant difference was found with higher total pressure under the left Schial Tuberosity (2.22 N/cm²) compared to the right (1.82 N/cm²) Ischial Tuberosity (P=0.04). No significant difference (P=0.95) was found in total rein pressure between left (6.37 N) and right (6.38 N). **Conclusions:** The left Ischial Tuberosity was significantly more weighted despite the rider’s perception of equally weighted SEAT BONES. However, the perception of EVEN rein contact was more sensitive with no significant difference found. Further investigation is needed to determine the effect of unequal rider weight on equine locomotion.

**Ethical Research:** Informed consent was obtained from all participants. **Sources of funding:** Society of Master Saddlers. **Competing interests:** None declared.

**EQUINE TRUNK MORPHOMETRY ACROSS DIFFERENT BREEDS AND ATHLETIC DISCIPLINES**

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**Reasons for performing study:** Fitting a garment or similar object (e.g., a saddle) to a contoured shape requires quantifying the amount of variation present within the object (e.g., a horse’s trunk) to be fitted. Categorizing the range of sizes and shapes of the equine trunk across breeds and athletic disciplines would help to define a feasible number of required saddle sizes and shapes needed for standardizing saddle fit and construction. **Objectives:** To quantify trunk morphology across different horse breeds and athletic disciplines based on perceived differences in trunk conformation. **Study design:** Observational, cross-sectional study. **Methods:** 211 skeletally-mature horses that included Quarter Horses (n=116), Warmbloods (n=51), Morgans (n=30), and Thoroughbreds (n=14) were used to quantify morphometric features (i.e., height, length, depth and width) of the trunk. Body weights and body condition scores were also recorded. Disciplines included cutting (n=47), reining (n=34), dressage (n=36), hunter-jumper (n=36), show (n=30), and unridden, research horses (n=28). Differences among mean values for specified body measurement variables within breed classifications and athletic disciplines were analyzed by ANOVA followed by Tukey’s HSD. **Results:** Quarter Horses had the shortest wither height (149 ± 7 cm) and overall trunk length (82.7 ± 3.3 cm), but had some of the widest transverse contours at the withers. Morgans were intermediate in wither height, but they also had short overall trunk lengths. Warmbloods and Thoroughbreds were the tallest (166 ± 5 cm), longest (90.2 ± 4.1 cm) and heaviest, but they often had the narrowest trunk contours among breeds. Quarter Horses involved in cutting versus reining differ in some trunk morphometric parameters; similarly, Warmbloods differ if involved in dressage or jumping disciplines.
Conclusions: Trunk morphometry varies between horse breeds and equine disciplines, which is likely due to a strong selection bias for specific athletic capabilities.

Ethical animal research: Horses were handled in accordance with approved Institutional Animal Care and Use protocols. Informed client consent was obtained. Sources of funding: PVM student grant program in the Center for Companion Animal Studies at Colorado State University. Competing interests: None declared.

ROCKING HORSE OR RACE HORSE?
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Reasons for performing study: Horse riding in the modern race style is a complex task with the jockey mechanically isolating themselves from the movements of the horse for energetic benefit [1]. The optimum style is not clear so training is complex. Horse simulators are used in jockey training but it is not known if they accurately recreate the horse motion for optimum jockey training or motion simulation. Objectives: To quantify kinematic differences in jockey–mount interaction between racehorse and simulator riding. Study design: Prospective, cohort study. Methods: Inertial measurement units (MTw, Xsens) were attached to the sacrum of the horse/simulator, mid-thigh and tibia, sternum and pelvis of six jockeys. Both stirrups were instrumented for force measurement. Data were collected during gallop on a synthetic track and while riding a racehorse simulator (Racewood). Results: Real horse kinematics were more variable compared to the simulator, and exhibited greater vertical (47%) and medio-lateral (259%) amplitudes and smaller cranio-caudal (83%) displacement amplitude, defined using a linear mixed model (SPSS). Movement of the real horse is clockwise when viewed from the left side while the simulator trajectory is anticlockwise. Jockey pelvis displacement was 180 degrees out of phase with the horse or simulator. Peak stirrup forces during real gallop were more asymmetric and over double those recorded on the simulator. Conclusions: Racehorse simulators enable physical manipulation of jockeys into optimal positions. Their movement is consistent so it should be easier to learn the style without the challenges of balancing from stride to stride on real horses and maintaining optimum technique. The difference in phasing is the subject of further analysis and modelling.

Ethical Animal Research: Informed subject consent was obtained for all animals and jockeys used in the study. Sources of funding: Horserace Betting Levy Board. Competing interests: None declared.


INFLUENCE OF BREAKING-IN AND RIDDEN EXERCISE ON TRUNK MOVEMENT SYMMETRY IN YOUNG WARMBLOOD HORSES

Nissen, A.L., Andersen, P.H., Buhl, R., Kühnel, L., Størensen, H., Thomsen, M.H.

1Department of Large Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, 2Department of Clinical Sciences, Division of Diagnostics, Swedish University of Agricultural Sciences, 3Laboratory for Applied Statistics, Department of Mathematical Sciences, Faculty of Science, University of Copenhagen, Email: hqr298@alumni.ku.dk

Reasons for performing study: Breaking-in is an intense and career-defining phase for young Warmblood horses and may affect movement symmetry. Objectives: To describe trunk movement symmetry before and after breaking-in including approximately 7 weeks of training. Study Design: Prospective field study. Methods: Trunk movement symmetry was determined in 26 horses using a 3-D accelerometer mounted dorsally in the thoracic midline. Data were collected from an in-hand trot on a hard surface in a straight line. First measurement (‘before’) was performed when the horse was familiar with to girth and lunging, typically after 2-5 days of training. Second measurement (‘after’) was after approximately 7 weeks just before first show or before sale. Based on trunk accelerations of eight strides measured at 240Hz, three symmetry indices were calculated: overall symmetry (Index S), symmetry of diagonal limb loading (Index A) and symmetry of diagonal timing (Index W). Indices derived from ‘before’ measurements ($S_1$, $A_1$ and $W_1$) were compared to indices from ‘after’ measurements ($S_2$, $A_2$ and $W_2$) with two-sided paired t-tests. Indices A and W were directional and absolute values were used in the comparison. Results: Symmetry indices were presented as mean (SD) [CI]. Overall symmetry $S_1$: -6.45 (0.87) [-
6.80, -6.09]; S: -6.47 (0.84) [-6.81, -6.13]. Loading symmetry A: 0.87×10⁻² (6.30×10⁻²) [-1.68,3.42]×10⁻²]; A: -0.71×10⁻² (3.75×10⁻²) [-2.23,0.80]×10⁻²]. Symmetry of timing W: 3.32×10⁻¹ (9.29×10⁻¹) [-0.43,7.07]×10⁻¹]; W: 2.89×10⁻³ (12.28×10⁻⁴) [-2.07,7.85]×10⁻⁴]. Index |A| showed statistically significant change towards higher symmetry (P=0.0002). Changes in indices S and |W| were not statistically significant. Conclusions: Symmetry of diagonal loading in young horses was increased after 7 weeks of training. Whether this increase in loading symmetry was due to conditioning of the body and increased muscle mass or directly related to effect of rider remains unknown.

