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# Evaluation of a Shock Absorbing Woodchip Layer on a Harness Race-track

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ABSTRACT. Improvement of the cushioning of courses for training and racing could be a successful approach to lameness prevention in racehorses. The purpose of this study was to determine hardness and energy loss on an experimental harness race-track. Measurements were carried out by use of a drop test technique simulating the impact forces created between hoof and ground in harness trotters moving at moderate racing speed. A hardness index and energy loss were calculated for 30 test fields evenly distributed along the track. The results showed that hardness index and energy loss were different and could vary between test sites, possibly due to differences in uniformity of the ground material. A significant ($p<0.001$) long term cushioning effect attributed to the woodchip layer was demonstrated. It was concluded that shock force absorbancy of woodchip makes it a suitable material to include in track construction.

*Key words*: Race-track surface; woodchips; shock absorbancy; drop test; horses.

## INTRODUCTION

Information on race-track construction which can assist in minimizing risk of acute and chronic damage to the horse's locomotory system is limited. During the last two decades, the general geometric design of racetracks has been improved[2,5,6] but very few studies have been published describing mechanical properties of these surfaces.[1,18,25] Experimental evidence in animals[4,20,21,23] and clinical evidence in humans[11,12,13,24] indicate that the shock forces created between foot and ground at impact may play an important role in injury and be indirectly involved in impaired performance. It is therefore desirable to build tracks which reduce these shock forces. Impact can be described by computing the hardness and energy loss from measurements of a rigid body falling onto the surface.[17] The present study was designed to quantify hardness and energy loss on an experimental harness race-track and to evaluate the possible cushioning effect of a woodchip layer.

## MATERIAL AND METHODS

Recordings took place on an experimental harness race-track, 4 years after the course had been completed. During this time, only normal maintenance had been carried out which included harrowing, clod-crushing and watering of the track surface. Occasionally, a thin layer of new surface material has been added. All measurements were carried out under dry conditions using a drop hammer system. The components of the track surface are shown in Fig. 1. A 6 cm woodchip layer (compacted from 10 cm of woodchips) was placed under a conventional surface from the inner rail out to approximately 15 m of the track width in an attempt to test cushioning qualities as compared to traditional harness race-tracks.

The drop hammer system was designed to simulate the conditions occurring between hoof and ground in a horse at moderate racing speed (11 m $s^{-1}$) with regard to landing velocity, active mass, and size and geometrical shape of the contact area. The drop

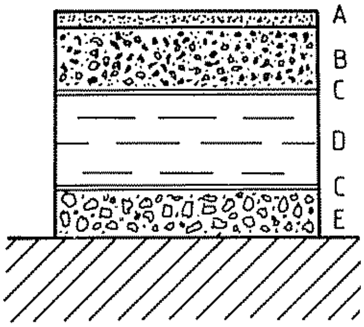

*Fig. 1.* The components of a section of the track. (A) Surface layer (sand 0–4 mm), (B) gravel (0–8 mm), (C) fibre cloth, (D) woodchips, (E) crushed stone.

weight was allowed to fall freely from a height of approximately 1.5 m. The weight was equipped with a 2-dimensional low mass accelerometer (Entran International EGA-125-250) connected by cable to the data acquisition system. This data system was composed of a microcomputer with a signal amplifier, 8-bit A/D converter and a disc drive. For subsequent analyses, the test system was calibrated automatically after each drop for signal levels of 50, 100 and 150 G by connecting resistances to a Wheatstone bridge.

The recordings were carried out on 3 lanes of the track located at 1, 14 and 16 m from the inner rail at 100 m intervals measured from the finishing line. Each test measuring field was approximately 1 $m^2$, within which the weight was dropped 5 times at randomly selected spots without hitting the same spot twice.

