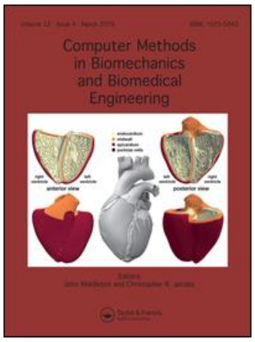

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Computer Methods in Biomechanics and Biomedical Engineering

ISSN: 1025-5842 (Print) 1476-8259 (Online) Journal homepage: https://www.tandfonline.com/loi/gcmb20

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To cite this article: N. Crevier-Denoix, F. Munoz-Nates, M. Camus, B. Ravary-Plumioen, J.M. Denoix, P. Pourcelot & H. Chateau (2017) Comparison of peak vertical force and vertical impulse in the inside and outside hind limbs in horses circling on a soft surface, at trot and canter, Computer Methods in Biomechanics and Biomedical Engineering, 20:sup1, S51-S52, DOI: 10.1080/10255842.2017.1382856

To link to this article: https://doi.org/10.1080/10255842.2017.1382856

Published online: 27 Oct 2017.

COMPUTER METHODS IN BIOMECHANICS AND BIOMEDICAL ENGINEERING, 2017
VOL. 20, NO. S1, S51–S52
https://doi.org/10.1080/10255842.2017.1382856

Comparison of peak vertical force and vertical impulse in the inside and outside hind limbs in horses circling on a soft surface, at trot and canter

N. Crevier-Denoix[a], F. Munoz-Nates[a], M. Camus[a], B. Ravary-Plumioen[a], J.M. Denoix[b], P. Pourcelot[a] and H. Chateau[a]

[a]Unité 957, BPLC, INRA, Ecole Nationale Vétérinaire d'Alfort, Université Paris Est, 94700, Maisons-Alfort, France; [b]CIRALE, Unité 957, BPLC, Ecole Nationale Vétérinaire d'Alfort, 14430, Goustranville, France

KEYWORDS Hind limb; circle; horse; outside limb; ground reaction force

1. Introduction

In horses, lameness is often more pronounced on a circle, compared to straight line (Ross and Dyson, 2011). At trot, some lameness conditions worsen when the affected limb is on the inside of the circle while others worsen when the affected limb is on the outside. In addition to asymmetrical loading of the anatomical structures (e.g. loading of the medial structures increased on the outside limb), an increased overall loading of the outside limb has been demonstrated in the forelimb. In horses circling at trot, Chateau et al. (2013) using a dynamometric horseshoe, demonstrated that the peak vertical force during stance is significantly larger on the outside forelimb. However to date, no kinetic data is available in the hind limb.

In sport horses it is usual to lunge horses on circles, at trot but also at the canter, on soft ground, for training or rehabilitation purposes. Contrary to trot, canter is an asymmetrical gait. Previous studies using force plates (Merkens et al., 1993) have shown that in a horse cantering in straight line, the trailing hind limb (first to land) supports the lowest peak vertical force. At the canter on a circle, the inside limbs are the leading limbs, and the outside limbs, the trailing limbs. If load distribution is similar in circle as in straight line, this would imply that the outside hind limb would support the lowest peak vertical force, which would then be the opposite as what could be hypothesized given the previous results obtained at trot on the forelimb (Chateau et al. 2013).

Therefore, the objective of the present study was to compare the peak vertical force and vertical impulse measured in the outside and inside hind limbs in horses circling, both at trot and canter, on a soft surface.

2. Methods

Three clinically sound saddle horses (mean (SD): 8 (1) years, 590 (18) kg) were used. After trimming, the right hind hoof of each horse was equipped with a dynamometric horseshoe (DHS), composed of 4 triaxial piezoelectric force sensors (9251A, Kistler) sandwiched between two aluminium plates (Chateau et al., 2013). A non-instrumented horseshoe with matching height and weight was attached to the left hind, as well as to both fore hooves. The hoof reaction force was calculated as the sum of forces applied on each sensor and was expressed in a local reference frame with the vertical (Z) axis perpendicular to the solar plane of the shoe, pointing downward.

The DHS wires were connected an analogue-to-digital converter (NI-USB 6218) plugged in a computer remotely controlled (Wi-Fi). Data were acquired at 7.8 kHz. The horse's speed was measured and recorded by a global positioning system (GPS, Racelogic RLVBSS 100), the antenna of which was glued to the horse's croup. The complete acquisition system was placed in saddle bags.

The horses were lunged on a 5-m radius circle, on a sand&fiber mix surface, at trot then canter, alternatively at both hands. The equipped right hind limb was inside the circle at the right hand, and outside the circle at the left hand.

For each trial, force and speed data were recorded on 10 successive strides. For each horse, 4 trials were selected for each condition. The stance phase was delimited (100 N vertical force threshold). Customised programmes developed in Matlab (MathWorks) were used to determine the peak vertical force and vertical impulse of each stance.

Linear mixed-effects regression models were used in order to compare left and right circle conditions at each gait, taking into account repeated measurements per horse within each trial and adjusted for speed (SAS 9.2). Significance was set at $p < 0.05$.

CONTACT N. Crevier-Denoix nathalie.crevier-denoix@vet-alfort.fr

Table 1. Means (SD) and estimate of stance and vertical loading parameters in 3 horses at trot and canter, on right and left circles, on a soft surface.