Ethical Animal Research: Informed consent for data collection was obtained from the general manager and responsible person of the horses and training. Sources of funding: The University of Copenhagen, The Jubilee Fund of the Royal Danish Horse Insurance Company and Kustos. Competing interests: None declared.
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<td>IMPACT FIRMNESS, CUSHIONING AND HOOF KINEMATICS IN HARNESS RACING TROTTERS RACING ON TWO DIFFERENT SURFACES</td>
<td>Roepstorff, L., Bernhardsson, I., Hernlund, E., Egenvall, A.</td>
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<td>12:03-12:15</td>
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<td>HORSES MODIFY THEIR GAIT IN RESPONSE TO A CAMOUFLAGED ABRUPT CHANGE IN FUNCTIONAL SURFACE PROPERTIES</td>
<td>Holt, D., Martin, J. H., St. George, L. B., Northrop, A., Peterson, M. L. and Hobbs, S. J.</td>
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<td>GENERAL DISCUSSION</td>
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CONSTITUTIVE MODELING OF EQUESTRIAN SURFACE MATERIALS

Peterson, M., Vel, S. and Jin, Z.

Mechanical Engineering, University of Maine, Orono Maine USA, Email: mlpeterson23@gmail.com

Reasons for performing study: Sand with a range of coatings and reinforcements are used for both racing and sport horse surfaces. These surfaces have properties critical to performance of athletes and safety of horses and riders. Equestrian surfaces are subject to high loads occurring at higher loading rates than other sports surfaces. Because of non-linear and strain rate dependent behavior of granular materials these load and load rate factors are critical to understanding the material. Objectives: Since 2004 more than 12,000 measurements have been made on 100 racetracks/arenas using a system replicating the load rate and load of a horse. While the quantity of data is impressive, the data currently have limited utility for musculoskeletal modeling since they have not been presented in a form that is conducive to inclusion in multi-body dynamics models or finite elements models. Study Design: In silica. Methods: A general constitutive model of the surface was developed which represents key variables associated with the testing. The constitutive model was used to capture the essential results from this extensive data set. A semi-phenomenological constitutive model of granular equestrian surfaces is used. The model was based on accepted terra-mechanics literature but was extended to include potential effects from wax coatings and fibers reinforcement used in the partially saturated granular materials which predominate in equestrian surfaces. Dynamic and layering effects were also considered. Results: A linear Drucker Prager plasticity model was developed using laboratory material test data from Thoroughbred racing and show jumping surfaces. Friction angles range from 25 to 45 degrees with constant dilatation angles. Conclusions: While some general characteristics of the response were captured, future work will require modeling of the hoof surface interactions to test the general model against the test data. Modeling turf or fiber reinforced surfaces presents challenges that are not addressed by the model.

Ethical Animal Research: Not applicable Sources of funding: Private donor. Competing interests: None declared.

MECHANICAL PROPERTIES OF A GRASS SURFACE IN THE COURSE OF A YEAR.

Schramel, J. P., Peham, C.

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Reasons for performing study: Arena properties may pose a potential risk in the development of musculoskeletal disorders in equestrian sports. Mechanical properties of grass depend on moisture, substrate composition and herbs that vary with regions and seasons. We speculate that horses are adapted by evolution to grass surfaces. Hence mechanical properties of grass may support the design of safe equestrian surfaces. Objectives: To determine parameters for modelling and arena comparison. Study design: Descriptive. Methods: Grass within an area of 4m² at the campus of the Veterinary University of Vienna was measured from December 2014 to November 2015 with the Vienna Equine Surface Tester. It consists of a ball with 6.15kg and 20.4cm diameter equipped with accelerometers and portable electronics. Monthly about 30 drop tests from heights between 5cm and 140cm were performed randomly on different spots. Prior to measurements moisture was determined with a TRIME Pico 64 HD2 (IMKO Germany) sensor. The parameters stiffness (cushioning), displacement (penetration depth) and energy restitution (rebound) were determined at 1m/s and 4m/s impact speeds calculated post-hoc by linear regression method. Pearson correlation of parameters with moisture and equations of regression were determined by curve fitting. Results: Moisture changed from 36.4% in December to 9.1% in June. Stiffness at 4m/s impact speed raise from 240kN/m to 1693kN/m respectively. Energy restitution remained largely constant (5.3% to 7.1% respectively). Moisture M and stiffness k were negatively correlated (r = - 0.97) and approximated by k = 21880 x M¹.²⁵. Conclusions: Stiffness was progressively negative correlated with moisture. This may raise the risk of injuries in particular in show jumping on very dry turf. Energy restitution remained essentially constant. Measurements should be extended to other regions to cover different soils, botanic and climatic conditions.

Ethical Animal Research: Not applicable. Sources of funding: None. Competing interests: None declared.

THE INTERACTION BETWEEN RACE SURFACE MECHANICS AND SIMULATED FETLOCK ANGLE IN GALLOPING RACEHORSES

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Reasons for performing study: Optimal race surface materials (natural or artificial) and preparation techniques to minimize injury risk are highly debated. Further scientific research is needed to understand the interaction between factors affecting race surface mechanics and horse/jockey musculoskeletal health. Objectives: To model the relationship between race surface mechanics and peak fetlock angles, which are associated with multiple pathologies common in racehorses. Study design: Combined forward/inverse dynamics simulations. Methods: A previously developed, integrated racehorse and race surface computational model, capable of simulating lower limb kinematic profiles of similar qualitative shape and comparable magnitude to actual galloping racehorses on mechanically measured race surfaces, was used to simulate racehorse gallop on a series of virtual race surfaces. Race surfaces were modelled as 2 layers: an upper, aerated, softer cushion layer and a lower, consolidated, stiffer pad layer. Parameters affecting cushion and pad mechanics, as well as horizontal friction, were altered between simulations. All distal forelimb joints were free to move in response to differing race surface mechanics. Proximal forelimb, trunk and hindlimb joints were defined as functions of time, based on previously recorded kinematic profiles of actual galloping racehorses. Results: Simulated fetlock hyperextension was greater on virtual race surfaces with greater average vertical stiffness. Cushion depth produced the greatest change in fetlock motion (up to 10°), with more deeply harrowed and aerated surfaces yielding less fetlock hyperextension. Lesser changes in fetlock motion were observed for changes in pad mechanics (up to 4°), with increases in stiffness yielding greater peak fetlock hyperextension. Changes in horizontal friction parameters produced the smallest changes in fetlock motion (<1°). Conclusions: Cushion depth is a function of maintenance procedures, whereas pad mechanics are a function of material properties. Therefore, harrowing depth has the potential to produce greater changes in fetlock hyperextension, compared to race surface material composition.

Ethical Animal Research: Not applicable. Sources of funding: Grayson Jockey Club Research Foundation Inc., the Dolly Green Research Foundation through the Southern California Equine Foundation, the UC Davis Center for Equine Health and Bill Casner. Competing interests: None declared.

IMPACT FIRMNESS, CUSHIONING AND HOOF KINEMATICS IN HARNESS RACING TROTTERS RACING ON TWO DIFFERENT SURFACES

Roepstorff, L., Bernhardsson, I., Hernlund, E., Egenvall, A.

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Reasons for performing study: Surface functional properties of racing tracks can influence the risk of orthopaedic injury. Trotters race on tracks with comparably high impact firmness and low cushioning. If objective measurements of track functional properties would show lowered surface firmness and higher cushioning in an alternative track design where the kinematics of hoof-ground interaction were not significantly altered compared to a normal track design, there is a potential to lower risk of injury. Study design: Paired experimental study. Methods: Six trotters were trotted at 80, 90 and 100% of their maximal speed on a normal trotting competition race track (RT) and on a waxed fibre sand track (WFS), the latter prepared in two different ways, firstly power harrowed and thereafter compacted to two different degrees with a roller. Hoof, cannon bone and radius/tibia 6-DOF movements were recorded with clusters of optical markers and high-speed video analysis system (800 Hz, Qualisys AB) over a 12 m stretch enabling full analysis of two strides. Additionally the tracks were tested with an Orono Biomechanical Surface Tester (OBST). Results: The impact surface firmness was reduced by 55% in compacted WSF and by 68% in less compacted WSF compared to RT. The trotting speeds were higher though not significantly on both WFS compared to the RT. There were no significant changes in hoof brake time and hoof brake distance when comparing RT and the more compacted WFS while significantly decreased time and longer distance when comparing RT to the less compacted WFS. Conclusions: Non-traditional surface designs of harness trotting racetracks can, if relevantly maintained, provide reduced impact firmness and increased cushioning for the horse without obvious changes in hoof kinematics.

