Evaluation of the sliding-phase between the hoof and ground for horses with rubbershoes (Öllöv Original)

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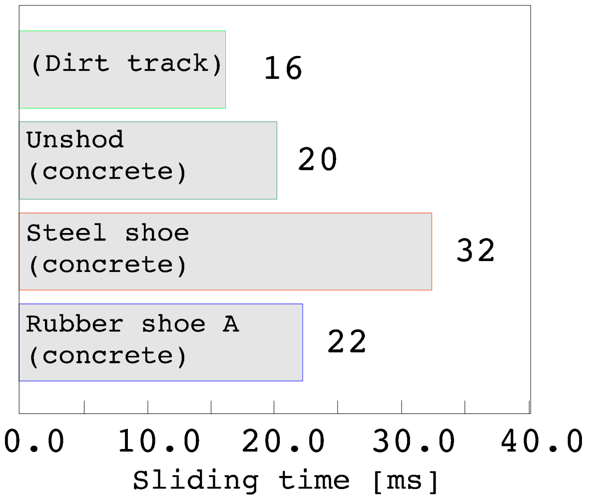
This report is based on a study performed by Prof. Stig Drevemo and Vet. Christopher Johnston at the Swedish University of Agricultural Sciences [1]. All data used in this report were measured by Drevemo and Johnston in Ref. (1), the statistical analysis of these data presented in Figs. 4-5 are new.

The gait of three horses were investigated. They were normally shod with steel-shoes. The horses were brought forward at hand with a speed of 3 m/s. The time of the sliding-phase between hoof/shoe and the ground was measured for an unshod, steelshod and rubbershod hoof (Öllöv shoe), as were the vertical acceleration of the hoof at the initial contact with the hard ground. Changes in the angles of the hoof, fetlock, and carpal joints were registered with a high-speed camera (250 frames/s) and analysed in the Track-Eye® [2] system. Two different ground surfaces were tested: i) concrete floor (hard), and ii) dirt track (soft).



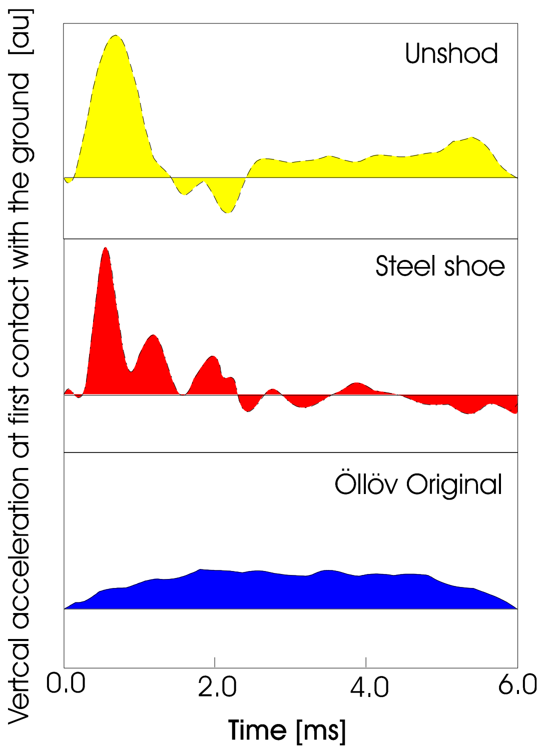
Figur 1 Sliding-times for the different shoe alternatives and surfaces, measured by Drevemo and Johnston (1992).

No detectable differences between the unshod, steelshod, and rubbershod hoof could be seen for the soft ground (dirt track), whereas on the concrete floor deviations between the alternatives were observed.

The measured duration of the sliding-phase for the different shoe alternatives were: 20 ms for unshod hoof, 32 ms for the steelshoe, and 22 ms for Öllöv Original (Fig1). The sliding-time on the dirt track did not differ between the shoe alternatives, and was measured to be 16 ms. This means that the friction between the rubbershoe and hard ground is similar to the natural hoof's interaction with the ground, while the steelshoe feels more slippery for the horse. The differences between the sliding-times of the dirt track and the ones obtained for unshod or rubbershod hoof on hard ground were small.

The measurements of the vertical acceleration of the hoof at first contact with the hard ground (Fig 2), show that the rubbershoe completely attenuates the initial shock that arises at first contact between hoof and ground. The damping mechanism of the unshod hoof is insufficient to do a complete attenuation of the initial shock coming from the hoof/concrete interaction, therefore small oscillations in the vertical acceleration arises. Large oscillations in the vertical acceleration were found for the steel-shoe, i.e. no damping occurred and a high frequency vibration is transmitted into the leg of the horse.

