Comparison between Clegg Impact Soil Tester and hoof impact shock measurements on 13 surfaces used for training trotters or sport horses

F. Munoz-Nates, P. Pourcelot, A. Van Hamme, J. Martinot, M. Pauchard, M. Nouvel, B. Ravary-Plumioen, H. Chateau and N. Crevier-Denoix

Unité 957, BPLC, INRA, Ecole Nationale Vétérinaire d'Alfort, Université Paris Est, Maisons-Alfort, France

KEYWORDS Clegg; impact shock; sport surface; hoof; deceleration peak

1. Introduction

Sport surfaces can be a risk factor for injury in human and equine athletes. It was recently demonstrated that more severe lesions occurred in young trotters after 4 months of training on a hard track, compared to a soft one (Crevier-Denoix et al., 2016). Biomechanical measurements performed on both tracks revealed that maximal forces and loading rates, as well as vertical deceleration peak at impact (impact shock), were significantly larger on the horses exercising on the hard track. Although the respective influence of these biomechanical variables on injury occurrence is not established yet, it is likely that repetitive high impact shocks contribute to risk for subchondral bone damage and even fracture in the distal limb segments, as well as for superficial digital flexor tendon injury, although maximal landing and loading rates are probably major risk factors for severe limb injuries.

Direct biomechanical measurements on subjects under race or sport conditions are difficult and expensive. Furthermore inter-individual variability can be large. In this context, standardized mechanical testing devices are used on human sport surfaces. Among them, the 2.25 kg Clegg Impact Soil Tester (CIST, SD Instrumentation) has been also recommended for evaluating equestrian soils. Its principle is based on the dropping of a 2.25 kg mass (hammer), guided in a tube. An accelerometer is mounted on the top of the hammer; drop height is 45 cm. Three to 5 successive drops on a given site are generally recommended. The accelerometer measurement is expressed in gravities [g]. The mass involved and the velocity of impact, i.e. about 3 m/s) in the CIST are close, respectively, to the effective mass and vertical velocity of the equine fore hoof at impact under training conditions (Munoz-Nates et al., 2015; Crevier-Denoix et al., 2012). Therefore the objectives of the present study were to test the correlations between CIST measurements and vertical deceleration peak measured on horses' hooves at impact on different surfaces and exercise conditions, in order to assess the interest of CIST for assessing equestrian surfaces.

2. Material and methods

Thirteen surfaces, used for training either racing trotters (8) or show jumping and dressage (sport) horses (5), were tested on 5 different sites. In all cases, the top layer had sand as major component; however the latter differed in origin and granulometry, and in some sites it was "sand & fibre" mix (Table 1). Under-layers also varied depending on the surfaces. Regarding surfaces for sport horses, influence of thickness or preparation (harrowing versus rolling/compaction) of the top layer was tested.

Each measurement session (1 to 4 per site, Table 1) comprised biomechanical, including accelerometric, recordings on one horse exercising alternatively on 2 to 3 different surfaces, and CIST tests performed the same day on the same surfaces. Nine different horses were used: 4 French trotters and 5 Selle Français (mean(SD): 556(50) kg; 7.6(2.7) years). The right fore hoof of each horse was equipped with a triaxial piezoelectric accelerometer (356B20, PCB). This device was rigidly fixed to the dorsal hoof wall. The hoof angle was used to express acceleration in a reference frame in which vertical acceleration was perpendicular to the hoof sole (and positive downwards). Data were acquired at 7.8 kHz.

All 4 trotters were conducted by the same driver (harness trot), while each sport horse was ridden by his own regular rider. On surfaces for trotters, tests were performed at 40 km/h in straight line, while the condition chosen in sport horses was landing after a 1.20 m straight fence jump, at both hands, i.e. the equipped forelimb being alternatively leading and trailing. On trotters, an average of 50 (5 series of 10) strides were recorded per horse on each surface. In sport horses, an average of 14 landing strides were recorded per horse on each surface (with about half recorded with the equipped forelimb leading, and half trailing). Customised programmes developed in Matlab (The MathWorks) were used to determine the vertical deceleration peak at the onset of each stance. On each surface, on a given day (i.e. measurement session), CIST tests consisted in 5 successive impacts.
all significant. The coefficients of correlation (r) were: 0.944, 0.971, 0.952, 0.942, 0.937, 0.958, respectively for the impacts #1 to 5, and the mean of the 5 impacts (Figure 1). Repeating impacts above the 2nd appears relevant only for assessing the surface’s compaction capacity. Two to 3 successive impacts at a given site are enough for assessing the surface’s impact shock absorption capacity at this site.

4. Conclusions

Clegg hammer appears as a relevant tool for assessing the impact shock absorption capacity of equestrian surfaces whatever the discipline. However it should be kept in mind that, given the reduced effective mass and low energy involved in the hoof’s impact shock, the latter may only represent a limited part of the overall risk associated with a sport surface.

Acknowledgements

The Région Basse-Normandie, FEDER, Fonds Eperon and IFCE for financial support. Mr C. Walazyc (Le Trot), J.M. Monclin, S. Blondeau, T. Duvaldestin, Y. Giquel, and the firms Toubin & Clément and Normandie drainage, for providing the surfaces. IFCE, Garde Républicaine de Paris, and CSEM de Fontainebleau, for loaning the horses.

References

Crevier-Denoix N, Pourcelot P, Camus M, Denoix J-M, Chateau H. 2012. Effets biomécaniques des pistes équestres. In Proceedings 12th Geneva Congress on Equine Medicine and Surgery, 126–140.

Crevier-Denoix N, Pourcelot P, Munoz F, Ravary-Plumieno B, Denoix JM, Chateau H. 2016. Biomechanical effects of training surfaces on the locomotor system – Effect on the horse's health. J Vet Behav. 15:80.

Munoz-Nates F, Chateau H, Ravary B, Pourcelot P, Crevier-Denoix N. 2015. Accelerometric and dynamometric measurements of the impact shock of the equine forelimb and hind limb at high speed trot on six different tracks. Comput Methods Biomech Biomed Eng. 18(Suppl 1):2012–2013.