Ethical Animal Research: Informed client consent was obtained. Sources of funding: University funding. Competing interests: None declared.
HORSES MODIFY THEIR GAIT IN RESPONSE TO A CAMOUFLAGED ABRUPT CHANGE IN FUNCTIONAL SURFACE PROPERTIES

Holt, D., Martin, J. H., St. George, L. B., Northrop, A., Peterson, M. L. and Hobbs, S. J.

Myerscough College, St Michaels Road, Preston, PR3 0RY, United Kingdom; University of Central Lancashire, Centre for Applied Sport and Exercise Sciences, Preston, PR1 2HE, United Kingdom; Anglia Ruskin University, Department of Life Sciences, East Road, Cambridge, CB1 1PT, United Kingdom; College of Mechanical Engineering, University of Maine, Orono, Maine 04473, Email: daniholt123@aol.co.uk

Reasons for performing study: Arena surfaces used for training and competition are influenced by factors such as weather and maintenance, which can lead to spatial variations in functional surface properties. The ability of the horse to adapt to such changes may have implications for injury prevention [1]. Objectives: The aim of the study was to quantify kinematic and neuromuscular responses of horses to an abrupt change in functional surface properties. Study Design: Experimental, within-subject. Methods: Horses (n=7) were trotted in hand at a consistent speed (3.84 ± 0.25m/s) eight times across a waxed sand and fibre surface that presented a camouflaged, abrupt change from firmer (replicated peak force; 13.59 ± 0.39 kN) to softer (12.38 ± 0.81 kN) conditions. Kinematic data (232Hz) synchronised with surface electromyography (sEMG) (2088Hz) from selected forelimb muscles were recorded. The first trial (no awareness of change) was categorised separately to the subsequent trials (2-8; aware of change). A General Linear Model was used to assess the effect of horse, surface preparation and awareness on kinematics and sEMG. Results: Horse had a significant (P<0.0001) effect on kinematics. Forelimb retraction angle significantly (P<0.0001) reduced by 0.72º as the horse stepped onto the softer surface. Awareness of the abrupt change also significantly (P=0.005) reduced forelimb retraction angle by 0.53º. The mean neuromuscular activity within the forelimb muscles (with the exception of the extensor carpi radialis) during stance also reduced on the softer surface. Conclusions: Reducing forelimb retraction appears to be the main alteration that horses make to cope with an abrupt change in surface. This would suggest a more caudal centre of mass position relative to forelimb at lift off, which may aid balance.

Ethical Animal Research: The study was approved by the University of Central Lancashire’s ethics committee (RE/13/01/SH). Owners provided informed consent. Competing Interests: None declared. Sources of Funding: The study was funded by Myerscough College and University of Central Lancashire.


COMPARISON OF TRACK SURFACES WITH TWO DIFFERENT FOUNDATIONS: EFFECTS ON THE DYNAMIC VARIABLES MEASURED IN ONE HARNES S HORSE AT A TRAINING TROT

Munoz-Nates, F., Pouchelot, P., Ravary-Plamoen, B., Dardillat, C., Denoix, J.-M., Château, H., Crevier-Denoix, N.

Université Paris Est, Ecole Nationale Vétérinaire d’Alfort, USC 957 BPLC, 94700 Maisons-Alfort, France; INRA, USC 957 BPLC, 94700 Maisons-Alfort, France; Université Paris Est, Ecole Nationale Vétérinaire d’Alfort, CIRALE, 14430 Goustranville, France. Email: nathalie.crevier-denoix@vet-alfort.fr

Reasons for performing study: Biomechanical effects of the foundation, or base layer, of equestrian surfaces are unknown. Objectives: To compare dynamic variables in the fore- and hind limbs of one harness horse trotting on two tracks only differing by their foundations. Study design: In vivo experiment. Methods: A French trotter mare (550kg) was used. Her right fore and hind hooves were equipped with a dynamometric horseshoe composed of 4 triaxial piezoelectric force sensors (Kistler-9251A) sandwiched between two aluminium plates, and a triaxial piezoelectric accelerometer (PCB-356B20) rigidly fixed to the dorsal hoof wall. A wifi-connection enabled to remote-control data acquisition (7.8 kHz). Speed was recorded by means of a third wheel (fixed behind the bulky) equipped with a hub-dynamo. The horse repeated trials alternately on two parallel tracks, both covered with 12.5cm of sand&fibre mix, with different foundations: the “soft base” (SB) consisted of a “draining” 0-4 sand (15cm), while the “hard base” (HB) was made of 0.1 sand (15cm) covered by a 5cm “closing layer” (sand rich in fines). The target speed was 30 km/h. Linear mixed-effects regression models were used (SAS,P<0.05). Results: 70 (SB) and 40 (HB) strides were analyzed. Speed was not significantly different between tracks. Impact shock (maximum deceleration peak) was not either; however density of 0-50Hz and 50-100Hz vibrations was lower on SB in the fore hoof but not significant in the hind hoof. Vertical loading rates for forces above 5000N (hind limb) and 6000N (forelimb) were significantly lower on SB. Although maximal vertical forces tended to be lower on SB, the differences were not significant (P=0.1 in the hind limb). There were no differences in the longitudinal forces. Conclusions: With a 12.5 cm sand&fibre cushion above them, two classical foundations of

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different hardness induced slight dynamic differences. Vertical loading rates are the most sensitive variables to measure these effects.

**Ethical Animal Research:** Informed owner consent was obtained. **Sources of funding:** Feder, Conseil Régional de Basse-Normandie, IFCE, Fonds Eperon. **Competing interests:** None declared.

**THE EFFECT OF DIFFERENT BRIDLEWAY SURFACES ON FOOT PLACEMENT, MOVEMENT SYMMETRY AND 3D HOOF VIBRATIONS IN RIDDEN TROT**

Campbell, J., Bailey, J., Harris, C., Barstow, A., Weller, R., Pfau, T.

Department of Clinical Science and Services, The Royal Veterinary College, London, UK, Email: tpfau@rvc.ac.uk

**Reasons for performing study:** Horses encounter different surfaces during riding. Research has focused on performance surfaces and there is a paucity of data on surfaces encountered by many horses during leisure activities. **Objectives:** To characterize foot placement, movement symmetry and hoof accelerations on three common bridleway surfaces. **Study design:** Quantitative gait study in a convenience sample.

**Methods:** 6 horses (1.35-1.63m; 6-16years) equipped with 4 inertial sensors (head, sacrum, tubera coxae), one high range 3D accelerometer (1000x gravity, 5000 samples/s) attached to the left forelimb dorsal hoof wall were filmed with three cameras (2 lateral, 1 cranial/caudal view, 640x240/400 fps) during ridden trot on grass, gravel and tarmac. Average head and pelvic movement symmetry, predominant foot placement (>=75% of 12 stances) and hoof accelerations were calculated per horse and surface. Hoof accelerations were characterized by quantifying total and maximum signal power up to 1000Hz from FFT and frequency of maximum (Fmax) signal power for 50ms after impact (8 stances). A mixed model (P<0.05) with horse as random factor and surface as fixed factor was used to test differences in hoof vibrations. Repeated measures ANOVA was used to assess difference in movement symmetry. Predominant foot placement between surfaces was compared with a Bowker symmetry test. **Results:** No significant differences between surfaces were found for foot placement (P>0.32) and movement asymmetry (P>0.05). Total power of vibrations was significantly different between all surfaces in all three directions (P<0.002). Fmax along the dorsal hoof wall increased from grass (36Hz) to gravel (95Hz) to tarmac (388Hz) (P<0.0001). **Conclusions:** While no significant differences in foot placement and movement symmetry were found between three different hacking surfaces, the clear increase in total power and Fmax warrants further investigations into the role of trotting on tarmac on musculoskeletal problems such as osteoarthritis.