	Trot					Canter				
	Right circle (inside hind limb)		Left circle (outside hind limb)			Right circle (inside hind limb)		Left circle (outside hind limb)		
	Mean (SD)	Estimate	Mean (SD)	Estimate	*P*	Mean (SD)	Estimate	Mean (SD)	Estimate	*P*
Stance duration (s)	0.316 (0.013)	0.319	0.284 (0.015)	0.284	<.0001	0.276 (0.016)	0.278	0.244 (0.013)	0.244	<.0001
Stance/stride duration (%)	43.6 (1.7)	43.7	38.8 (1.2)	38.8	<.0001	46.2 (2.1)	46.4	40.6 (1.7)	40.6	<.0001
Peak vertical force (N/kg)	9.16 (0.71)	9.13	9.70 (1.16)	9.71	0.0003	9.44 (0.90)	9.26	11.26 (1.29)	11.33	<.0001
Vertical impulse (N.s/kg)	1.79 (0.15)	1.80	1.70 (0.25)	1.70	0.001	1.68 (0.15)	1.66	1.69 (0.16)	1.69	0.098

3. Results and discussion

Among the 3 horses, speed was not significantly different between left and right circles at trot (3.47 (0.22) and 3.52 (0.24) m/s, respectively), while it was at the canter (4.43 (0.36) and 4.58 (0.31) m/s).

Stance duration and stance/stride duration ratio were significantly larger on the inside hind limb (Table 1), alike what has been observed on the forelimbs for similar speeds (3.26 and 3.28 m/s, respectively on right and left circles; Chateau et al. 2013).

Peak vertical force was significantly higher on the outside hind limb, both at trot and at the canter (Table 1 and Figure 1). The values measured here on hind limbs at trot are lower than those measured on forelimbs (11.75 and 10.92 N/kg, respectively in the outside and inside forelimbs; Chateau et al., 2013), but the difference between outside and inside limbs is similar (about 6% here vs. 7% on forelimbs).

The difference in peak vertical force between outside and inside hind limbs was more than 3.5 times larger at the canter compared to trot. While the increase from trot to canter was about 1% on the inside hind limb, it was 17% on the outside hind limb. Comparing with canter in straight line (Merkens et al., 1993; speed: 4.4 to 5.6 m/s), peak vertical forces were rather similar in amplitude but distribution between the leading (inside the circle) and trailing (outside the circle) hind limbs was inverted (11.28 N/kg in the leading hind limb and 9.95 N/kg in the trailing hind limb, in straight line).

Vertical impulse was larger on the inside hind limb at trot, a result also observed on forelimbs (although not significantly on the soft surface in Chateau et al., 2013). This is due to the increased stance time on the limbs inside the circle. However, at canter, the vertical impulse of the outside hind limb tended to be larger than that of the inside one ($p = 0.098$), in spite of a shorter stance duration. Again, this is different from canter in straight line, where vertical impulse of the trailing hind limb was the lowest of all 4 limbs (1.31 N.s/kg, vs. 1.55 N.s/kg in the leading hind limb; Merkens et al., 1993).

4. Conclusions

In horses on a circle, peak vertical force in the outside hind limb is larger than in the inside one, both at trot and canter, but the inter-limb difference is more than 3.5 times larger at the canter compared to trot.

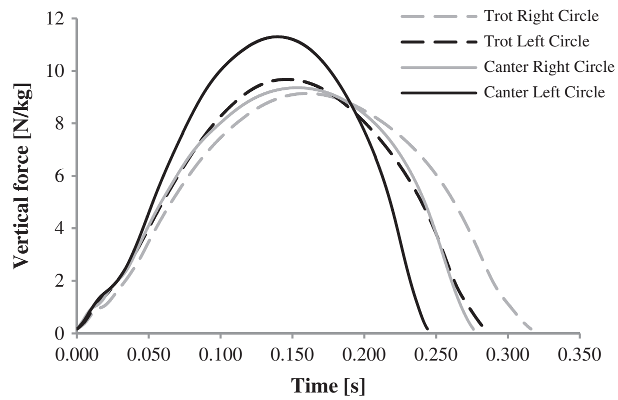

Figure 1. Average vertical forces in the leading (right circle, grey) and trailing (left circle, black) hind limbs of 3 horses at trot (dotted line) and canter (solid line).

These results have applications in the context of rehabilitation. Some conditions, for instance proximal suspensory desmitis, are known to be worse (horse more lame) at trot when the affected limb is outside the circle. From the results of this study, lungeing at the canter a horse suffering from hind limb proximal suspensory desmitis on a circle opposite to the affected limb (e.g. left circle in case of a right hind limb suspensory desmitis) should be definitely avoided; only circles on the side of the affected limb should be recommended.

Acknowledgements

The Région Basse-Normandie, FEDER, Fonds Eperon and IFCE for financial support; the Haras du Pin (IFCE), Garde Républicaine de Paris, and Centre Sportif d'Equitation Militaire de Fontainebleau, for loaning the horses; the firm Toubin & Clément for providing the experimental site and surface.

References

Chateau H, Camus M, Holden-Douilly L, Falala S, Ravary B, Vergari C, Lepley J, Denoix JM, Pourcelot P, Crevier-Denoix N. 2013. Kinetics of the forelimb in horses circling on different ground surfaces at the trot. Vet J. 198 Suppl 1: 20–26.

Merkens HW, Schamhardt HC, Van Osch GJVM, Hartman W. 1993. Ground reaction force pattern of Dutch Warmbloods at the canter. Am J Vet Res. 54: 670–674.

Ross MW, Dyson SJ. 2011. Diagnosis and Management of Lameness in the Horse. 2nd ed. Elsevier Saunders, 77–79.