Pressure plate analysis for the dynamic evaluation of toe-heel balance at the walk and trot in sound horses

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Introduction

Common equine locomotor pathologies like laminitis and navicular disease alter the toe-heel balance with an increase, respectively a decrease in loading of the heel region. Therefore, the assessment of hoof balance should be an integral part of a lameness examination. However, hoof balance is traditionally evaluated using a static visual observation and even for an experienced clinician, subtle abnormalities may not be readily observable, especially at gaits faster than walk. Pressure plate analysis has been used to objectively evaluate the hoof-unrollment pattern[1] and limb-loading symmetry[2]. The aim of this study was to use a pressure plate for the objective evaluation of toe-heel balance in normal, sound horses throughout the stance phase.

Materials and methods

Seven sound Dutch Warmblood horses (11 ± 4 years; 539 ± 28 kg) were led at the walk and trot over a pressure plate (Footscan 3D 1m-system, RsScan International) with dedicated software (Footscan Scientific Gait 7, RsScan International), mounted on top of a force platform (Z4852C, Kistler), embedded in a 20m long track, covered with a 5mm rubber mat. A trial was considered valid if the horse moved at a constant pace, looking straight forward, while gait velocity was within a preset range and the hoof of at least one forelimb fully contacted the plate surface. Five valid measurements were collected for both forelimbs. Hoof prints were divided in a toe and heel region by a line through the maximal hoof width. The vertical force (VF) was recorded for the toe and heel region at every single time frame (250 Hz), and toe-versus-heel hoof balance was calculated as: $[(VF_{TOE} - VF_{HEEL}) / 0.5 (VF_{TOE} + VF_{HEEL})] \times 100\%$. Left and right hoof balance of the vertical force at the walk and trot were presented as mean ± SD curves throughout the stance phase.

Results

The left and right limb balance showed a similar pattern at the walk and the trot for all horses. In general, the balance curve started below zero (i.e. heel landing) and quickly changed to slightly positive values during the first 5% of stance. Subsequently, the balance index remained low (i.e. similar toe and heel values). Finally, from 60-65% of stance, a gradual increase was observed, towards a maximal value at toe-off.

Discussion

Pressure plate analysis allowed objective and dynamic evaluation of the toe-versus-heel balance. Normative forelimb data of sound horses were obtained at the walk and trot. A limitation of this study is the manual subdivision in a toe and heel region, based on the widest part of the hoof. In humans, it has been shown that manual region definition is subjective to bias, the landmarks being anatomical rather than functional[3]. Moreover, the subdivision in a toe- and heel-region is a rather low-resolution view of the continuous hoof-ground interaction and based on recent advances in humans, analysis on a pixel-level[4] should be explored.

References

1. Van Heel, M.C.V., Van Weeren, P.R. and Back, W. Shoeing sound warmblood horses with a rolled toe optimises hoof-unrollment and lowers peak loading during breakover. *Equine vet J.* 38: 258-62, 2006.
2. Oosterlinck, M., Pille, F., Back, W., Dewulf, J. and Gasthuys, F. Use of a stand-alone pressure plate for the objective evaluation of forelimb symmetry in sound ponies at walk and trot. *Vet. J.* 183: 305-309, 2010.
3. Pataky, T.C., Caravaggi, P., Savage, R. and Crompton, R.H. Regional peak plantar pressures are highly sensitive to region boundary definitions. *J. Biomech.* 41: 2772-2775, 2008.
4. Pataky, T.C. and Goulermas, J.Y. Pedobarographic statistical parametric mapping (pSPM): a pixel level approach to foot pressure image analysis. *J. Biomech.* 41: 2136-2143, 2008.