A *mean hardness index* ($s^{-1}$) was computed for each test field by calculating the mean ratio of the recorded maximum peak deceleration and the landing velocity ($v_l$) of the solid. The impact velocity was calculated by the formula:

$$v_l = \sqrt{2Gh} \tag{1}$$

where $h$ is the drop height and $G$ is the acceleration due to gravity. The return velocity of the solid after the impact was denoted $v_r$ while the duration of the impact acceleration peak is the impact time. The *loss of energy* ($E_{\text{loss}}$) in per cent caused by the cushioning of the ground was calculated by the formula:

$$E_{\text{loss}} = (1-(v_r/v_l)^2)\times 100 \tag{2}$$

The area ($a$) under the impact peak curve is equal to the impulse divided by the drop hammer mass or equal to:

$$a = v_l - v_r \tag{3}$$

The deflection was calculated by numerical integrations of the deceleration curve. It can be deduced from formulas 2 and 3 that there is a negative correlation between the impulse and the energy loss and the impulse at 0% energy loss is double the impulse at 100% energy loss.

Descriptive statistics comprising means and standard deviation (SD) were computed for each test field and the hardness and energy loss data, respectively, were compared by the use of Student's *t*-tests.

## RESULTS

The deceleration time history of representative drops on the woodchip part of the track and on a part of the track without woodchips is illustrated in Figs. 2*a* and 2*b*. Peak impact decelerations were 151.6 and 226.6 G, the impact times were 9.7 and 7.8 milliseconds (ms) and impulses divided by the mass of the drop hammer were 7.1 and 7.8 m $s^{-1}$, respectively. The corresponding hardness indices were 275.6 and 411.2, the maximum deflections were 19.4 and 15.9 mm and the energy losses were 89.8 and 85.7%, respectively.

The mean hardness indices from recordings 1 m from the inner rail are shown in Fig. 3*a*. The overall mean hardness index for the 10 test fields was 282±41.8 (range 231–367) with the maximum value on the farther straight. Within each test area SD ranged between 4.9 to 42.0.

Fig. 3*b* shows the corresponding data from measurements 14 m from the inner rail. The overall mean hardness index in this lane was 247±45.1 (range 187–318), which did not differ significantly from the 1 m re-

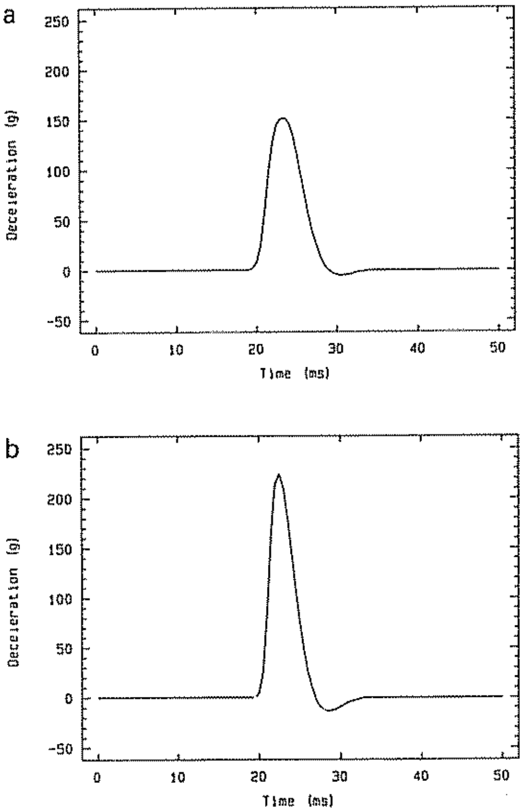

*Fig.* 2 (*a*) A representative impact deceleration curve from a track section with woodchips. (*b*) A representative impact deceleration curve from a track section without woodchips.