**Ethical Animal Research:** The study was approved the RVC Ethics and Welfare Committee. Informed client consent was obtained. **Sources of funding:** RVC and British Horse Society. **Competing interests:** None declared.
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<td>1Guire, R., 2Barstow, A., 3Fisher, M., 4Mathie, H., 5Benson, B., 6Weller, R., 7Pfau, T.</td>
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<td>14:00-14:45</td>
<td>EVJ17</td>
<td>UTILITY OF THE EQUINE BACK PROFILING SYSTEM IN QUANTIFYING DORSAL TRUNK CONTOURS RELATED TO SADDLE FITTING</td>
<td>1Haussler, K.K., 2Blauvelt, S.L., 2Hill, A.E., 3Kawcak, C.E.</td>
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<td>EVJ49</td>
<td>REIN TENSION DURING TRANSITIONS</td>
<td>1Egenvall, A., 2Rhodin, M., 3Roepstorff, L., 4Eisersiö, M., 5Yngvesson, J., 6Clayton, H.M.</td>
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<td>1Egenvall, A., 2Rhodin, M., 3Roepstorff, L., 4Eisersiö, M., 5Clayton, H.M.</td>
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<td>14:45-15:30</td>
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<td>14:45-15:30</td>
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<td>14:45-15:30</td>
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<td>1Tranquille, C., 2Hernlund, E., 1Egenvall, A., 2Dyson, S., 1Walker, V., 2Roepstorff, L., 1Murray, R.</td>
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<td>14:45-15:30</td>
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**DIFFERENCE BETWEEN CENTRALLY AND LATERALLY POSITIONED SADDLE ON EQUINE HEAD AND PELVIC RANGE OF MOTION IN TROT AND CANTER**

1,2Guire, R., 1Barstow, A., 1Fisher, M., 1Mathie, H., 1Benson, B., 1Weller, R., 1Pfau, T.

1Department of Clinical Science and Services, The Royal Veterinary College, London, UK, 2Centaur Biomechanics, Moreton Morrell, UK, 3Woolcroft Equine Services Ltd, Levington, Wisbech. UK, 4Aegrus Equine Physiotherapy, Burrington, UK, 5BT Benson Farrier LTD, Swalcilfe, Banbury, UK, Email: info@centaurbiomechanics.co.uk

Reasons for performing study: Saddle fit and positioning is vital for optimizing equine spinal kinematics and providing the rider with stability and support to execute their desired movements. **Objectives:** To evaluate the effect of a saddle positioned laterally to the vertebrae (SLIP) on equine kinematics compared to a correctly (centrally) positioned saddle (STRAIGHT). **Study design:** Quantitative gait study in a convenience sample. **Methods:** Seven horses (1.63-1.80m; 6-12 years), displaying saddle SLIP, assessed for lameness by two veterinarians. Saddle fit was assessed and adjusted by 3 Society of Master Saddlers Qualified Saddle Fitters. Horses were equipped with 4 inertial sensors (poll, sacrum, tubera coxae), warmed up following a standard 20 minute protocol and then trotted (rising trot) and cantered by their associated rider on both reins (3 repeats). Data were collected with SLIP, then saddles were adjusted/rebalanced (STRAIGHT) using Prolite shims and differences in range of movement (ROM) were assessed with a paired T-test (P≤0.05) after normalizing data to mimic SLIP to the left. **Results:** Saddle slip grade using a paired T-test (P<0.05) was significantly smaller for STRAIGHT (graded 0-5, mean 0.78) versus SLIP (mean 3.32, P=0.003). In left rein trot, larger values were found for STRAIGHT for mediolateral ROM of poll, sacrum and right tuber coxae (all P<0.04) and cranio-caudal ROM of left tuber coxae (P=0.001). In right rein trot, smaller values were found in the left tuber coxae (P=0.02) when STRAIGHT. In left rein canter, smaller sacrum and right tuber coxae ROM were found for STRAIGHT (P<0.04) and no difference on the right rein. **Conclusions:** In trot, a saddle positioned STRAIGHT significantly increases mediolateral ROM on the rein coinciding with the direction of SLIP. In canter, reduced ROM was observed with a STRAIGHT saddle. Further research needs to investigate the underlying mechanics of these observations.

Ethical Animal Research: Informed client consent was obtained for all animals used in the study. **Sources of funding:** RVC. **Competing interests:** None declared.

**UTILITY OF THE EQUINE BACK PROFILING SYSTEM IN QUANTIFYING DORSAL TRUNK CONTOURS RELATED TO SADDLE FITTING**

1Haussler, K.K., 1Blauvelt, S.L., 2Hill, A.E., 1Kawcak, C.E.

1Gail Holmes Equine Orthopaedic Research Center, Colorado State University, Fort Collins, CO, 2California Animal Health and Food Safety Laboratory System, University of California at Davis, Davis, CA, Email: Kevin.Haussler@colostate.edu

Reasons for performing study: Dorsal trunk contours can vary widely between horses and are considered a critical component of proper saddle fitting. An objective method that readily captures dorsal trunk contours is greatly needed to provide uniform, low-pressure distribution patterns between horse and saddle. **Objectives:** To determine the ability of the Equine Back Profiling System (EBPS), which consists of a series of 33 pre-defined contours cut into plastic sheets, to quantifying dorsal trunk contours in different horse breeds. **Study design:** Observational, cross-sectional study. **Methods:** 211 skeletally-mature horses consisting of Quarter Horses (n=116), Warmbloods (n=51), Morgans (n=30), and Thoroughbreds (n=14) were selected based on perceived breed differences in dorsal trunk contours. The gap widths between the EBPS cards and the dorsal trunk were measured in transverse and parasagittal planes during quiet stance in a neutral spinal posture. The cards were
placed transversely at six specified dorsal trunk locations that included: 1) the widest portion of the withers, 2) highest point of the withers, 3) caudal edge of the scapula, 4) base of the withers, 5) lowest point of the trunk, and 6) the thoracolumbar junction. The left-right parasagittal contours were measured 10-cm lateral to dorsal midline, corresponding to primary sites of saddle contact. All measures were done once by a single examiner. **Results:** The EBPS readily captured the dorsal trunk contours in all horses. Using the three transverse locations and the left parasagittal site recommended by the EBPS manufacturer, the overall success rate was 92% as defined by gap widths ≤ 0.5 cm. **Conclusions:** The EBPS provides a simple method to quantitatively capture subtle differences in trunk contours across horse breeds judged to have diverse trunk conformations. The EBPS may provide a reliable method to standardize trunk morphometry in optimizing saddle fit.

**Ethical animal research:** Horses were handled in accordance with approved Institutional Animal Care and Use protocols. Informed client consent was obtained. **Sources of funding:** PVM student grant program in the Center for Companion Animal Studies at Colorado State University. **Competing interests:** None declared.

