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Original Research

# The Use of a Technical Device for Testing the Sport-Functional Properties of Riding Surfaces

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A B S T R A C T

The riding surface is an important and modifiable factor in the development injuries in sport horses. An objective and simple examination of the sport-functional properties of riding surfaces, such as shock absorption, is thus desirable. The aim of the present study was to evaluate the use of a handy device to test the sport-functional properties of riding surfaces. Therefore, a technical device, called Artificial Athlete, was used on five riding surfaces: two sand–synthetic indoor arenas, one sand–sawdust indoor arena, and two outdoor arenas, one with a sand footing layer and one with a grass surface. The shock absorption, the energy restitution, and the vertical deformation measurements were acquired by the Artificial Athlete. Additionally, the hoof acceleration of six warmblood horses trotting by hand on the five investigated riding surfaces was recorded. The parameters of the Artificial Athlete and the acceleration data during hoof landing were compared. The outcome of the statistical analysis illustrated that the shock absorbing parameter was not in agreement with the results of the acceleration data, whereas the results of the vertical deformation parameter were mostly in accordance with the results of the hoof-acceleration measurement. In conclusion, the use of the Artificial Athlete for testing the sport-functional properties of riding surfaces was assessed as unsuitable because of the large deviations between the results of the shock absorption measured by the Artificial Athlete and the hoof-acceleration data. However, it could be shown that the vertical deformation parameter could be helpful in the assessment of the sport-functional quality of riding surfaces.



## 1. Introduction

Earlier studies on racehorses have shown that injuries are multifactorial events [1]. The track surface is one issue in this multifactorial event, which is an important and modifiable factor. In the traditional riding disciplines such as dressage and jumping, injuries and, in particular, diseases of the locomotor apparatus are a major cause of the culling and attrition of sport horses. Further, there are a multitude of riding surface types. For example, sand, sawdust, and synthetic fiber are used as footing layers in riding arenas. Therefore, differences in the sport-functional properties of riding surfaces can be expected. Some previous studies have shown the possibility to illustrate the influence of the surface on the stress on the horse's limbs by acceleration measurements on the horse's hooves [2-8]. However, a high variability between and within horses has been found in acceleration data [6]. Therefore, several horses and a greater number of recorded strides must be investigated to obtain robust statistical results. Thus, the acquisition of differences in the sport-functional properties of riding surfaces with an objective technical device would be easier and more favorable. In human sports, such as football, a simple technical device, called Artificial Athlete,

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and field test requirements are recommended [9,10]. Therefore, it is possible to evaluate objectively the sport-functional quality of human sports arenas. In equestrian sports, a few technical devices for racetrack testing have been developed [11-18], but they have not been successfully established in practice. The disadvantages of these surface-testing systems are that often a motor vehicle is needed to deploy such devices [17,18] or the devices reproduce the impact power inadequately during hoof landing [2,18,19]. Further, in the studies mentioned, only racetracks were tested with technical devices. Therefore, the development of a small and simple-to-operate device for testing riding surfaces with footing for dressage and jumping horses will be useful.

In the present study, five different riding surfaces were tested by the Artificial Athlete and by acceleration measurement on the horse's hoof. At impact of the Artificial Athlete on a concrete surface, 6,600 N were loaded. The Artificial Athlete was developed to mimic a human athlete, but nevertheless, the force corresponds to the data supplied by Dohne of a trotting horse with a mass of 650 kg [20]. The aim of the investigation was to compare the results of the Artificial Athlete with the results of the hoof acceleration to evaluate the use of this technical device in testing the sport-functional properties of riding surfaces. It is expected that evaluation of the sport-functional properties of the riding surfaces done by the hoof-acceleration measurement in trot and by the Artificial Athlete would show similar results.