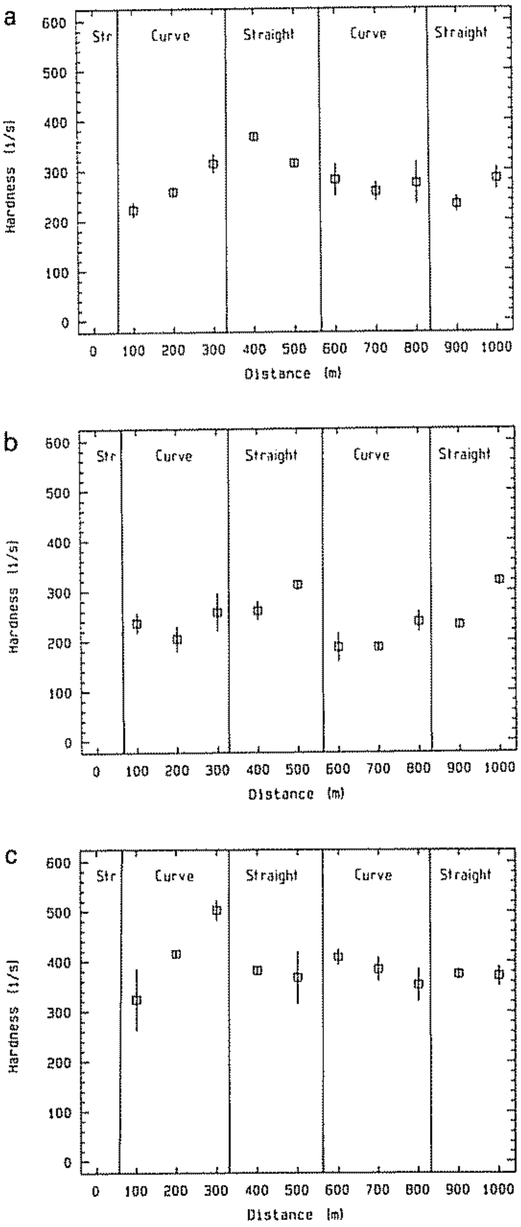

*Fig.* 3*a,b,c* The mean hardness indices calculated from measurements along the 1 m, 14 m and 16 m lanes, respectively, measured from the finishing line.

cordings ($p > 0.05$). SD within each test field varied between 6.8 and 38.2.

Fig. 3*c* demonstrates the mean hardness indices from the recordings carried out 16 m from the inner rail, i.e. on a track surface without woodchips. The overall mean hardness index was 392 ± 43.1 (range 352–502). This lane without woodchips was significantly harder compared both to the 1 m and 14 m measurements ($p < 0.001$). Mean SD of the hardness measurements in each test field ranged between 4.7 and 62.0.

The energy loss from all 30 test fields is shown in Figs. 4*a–c*. Overall mean energy loss in the 1 m lane was 92 ± 2.4% (range 88.5–94.6%), in the 14 m lane 91 ± 2.4% (range 85.7–94.2%) and in the 16 m lane 83 ± 2.9% (range 79.3–94.2%), the latter being significantly lower compared to the other lanes ($p < 0.001$).