## REIN TENSION DURING TRANSITIONS

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**Reasons for performing study:** In general, rein tension (RT) levels rank from walk< trot< canter. Aids, including reins, are used to regulate transitions but RT has not been characterized in this situation. **Objectives:** To determine RT during transitions- in a project studying ordinary riding sessions. **Study design:** Small-scale cross-sectional study. **Methods:** Left and right RT were measured during flatwork sessions in 6 professional riders, each riding 3 horses that they trained regularly. RT was measured at 128 Hz with strain gauge meters. Synchronized videos were used to code transitions between walk, trot and canter according to footfall sequence as type 1 (no intermediate steps between gaits) or type 2 (intermediate steps present). Canter to trot transitions were also coded for the initiating limb (fore, hind). Mixed models were used to model the log-transformed left-right average median RT, controlling for riders and horses as random effects and modelling transition types as fixed effects. Pairwise comparisons were done between transition types. **Results:** Transition type was significant (P<0.0001, 404 transitions, 1-115 per transition type- median 19 per transition type). The RT values were highest during canter-walk transitions (type 1/type 2: 41.6/41.4 N) and lowest during walk-trot transitions (12.6/13.7 N). Between -type within-gait, type 1 trot-canter transitions had higher RT (22.6 N) than type 2 (16.1 N) (P<0.05), otherwise most significant comparisons were found comparing transitions between various gaits, not between types within gaits. **Conclusions:** Not surprisingly, transitions that involved increasing speed were associated with larger RT values. Also, in transitions to and from canter, the large pendular motion of the head and neck was associated with relatively large RT values.

**Ethical Animal Research:** Informed owner consent was obtained. **Sources of funding:** No funding. **Competing interests:** None declared.

## How the method of analysis affects interpretation of chaotic rein tension data

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**Reasons for performing study:** Rein tension (RT) is a chaotic signal with variation attributable to gait, exercises, rider factors, horse factors, and horse-rider interaction, which makes it difficult to find a perfect analytical strategy. Biomechanical data are often analysed in a normalized and averaged format, which facilitates a simple and conservative analysis but ignores stride-to-stride variability. Alternatives include focusing crudely on low, average or high levels, or analyzing events within the stride. **Objectives:** The aim was to demonstrate an example in which the conclusions, especially those regarding the variation due to the effects of the horse versus the rider, differed according to whether the data were analysed at a crude level, in a normalized averaged format or by determining maximum and minimum values at stride level. **Study design:** Small-scale cross-sectional study. **Methods:** Left
and right RT were measured during flatwork in 6-8 professional riders, each riding 3 horses that they trained regularly. RT was measured at 128 Hz using strain gauges. Data were analysed with a mixed models technique, crudely (n=1,188 datapoints, 5 outcome parameters), normalized over strides per gait (walk n=21,008, trot n=37,168 and canter n=36,764), and at the level of the individual strides in canter (n=22,213; 3 parameters).

Results: At the crude level, variation associated with rider/horse was 0/28-35% for parameters with ‘high’ levels and 33/2% for parameters at ‘low’ levels. At the normalised level the rider/horse variation was 29/27% at walk, 20/7% at trot and 26/21% at canter. At the canter stride level, for ‘high’ level and ‘low’ level parameters the variation attributable to the rider/horse, respectively, was 0/27-29% for parameters with ‘high’ levels and 18/7% for parameters with a low level. Conclusions: Interpretation of the chaotic rein tension signal varied according to the level of analysis. There may be implications for less chaotic data as well.

Ethical Animal Research: Informed owner consent was obtained. Sources of funding: None. Competing interests: None declared.

EFFECTS OF A PROTOTYPE SADDLE (COMFORT PANELS) ON THE BIOMECHANICS OF THE EQUINE BACK DURING RISING TROT: PRELIMINARY RESULTS

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Reasons for performing study: Saddle panels are an important element to optimise saddle fit and horses’ comfort. The effect of the shape of the panels on the biomechanics of the horse including the thoracic region under the saddle have not been studied. Objectives: The aim of this study was to better understand the effect of the saddle panels on the horse’s back, by evaluating a saddle with two exchangeable panels: larger (comfort panels: CP) compared to standard (STD). Study Design: Quantitative biomechanical analysis. Methods: In 3 non-lame horses back movements were measured using inertial measurement units fixed at T6, T12, T16, L2 and L5 vertebrae. 2D reflective markers, pressure mat and stirrup force sensors were used to assess the rider’s chest inclination and the horse-saddle-rider interactions. Three horses were trotted at the right rising trot (3.8 m/s) by the same rider using randomly CP (60 strides) and STD (80 strides). Conditions were compared using linear mixed-effects regression models. The estimated means (SE) were calculated (P<0.05). Results: During the sitting phase, pressure in the cranial and middle areas of the saddle significantly increased for CP compared to STD (+0.9(0.2) kPa; +1.0(0.1) kPa respectively) while caudal pressure decreased (-1.8(0.4) kPa). Concurrently, the range of motion (ROM) of angles T12-T16 and T16-L2 under the saddle significantly increased (+1.8(0.2)°; +2.3(0.3)° respectively) with CP. The rider stood straighter (about 2°) with CP and transferred his weight more caudally, which was confirmed by the backward displacement of the centre of pressure. No differences were found for stirrups force. Conclusions: These preliminary results showed that modifications of the panels’ shape not only affect the pressure distribution (more homogeneous pressure distribution along the longitudinal axis) but also induce changes (increase ROM) in the kinematics of the equine back under the saddle.

Ethical animal research: The study was approved by the Animal Ethics Committee Anses/ENVA/UPEC, France (number 16) with the number 15-042. All the horses are owned by the Ecole Nationale d’Equitation. Permission to examine them was granted by their representative. Sources of funding: Institut Français du Cheval et de l’Equitation, the Association Nationale de la Recherche et de la Technologie, the Conseil Régional d’Aquitaine and the Pôle Hippolia. Competing interests: None declared.

CHANGE IN FORCE ON THE SUPERFICIAL DIGITAL FLEXOR TENDON DUE TO FATIGUE IN THOROUGHBRED HORSES

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Reasons for performing study: Digital flexor muscles dysfunction caused by fatigue appears to be one of the causes of injury in the superficial digital flexor tendon. However, there is little information regarding fatigue-induced changes in force on the muscle tendons and the suspensory ligament (SL). Objectives: To evaluate the fatigue-induced changes in force on the superficial digital flexor tendon (SDFT), the deep digital flexor tendon (DDFT), and SL. Study Design: Intervention study. Methods: Ten healthy Thoroughbred horses were used (body mass, 460–549 kg, age, 4–9 years) for the experiment. The forces in SDFT, DDFT, and SL during trotting before and after standardized treadmill exercise protocols until fatigue were measured using a previously reported model [1]. The effect of fatigue on the forces in these tendons and ligament was compared using a paired t-test. Results: The speed and the ground reaction force did not change during trotting before and after exercise that induces fatigue. SDFT force at trot decreased with fatigue but this was not statistically significant (P=0.1, 5,221 +/- 1,852 N, 4,553 +/- 1,502 N, before and after fatigue exercise, respectively), whereas SL force at trot increased (P=0.01, 12,053 +/- 1,227 N, 13,088 +/- 796 N, before and after fatigue exercise, respectively). DDFT force at trot did not change with fatigue. Conclusions: Fatigue in the digital muscles might not be a major cause of injury in SDFT, as SDFT force decreased with fatigue.

Ethical Animal Research: The study was approved by the Animal Welfare and Ethics Committee of the Japan Racing Association Equine Research Institute. Sources of funding: Japan Racing Association. Competing interests: None declared.


HOW MANY MOTOR UNITS ARE DETECTED BY A STANDARD SURFACE EMG?