## 2. Material and Methods

### 2.1. Riding Surfaces

The data recording was carried out at the equestrian center of the Holsteiner Verband in Elmshorn (Germany). Five riding surfaces, two outdoor arenas and three indoor arenas, were tested by the Artificial Athlete and hoof-acceleration measurement. One outdoor arena had a grass surface (grass) and the other a sand surface (sand). Two indoor arenas had a sand—synthetic fiber footing layer, one used for lunging (sand—synthetic I) and the other used for jumping (sand—synthetic II). The third indoor arena was used for dressage and had a sand—sawdust footing layer (sand—sawdust). All riding surfaces were in a used condition but were regularly maintained. For the surface testing, a circle with a diameter of 16 m was defined on each surface. A disturbed sample of the footing layer was taken from each investigated riding surface at a randomly chosen location on the defined circle. The sample contained at least 341 g and was taken immediately after surface testing by the Artificial Athlete and the hoof-acceleration measurement. Each sample was weighed before and after drying in a drying cabinet with a temperature of 105°C for 24 hours. To obtain the organic substance, a minimum of 45 g of each sample was taken and burnt out in a muffle furnace with a temperature of 550°C over 3 hours. Afterward, the sample was weighed again. The particle size distribution and the content of synthetic substance of the five riding surfaces were obtained by dry and wet sieving. Therefore, 201 g of the dried sample was sieved in accordance with the relevant standard [21]. The determinations of the water content, the organic substance, and the synthetic substance were calculated by the following expressions:

$$\text{Water content} = (m_1 - m_2)/m_1 \times 100;$$

$$\text{Organic substance} = (m_2 - m_3)/m_2 \times 100;$$

$$\text{Synthetic substance} = m_4/m_2 \times 100$$

where $m_1$ is the mass (kg) of the sample before drying; $m_2$ is the mass (kg) of the sample after drying for 24 hours in a drying cabinet with a temperature of 105°C; $m_3$ is the mass (kg) of the sample after 3 hours of burnout in a muffle furnace with a temperature of 550°C; $m_4$ is the mass (kg) of the synthetic substance in the sample, which was filtered out by sieving.

### 2.2. Technical Device—Artificial Athlete

The Artificial Athlete (Fig. 1) consists of a guided falling weight (1, 3), with a mass of 20 kg (±0.1 kg), which dropped from a height of 55 mm (±0.25 mm) vertically to a testing foot [22]. The testing foot had a circular steel base plate (8) with a diameter of 70 mm (±0.1 mm) and included a spiral spring (5) and a hardened upper plate (4) [22]. The spiral spring, which damped the impact of the falling weight, is 0.1-7.5 kN linear with a spring rate of 2,000 ± 60 N/mm [22]. A force-sensing device (7) was built into the steel base plate [22]. The sampling rate of the force data was 1,219.5 Hz.

The Artificial Athlete was designed to simulate the impact of a human athlete on the ground. Three parameters shock absorption (*SA*), energy restitution (*ER*), and vertical deformation (*VD*) could be calculated by the measurement values. The determination of shock absorption (*SA*) was a measurement method based on DIN [22]. The shock absorption (*SA*) was calculated from the following formula:

$$SA = (1 - F_t/F_r) \times 100$$

where *SA* is the shock absorption in percentage (%); $F_t$ is the measured maximum peak force of the testing surface, expressed in Newton (N); and $F_r$ is the reference force and comprises 6.6 kN (±0.25 kN) for a calibrated measurement device, which corresponds to the maximum peak force (N) for a rigid, nonvibrating, smooth and even concrete floor [22]. Five testing spots on each riding surface were investigated. Each testing spot was randomly chosen on the circle where the acceleration measurement with the horses

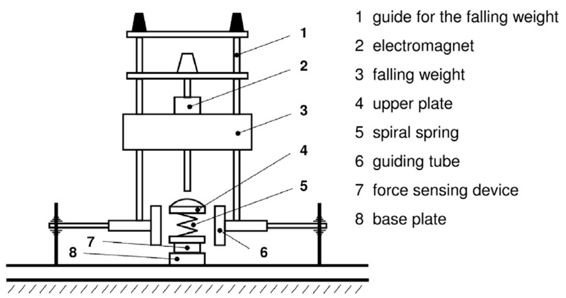


**Fig. 1.** Artificial Athlete (based on DIN [22]).