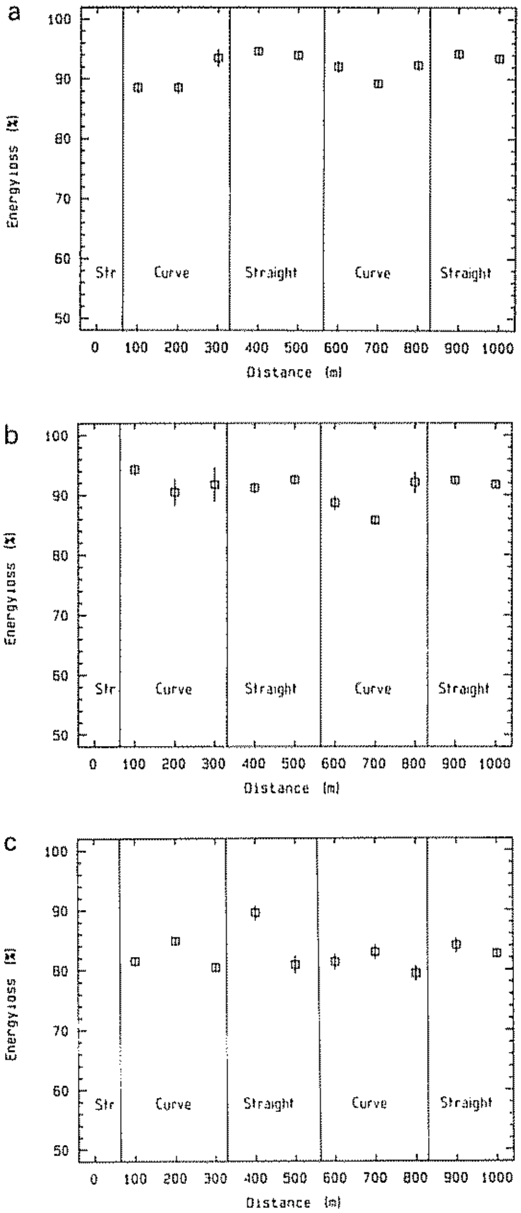

*Fig 4a,b,c* The mean energy loss (%) calculated from recordings along the 1 m, 14 m and 16 m lanes, respectively, measured from the finishing line

## DISCUSSION

In order to reduce the risk of injury among sport horses, cushioning of the surface used for training and competition is considered to be of great importance. Mechanical properties such as hardness are claimed to provoke injuries in human athletes by causing an increasing load on structures in the locomotory system beyond physiological limits.[3,8,15,19,22] Only a few reports mentioning mechanical properties of race-track surfaces have been published.[1,7,10,14,18,25] These studies were based on drop hammer techniques with varying specifications in the experimental design Few of these reports describe the impact shock forces which are postulated to be of major importance in causing musculoskeletal injury.

The present study provides data from drop hammer recordings carried out on an experimental harness race-track on which a woodchip layer had been laid under a surface of sand in an attempt to improve the cushioning qualities. Woodchips have been used earlier on tracks for Thoroughbred racing and were found to attenuate impact forces.[9] However, this type of surface is not suitable for harness racing and has, in some cases, turned out to suffer from management problems and decomposition of the woodchips.

A critical review of available test methods for the assessment of sports surfaces has recently been published.[17] The main criticism of drop test methods such as that used in the present study was that there was a poor correlation between impact force peaks from drop tests and the impact force peaks measured on the limb.[16] An appropriate test for the assessment of mechanical properties of sports surfaces would include quantification of internal forces and moments exerted by the athlete's musculoskeletal system.[16] This is however a complex procedure and is limited by the lack of basic kinematic and kinetic data, especially with regard to the horse. At present, the use of methods measuring the mechanical characteristics of the ground surface by use of test equipment simulating the horse limb is the most suitable approach towards an understanding of the factors influencing the locomotory system.

The movable drop hammer system used in

this study was developed to simulate the peak force at hoof impact in horses moving at moderate racing speed, taking into account the estimated effective mass acting during the first 10–15 ms of the stance, hoof dimensions, impact velocity and impact time. The hardness was defined as the ratio between the maximum deceleration and the landing velocity of the falling weight. It has not been proven that this measure is the most relevant parameter to describe the dynamic response of the horse's limb to external mechanical load from ground surface.

Generally, relatively low hardness values were measured compared to traditional harness tracks (Drevemo, unpublished data) but significant variations were seen between and, in some cases, within different test fields. This may be caused by differences in thickness of the woodchip layer or may indicate lack of consistency in upper layers of the surface. Such irregularities are expected to negatively influence the gait stability of the horse and may indirectly increase the risk for injury.

Differences ($p<0.001$) in hardness were found when comparing the two woodchip lanes with the lane without woodchips. These findings indicate that a woodchip layer improves the cushioning. This effect lasts several years as indicated by a comparison of the results of the present work with recordings carried out 4 years earlier on the same track.

As demonstrated earlier there is a negative correlation between the energy loss and the impulse. Consequently, a great energy loss is related to low hardness and good shock force absorbancy. However, the hardness index is also correlated to the impact time. This means that the hardness index and energy loss are both measures of the track characteristics, however not equivalent to each other. Higher energy loss with a woodchip layer ($p<0.001$) in the track surface indicates that woodchips give an increased shock force absorbancy.

Drop hammer techniques may be useful for determining basic ground properties of racetrack surfaces. It is concluded that significant long term reduction of impact hardness and increased energy absorption can be accomplished by introducing a woodchip layer in the surface of harness tracks.

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