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Reasons for performing study: Surface EMG signals are used to present the activity pattern of a muscle. The signal depends highly on the measurement setup (position of the electrodes, size of the muscle, contraction level, etc.). The goal was to create a model of the equine longissimus dorsi muscle and simulate specific EMG signals as a sum of the motor unit action potentials (MUAP). Objectives: To simulate a surface EMG signal of a specific movement, with as few as possibly MUAP’s involved. Study design: Experimental Study. Method: The generation of the activation signal and comparison with a recorded EMG signal (sample rate 2 kHz, Trigno™, Delsys Inc., USA) was done in Matlab® R2015b with Simulink® Version 8.6 (The Math Works, Inc., USA). A single action potential (SAP) was generated, and convolved with a Dirac comb, which represents the fire rate, to get the activation signal of one muscle unit (MU). The superposition of all MU signals, which differ in amplitude, polarity and fire rate, equals the generated EMG signal. For comparison least mean square error and the Pearson correlation were calculated. Results: The generated muscle activation signal was built up with 6 MU’s and showed a significant correlation coefficient (0.82, P<0.01) for a sequence of hundred samples (50ms). A least mean squares error of 6% was calculated. Conclusions: With a quantity of six signals (MU=6), it was possible to rebuild a surface EMG course with an acceptable goodness of fit (0.647). Signals of MU’s close to the surface are represented stronger by the surface EMG than MU’s with higher distance. Based on this knowledge we conclude that a surface EMG allows only an assumption about how the exact innervation of a muscle. Due to missing information, the simple approach of homogeneous innervation is chosen most often.

Ethical Animal Research: Not applicable. Source of funding: None. Competing interests: None declared.

WHAT IS THE EFFECT OF DIFFERENT MAINTENANCE TECHNIQUES ON SURFACE CHARACTERISTICS OF THREE DIFFERENT SAND-BASED ARENA SURFACES IN THE UK?

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Friday, August 19th

Reasons for performing the study: There has been limited study on the effect of maintenance on the properties of arena surfaces used by sports horses. Objectives: Describe how different maintenance equipment affects the properties of sand-based equestrian surfaces within an arena. Study design: Surface testing experiment. Methods: Test arenas were tested before maintenance with the Orono Biomechanical Surface Tester [1] and again after two different maintenance techniques. Thirty sand with rubber (SR), 20 sand with fibre (SF) and 21 waxed-sand with fibre (WSF) arenas were recruited. Two maintenance techniques were tested on each arena (one per half to ensure similar weather conditions): 1) the venue’s own equipment (harrow, leveler or roller) 2) study standard (SS) equipment; a ‘Keep-A-Level’ with 5cms tines and a levelling bar. Data were collected on impact firmness, cushioning, responsiveness and grip pre- and post-maintenance. Student’s paired t-test, or a Wilcoxon-signed rank test were used as appropriate, to compare the mean values of the properties after maintenance with different equipment (P<0.05). Results: Harrowing WSF significantly increased cushioning and decreased grip; SS significantly decreased grip. Impact firmness and responsiveness were not affected by either equipment. Harrowing SF significantly changed surface responsiveness, rolling significantly increased impact firmness and grip and SS significantly decreased grip. Harrowing SR significantly increased impact firmness and decreased cushioning; levelling and SS significantly increased impact firmness. Conclusions: Effect of maintenance appears to be specific to the surface and equipment used. Maintenance of a SF surface with two different pieces of maintenance equipment resulted in opposite changes in grip. Care should be taken when selecting maintenance equipment based on the surface requiring treatment and what needs to be achieved.

Ethical Animal Research: Not applicable. Sources of Funding: The Animal Welfare Foundation Norman Hayward Fund (project number: NHF_2013_12_CT). Competing interests: None declared. Acknowledgements: The authors are grateful to the venues for their time and use of their arenas and Jessica Cooke and Karen Sweet for assisting with data collection.


THE INFLUENCE OF SURFACE PROPERTIES ON GROUND REACTION FORCES IN TROTTING HORSES DETERMINED BY MODELLING

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Reasons for performing study: Arena properties can be modelled by a nonlinear spring and damper arrangement in series with the leg spring and damper. Simulation of ground reaction force (GRF) elucidates the influence of surface properties on the representative curve appearance in vivo. Objectives: To analyse the influence of surface stiffness (k_s) and energy restitution (ER_s) on the shape of the GRF curves in trotting horses. Study design: Analytical. Methods: Calculation and analysis of GRF model composed of springs, dampers and leg spring parameters. Results: The slope of the GRF (load rate) after impact is proportional to k_s*V_0 (V_0=impact velocity). The k_s in horizontal direction can be estimated from vertical k_s by applying Poisson’s ratio (k_s, vertical~3k_s, horizontal). During mid stance the leg spring k_leg acts in series with k_s, resulting in k_tot. The latter determines the dynamic component of the peak force $F_{max} = mg + \sqrt{2mg\Delta z k_{tot}}$ with m=½BWT and $\Delta z$=deflection of COM. Leg stiffness adapts to surface stiffness to keep k_tot and in turn $\Delta z$ almost constant. The area under the GRF curve (impulse) needs to be maintained for a certain performance. Therefore a smaller k_tot reduces $F_{max}$ and in turn increases stance duration and stride frequency. The oscillation in the GRF raising limb is proportional to $\sqrt{k_s}$. The damping ratio DR_s, or -in other words- ER_s determines the amplitude (overshoot). The influence of ER_s on GRF sometimes interpreted as responsiveness however is small because ER_s is typically ten times smaller than ER of tendons. Moreover, the latter stores more energy due to its smaller stiffness ($k_{tot}$<k_s). Conclusions: Modelling the GRF with surface parameters enables the prediction of amplitude and shape and may indicate potentially harmful conditions. However, verification of the model needs simultaneous surface and in vivo measurements.

Ethical Animal Research: Not applicable. Sources of funding: None. Competing interests: None declared.
RIDERS PREFERENCES FOR ARENA CHARACTERISTICS IN SHOW JUMPING


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Reasons for performing study: Athlete guided assessments of equestrian arena surfaces can help provide information on the perceived importance of surface functional properties. Objectives: To investigate how rider-assessed overall rating of show jumping competition and warm-up arenas relate to subjective perception and objective measurements of specific functional properties of the arenas. Study design: Observational. Methods: Twenty-five show jumping arenas in nine 5 and 4* events were subjectively evaluated by 198 riders participating in the competitions, giving 669 arena evaluations. Riders gave an overall rating and rated six functional characteristics on visual analogue scales: impact firmness, cushioning, responsiveness, grip, uniformity and consistency. The Orono Biomechanical Surface Tester was used to objectively measure peak acceleration (impact firmness), peak load (cushioning), forward hoof slide during loading (grip), quotient of the compression and recoil time (responsiveness), and mean of coefficients of variations for all parameters (uniformity) on all arenas (consistency was not measured). The subjective assessments and objective measurements were used as explanatory variables in mixed models created to investigate how they affected the riders’ overall arena ratings. Arena, rider and rider-event clustering was controlled for (P<0.05). Results: Subjectively, impact firmness had significant two-way interactions with cushioning (P<0.0001), responsiveness (P=0.001) and consistency (P=0.007) when explaining overall score. Estimated effect of uniformity on overall score was 1.39 (P<0.0001). Grip did not have a significant effect. Objectively, cushioning interacted with responsiveness and grip influencing the overall score; interaction of grip with responsiveness was also found. Impact firmness and uniformity had no significant effect. Conclusions: The riders preferred higher firmness, less cushioning (more compacted), more responsive and more uniform surfaces during competition (subjectively assessed), referring to the spectrum of surfaces used at this competition level. The interacting effects of both subjective and objective surface properties emphasises the need to consider several functional properties to elucidate surface performance.