The changes in angles of the different joints in a



Figur 2. Results for the vertical acceleration of the hoof at first contact with hard ground, Drevemo and Johnston 1992.

forelimb were measured in order to understand the response in the leg of the horse for the different hoof/shoe interactions with the ground. The angles are defined in Fig. 3. The stance time (S.T.) is defined as the time when the hoof is in contact with the ground. The stance times for all horses and strides are normalised to 100 %. To be able to compare the strides of different horses, the amplitude of the joints during S.T. must be normalised. The measured change in a joint is normalised with respect to the maximum angle difference in that joint.

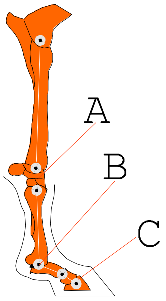


Figure 3. Definition of the angles: hoof, C; fetlock, B; and carpal, A, joints, the small dots are reference points monitoring the movements of the different joints.

For the hoof joint, Fig. 4, no clear difference can be

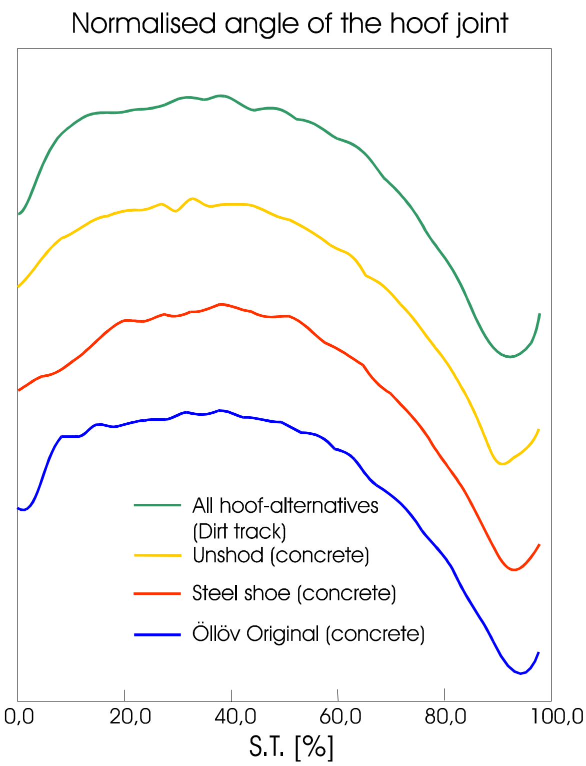


Figure 4. Normalised angle of the hoof joint during the stance phase. The different shoe alternatives relate to hard ground (concrete).

seen from 20 to 100 % of the stance time for the different shoe alternatives or ground surfaces. The only difference that occurs is in the beginning of the stance phase, during the gliding-phase (0-20 % of S.T.). The fastest increase in the angle of the hoof joint can be seen for the dirt track and for the rubber shoe. The unshod hoof has also a rather fast increase in the beginning of the S.T., but not as fast as for the dirt track or the rubber shoe. The far most slow alternative is the steelshoe on the hard ground, probably due to the lower friction i.e. a longer sliding-phase.

A similar normalisation has been done for the measurements regarding the changes in the angle of the fetlock joint. The result is presented in Fig. 5, and as for the hoof joint, the only difference is in the initial part of the stance phase. The angle of the fetlock is decreased dramatically in the beginning and reaches a plateau at approximately 10 % of S.T.. This holds for the dirt track, unshod hoof, and rubbershod hoof. The steelshod hoof has a longer sliding-time giving a time delay in the initial decrease, and no pronounced plateau is seen, see Fig. 5.

The changes in the angle of the carpal joint are

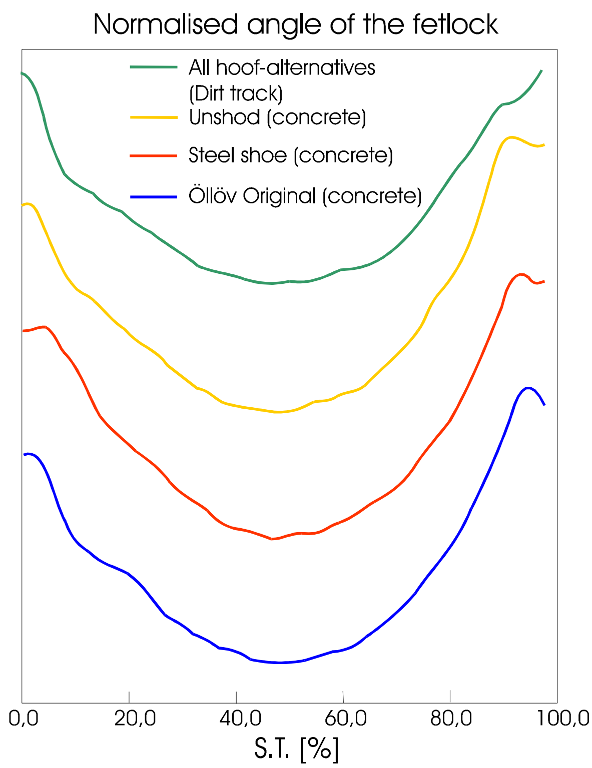


Figure 5. Normalised angle of the fetlock during the stance phase. The different shoe alternatives relate to hard ground.