Ethical Animal Research: Participating riders gave their consent to be included in the study. Sources of funding: FEI (Fédération Equestre Internationale) Competing interests: None declared.
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<td>1Buchner, H., 2Zimmer, L., 1Haase, L., 3Perrier, J., 4Peham, C.</td>
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<td>ELECTROMYOGRAPHIC EVALUATION OF HINDLIMB MUSCLE ACTIVITY PATTERNS IN ELITE AND NON-ELITE JUMPING ATHLETES: A PRELIMINARY REPORT ON SURFACE ELECTROMYOGRAPHY DATA</td>
<td>1St.George, L., B., 2Richards, J., 3Holt, D., 1Sinclair, J. and 1Hobbs, S. J. Email: <a href="mailto:lbst-george@uclan.ac.uk">lbst-george@uclan.ac.uk</a></td>
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<td>1Gorissen, B.M.C., 2Wolschrijn, C.F., 3Serra Bragança, F.M., 3Geerts, A.A.J., 3Leenders, W.O.J.L., 2Back, W., 2van Weeren, P.R.</td>
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<td>ISTRUNK MOVEMENT SYMMETRY BEFORE BREAKING-IN PREDICTIVE FOR SYMMETRY AFTER BREAKING-IN OF YOUNG HORSES?</td>
<td>1Nissen, A.L., 2Andersen, P.H., H., 1Buhl, R., Kühnel, L., 1Thom</td>
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<td>Thilo Pfau</td>
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EFFECTS OF WHOLE BODY VIBRATION (WBV) ON THE HORSE: ACTUAL VIBRATION, MUSCLE ACTIVITY, WARM UP AND RIDEABILITY.

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Reasons for performing study: Whole body vibration exercise (WBV), or „power plates” have been introduced into human sports and recently also equine training and rehabilitation. There is little knowledge about physical and physiological effects of WBV exercise on the standing horse. Objectives: At first we clarified the actual vibration of a commercial vibration plate, the induced body vibration and muscular activity in limbs and back. Furthermore, WBV effects on vital parameter, skin surface temperature and rideability of the horses was evaluated. Study design: Descriptive and experimental study. Methods: 10 sound horses (Vibration and muscle activity 6 horses), all habituated to the vibration device, were tested. Vibration (accelerometry) and muscle activity (EMG) were recorded while standing on the device without vibration (control) as well as during 10 min vibration exercise with 15 and 25 Hz (producer specification). Vibration of plate, hoof, fetlock, withers and sacrum were analyzed for vibration frequency, peak to peak displacement and peak acceleration. Muscle electric activity is evaluated for M. triceps, M. quadriiceps and M. longissimus dorsi. Warm up effect and rideability were compared between 4 warm up scenarios: standing (control), 10 min vibration, 10 min longping (walk) and 12 min longping (walk and trot), determining clinical parameter (core temperature, pulse and respiration rate) and maximal skin temperature of upper arm, thigh and back. Rideability is evaluated by a blinded rider questionnaire. ANOVA for repeated samples as well as t-tests were used for statistical analysis (P<0.05). Results: Actual vibration was found to be 7.2 and 11.4 Hz respectively with a varying peak-to-peak displacement between 4 mm and 9 mm mainly in horizontal, forward-backward direction. Vibration exercise did not cause additional EMG activity, changes in vital parameter, skin temperature or rideability. Conclusions: Vibration exercise using horizontal vibration was not effective enough for warm up purposes.

Ethical Animal Research: The study protocol was approved by the Ethics committee of the university. Informed client consent was obtained. Sources of funding: None. Competing interests: None declared.

ELECTROMYOGRAPHIC EVALUATION OF HINDLIMB MUSCLE ACTIVITY PATTERNS IN ELITE AND NON-ELITE JUMPING ATHLETES: A PRELIMINARY REPORT ON SURFACE ELECTROMYOGRAPHY DATA

1St George, L. B., 2Richards, J., 3Holt, D., 1Sinclair, J. and 1Hobbs, S. J.
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Reasons for performing study: Differences in jump technique in experienced and inexperienced jumping horses have been described. No studies have investigated differences in muscle activation between elite and non-elite athletes. Objectives: To quantify differences in hindlimb muscle activity between elite and non-elite jumping horses and whether differences in neuromuscular strategies exist between groups. Study design: Exploratory. Methods: Surface electromyography (sEMG) (2088Hz) and 3D kinematics (232Hz) were collected synchronously from elite (n=7) (age: 10.4±2.6 years, sex: three mares, four geldings, breed: Warmblood) and non-elite (n=7) (age: 9.7±1.7 years, sex: three mares, four geldings, breed: various) horses. sEMG data were collected using electrodes, placed on shaved and cleaned areas over the muscle belly of superficial gluteal (SG) and biceps femoris (BF). Horses performed six canter (average speed: 4.85±0.53m/s) and jump trials over a 1.0m fence (average approach speed: 6.20±0.58m/s). Integrated EMG (iEMG) (µV.s) were calculated for hindlimb stance phases (StP) during canter, jump approach and take-off. iEMG for each horse and muscle was normalised to the maximum iEMG observed during canter. Mixed measures ANOVA was used to examine intra-horse and inter-group differences in StP iEMG. Results: Average normalised SG StP iEMG (%) significantly (P<0.05) increased from 64.1±24.2 and 71.4±19.3 during canter StP to 107.6±50.3 and 166.7±95.6 during approach StP and to 439.8±182.0 and 507.0±499.2 during take-off StP in elite and non-elite groups, respectively. Average BF iEMG significantly (P<0.05) increased from canter to approach and take-off StP, with both groups exhibiting similar average iEMG for all StP. No significant differences were found (P>0.05) between groups for iEMG. Conclusions: Both groups employed similar neuromuscular strategies in BF during jump and canter. Although not significant, different strategies are apparent in SG between groups, with elite horses requiring less muscular effort at take-off. Increased variability in non-elite SG iEMG may account for lack of significant differences.
Ethical Animal Research: The study was approved by the University of Central Lancashire’s ethics committee (RE/13/04/SH). Owners provided informed consent. Competing Interests: None declared. Sources of Funding: None.

THE DEVELOPMENT OF GAIT KINETICS IN THE FOAL AND THE EFFECT OF OSTEOCHONDROSIS.

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Reasons for performing the study: As a precocious species, foals are known to stand and walk immediately after birth. However, insight in the subsequent longitudinal development of equine gait kinetics in the early juvenile phase is limited and there is no data on the possible effect of the most common developmental orthopaedic disease in the horse, osteochondrosis (OC). Objectives: To quantify gait kinetics in foals during the first half year of life and investigate the possible influence of osteochondrosis. Study design: Cohort study at a single stud farm. Methods: Pressure plate measurements at walk and trot were taken from eleven Dutch warmblood foals during the first 24 weeks of life to determine peak vertical force (PVF), vertical impulse (VI) and stance duration (StD). Coefficients of variation of PVF and StD were calculated as a measure of gait maturity. Radiographs of stifles and hocks were taken at 4-6 weeks and > 6 months to check for OC(D). A linear mixed model was used to determine the effects of age, limb, presence of OC and speed on gait parameters. Results: Speed at walk and trot increased over time, but body weight normalized PVF values stayed relatively constant, whereas StD and body weight normalized VI increased. None of the foals was visibly lame, but presence of OC led to a temporary but significant reduction in body weight normalized PVF, indicative of subclinical lameness. Variability of StD decreased rapidly during the first weeks of life and then more slowly. Conclusions: Gait and balance need time to mature in foals. Body weight normalized peak vertical forces are relatively constant during growth, although speed increases. Presence of subclinical OC lesions may lead to temporary changes in pressure plate parameters, making this device into a potential first screening tool.

Ethical Animal Research: This study was approved by the ethical committee of Utrecht University (DEC no.2014.III.04.038) and owner informed consent was obtained. Sources of Funding: None. Competing interests: None declared.

EFFECT OF SHOEING METHOD ON EX-VIVO IMPACT VIBRATIONS IN THE EQUINE FORELimb


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Reasons for performing study: Many horses in the UK are restricted to road exercise. This could increase their risk of distal limb osteoarthritis and lameness. Objectives: To determine the effect of different shoeing conditions on impact vibrations. Study design: Ex-vivo impact simulation, novel experimental method. Methods: The dorsal hoof walls of seven cadaver horse forelimbs were instrumented with one high range (1000x gravity, 5000 samples/s) 3D accelerometer. Limbs were mounted on a custom designed device which enabled a lightly pre-loaded limb to travel under gravity, and impact a bitumous-macadam surface, mimicking hoof-surface contact equivalent to trot at approximately 3m/s. Unshod (UNSHOD), shod with a plain, concave steel shoe (SHOD) and a shoe plus sole packing material (PACK) were tested. Shoe order was randomized and three trials were carried out for each limb under each condition. Total and maximum signal power (MAX), up to 1503Hz, and frequency of maximum power (FMAX) were calculated from FFT of acceleration signals from impact to 20ms after to characterize impact vibrations. Parameters were assessed using descriptive methods and mixed model analysis, on log transformed parameters, in SPSS. Results: In the proximodistal direction, along the dorsal hoof wall, Median (IQR) FMAX increased from 97Hz (39Hz) UNSHOD to 117Hz (156Hz) PACK and 175Hz (205Hz) SHOD conditions with a significant difference between UNSHOD and SHOD conditions (P=0.04). Median (IQR)
MAX in the proximodistal direction was 10437G² (8036G²) in UNSHOD conditions which was significantly higher compared to 8440G² (7025G²) in SHOD (p=0.024) and 8254G² (9411G²) in PACK (P=0.002). There was no significant difference in TOTAL or MAX in the craniocaudal direction. Conclusions: The unshod foot may experience vibrations of higher maximum power in the proximodistal direction but shod conditions can result in higher frequency vibrations during primary impact. The consequences for live horses require further investigation.

Ethical Animal Research: Cadaver studies conducted with approval of the Royal Veterinary College’s Ethics and Welfare Committee. The animals were derived from an abattoir and the abattoir gave consent. Sources of funding: RVC. Competing interests: None declared.

TOE-HEEL AND MEDIO-LATERAL HOOF BALANCE AND HOOF LANDING PATTERNS IN SOUND, UNSHOD STANDARDBRED HORSES

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Reasons for performing study: Pressure plate analysis of hoof balance has been limited to Warmblood horses. Objectives: To evaluate hoof balance and landing patterns in sound Standardbred horses with mild differences in hoof conformation. Study design: Cross-sectional study. Methods: Twenty-four unshod Standardbreds were clinically evaluated (hoof conformation, soundness) and walked/trotted over a pressure plate (RSscan International, Paal, Belgium) to obtain peak vertical force (PVF), vertical impulse (VI) and stance time (ST) of the landing phase. Results: At a velocity of 1.57±0.17m/s (walk) and 3.37±0.45m/s (trot), there was no significant effect of conformation on asymmetry of PVF, VI and ST. Flat landing was more frequent (39.6% and 70.8% of trials at walk and trot, respectively) than described in Warmbloods, highlighting the need for breed-specific reference data. There are reports on altered hoof balance with severe conformational defects, but this study suggests that, in Standardbreds at least, mild deviations in conformation do not necessarily affect hoof balance.

Ethical animal research: The study was approved by the ethical committee of the Faculty of Veterinary Medicine of Ghent University (n°2013/165). Owner provided informed consent. Sources of funding: This study was part of a larger project funded by Nutriquine N.V. (Drongen, Belgium) and Sonac, a Darling Ingredients brand (Son, The Netherlands). Competing interests: None declared. Acknowledgement: The help of H.T. Politiek and K. Tampere was greatly appreciated.

AXIAL COMPONENTS OF 3D ACCELERATION IN HORSES WITH DIFFERENT SHOEING


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Reasons for performing study: Different shoeing techniques can modify total effort in musculoskeletal system. Objectives: To investigate accelerometric changes due to six degrees heel or toe elevation in horses. Study design: Randomised trial of shoe designs. Methods: Eight sound adult Arabian horses were shod in the forelimbs with conventional shoes or six-degree heel or toe elevation shoes. All horses were submitted randomly to all shoeing technique with two-week intervals apart. With an accelerometric device at the sternum, horses were ridden for 120 meters on asphalt at trot and the velocity controlled by a GPS (Polar Equine RS-300X G1®), with uniform
speed 2.86±0.29m/s. Dorsoventral power (W/kg), propulsion power (W/kg) and total power (W/kg) were obtained by accelerometry data (Equimetrix™) sampled at 50Hz during ten seconds. Data were filtered by low-pass filter 50Hz (by hardware) than high-pass filter 1Hz (by software) with numerical results calculated by the software Centaure Métrix (Centaure Métrix, Fontainebleau, France). Power values were calculated by integrating over ten seconds of data acquisition, aproximately 16 strides. Data were submitted to ANOVA and means were compared by post-hoc paired t-test, with significance level P<0.05. Results: Compared to conventional shoe, at the same exercise intensity, heel elevation induced a significant decrease in all studied acceleration components. Dorsoventral power decreased 25.9% (P=0.02), propulsion power 35.5% (P=0.02) and total power 29.2% (P=0.02). Conclusions: Under this study conditions, our data suggest that, since power is proportional to acceleration, heel elevation might decrease total hoof impact due to a minor angular rotation around the fulcrum, as well as energetic cost during locomotion and musculoskeletal system loads. The impact of these findings on dressage and jumping horses need to be investigated.

Ethical Animal Research: The local Ethical Animal Welfare Committee approved this study. Sources of funding: FAPESP processes #2014/18232-8 and #2013/26783-1. Competing interests: None declared.

IS TRUNK MOVEMENT SYMMETRY BEFORE BREAKING-IN PREDICTIVE FOR SYMMETRY AFTER BREAKING-IN OF YOUNG HORSES?

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Reasons for performing study: Breaking-in and training for first show is costly. Movement symmetry may be of interest as a screening tool to support selection of horses for education. Objectives: To investigate effect of initial symmetry on symmetry after breaking-in. Study design: Observational study during breaking-in of young horses. Methods: Twenty-six horses trained in the same yard with the purpose of mare grading or sale were included. Data was collected using a 3D accelerometer mounted dorsally in the thoracic midline during an in-hand trot on a hard surface in a straight line. Initial symmetry measurement was conducted when the horse was familiar with girth and handling. The second measurement was after approximately 7 weeks of ridden exercise (final symmetry). Data on rider and exact training period were recorded for each horse. Based on trunk accelerations of eight strides measured at 240Hz, two symmetry indices were calculated: overall symmetry (Index S) and symmetry of diagonal limb loading (Index |A|). Linear regression with rider, training period, and initial symmetry (S₁ or |A₁|) as covariates and final symmetry (S₂ or |A₂|) as response were performed. Results: Each rider had responsibility for educating 1, 4, 5, 5 and 11 horses, respectively. The median training period was 49 days (range: 34-67 days). Rider and training period were not significant for any response. Index S₁ had statistically significant effect on S₂ (P<0.01); slope estimate 0.46; 95% CI [0.098, 0.813]. The effect of |A₁| on |A₂| was not significant. Conclusions: Rider and the length of the training period did not influence final symmetry in this yard. Final overall symmetry was affected by initial symmetry such that horses with high (low) are expected to present with high (low) symmetry after the training period. However, large variation between horses implied that the impact for screening might be limited.

Ethical animal research: Informed consent for data collection was obtained from the general manager and responsible person of the horses and training. Competing interests: None declared. Sources of funding: The University of Copenhagen, the Jubilee Fund of the Royal Danish Horse Insurance Company and Kustos.