very similar for the different alternatives. A slight flexion of the carpus occurs in the beginning, followed by an extension.

The maximal overextension is reached at ≅ 20 % of the stance time, the extension is then slightly decreased and is constant under the loading of the leg. At the end of the S.T. a rapid flexion takes over before the breakover.

Conclusions

The investigation made by Drevemo and Johnston is a pilot study and the results should be regarded as preliminary. The size of the study (only 3 horses), indoor measurements on hard ground (concrete), and the fact that the horses were not accustomed to rubber shoes, make it hard to draw any definite conclusions regarding the effect of Öllöv Original.

The results in this study imply that Öllöv Original and the unshod hoof on hard ground have very similar friction qualities. The measurements of the vertical acceleration of the hoof at first contact with a concrete floor showed that the rubber shoe completely attenuates the initial shock that arises. The damping mechanism of the natural hoof is insufficient on concrete and for the steelshoe a high frequency vibration is mediated into the leg of the horse. The changes in joint angles for Öllöv Original on hard ground are comparable with the corresponding changes on the dirt track. The unshod hoof seems to have a slower change in the angle of the hoof joint at the initial stance phase than the rubbershod hoof, but much faster than the change of the hoof angle for the steelshod hoof.

The angular velocities in the different joints of the leg can not be read in Figs. 4 or 5 because the stance time is normalised for all horses and strides. The absolute times for each stride is not published by Drevemo and Johnston [1]. This means that one can not compare the gradient in the initial part of the S.T. for the different hoof/shoe alternatives with each other, since the stance time can be different for different shoe alternatives. Regardless if the stance time is normalised or not, relative changes in the angle of the joints can be compared between the shoe alternatives, e.g. the amplitude of a given joint's angle at 10 % of the S.T. (at the end of the sliding-phase). The change in amplitude for a joint at a given time, t, is a measure on how fast the change in the angle of that joint really is, A^{10}_{h} is the relative change in the angle of the hoof joint at t= 10 % of S.T. and A^{10}_{f} is the corresponding change in amplitude for the fetlock joint. A comparison of A^{10}_{h} and A^{10}_{f} for the hoof/shoe alternatives shows large similarities between the unshod and rubbershod hoof on hard ground and the dirt track, whereas the steelshod alternative on concrete differs considerably. The conclusions to be made on such a small study are dubious, the material of the study is too limited and the statistics is poor. More measurements are needed, in order to make statistically secured conclusions.

With Öllöv Original there is a local maximum in the angle of the hoof joint at approximately 10 % of the S.T. (Fig.4). This characteristic feature was shown for all three horses and strides (only 1 unshod horse showed this feature), there can be many reasons for this behaviour: (i) The better damping in the rubber shoe gives the horse a longer and more powerful stride compared with the unshod or steelshod alternative on hard ground (this change in gait has been seen for many horses on hard ground); (ii) The horses were never accustomed to the rubber shoe; (iii) The hard ground in the study is in a way artificial, an indoor concrete floor is not a representative surface for horses, hard outdoor ground always has a larger or smaller amount of sand on top of it, which inhibits a too abrupt breaking of the hoof during the siding-phase. The understanding of this local maximum in the angle of the hoof joint occurring at app. 10 % of S.T. and its effect on the health of the horse is still missing. But, Öllöv Original has been used on horses with knee and hock injuries during convalescence and afterwards in training with very good results.

This study is not complete, and more investigations are certainly needed. More horses and strides are necessary to get better statistics, (a group of rubbershod horses and a steelshod reference group, 10-12 horses in each group). Different outdoor ground surfaces should be part of a more elaborate study, e.g. asphalt, hard-packed sand (gravel), and a dirt track. An analysis of the angular velocities of the joints as a function of hoof/shoe alternatives and ground surfaces is also important, similar to the analysis made for standardbred trotter horses in Ref. [3]. Another interesting aspect is the importance of the speed of the horse, 3 m/s (as in the study by Drevemo and Johnston) is a low velocity.

Acknowledgements

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