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Short Communication

How realistic is a racehorse simulator? ☆

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ABSTRACT

Race jockey training is demanding and technical. Increased horse care costs and demands on time have led to greater availability and use of racehorse simulators during training. Little is known about the accuracy of the simulated movement and therefore how effective they are for developing the desired technique. We quantified and compared sacral rotation and displacement vectors for a racehorse simulator and a real galloping horse. A single inertial measurement unit was placed on the sacrum of six horses (horse) during a training gallop along an all-weather seven furlong gallop and on the highest speed setting 'four' on the simulator. Displacements were calculated in all three axes before being cut into cycles and analysed along with roll and pitch. Displacement and rotation amplitudes were extracted and compared for the horse and simulator. Horse sacral movement parameters were more varied than those recorded on the simulator. The real horse exhibited greater dorso-ventral, medio-lateral and roll amplitude but smaller cranio-caudal displacement amplitude and no difference in pitch amplitude. Displacement trajectory of the simulator when viewed laterally from the left side, was anticlockwise, the opposite direction to that of the real horse leaving the regular use of a simulator during jockey training under question. Use of the racehorse simulator is beneficial to develop specific fitness and to enable physical manipulation into the optimal position. Care must be taken to avoid any detrimental effects of training with the opposite movement trajectory to that experienced during a race. The programming of the simulators may benefit from adaptations to maximise their benefits.

1. Introduction

Jockeys are a fundamental part of the £3.45 billion British racing industry (Deloitte, 2013). Riding a racehorse requires balance, coordination, flexibility and fitness, which can be trained but take time to develop. Simulators are increasingly used as training aids for skills from flying aircraft to performing surgery (Aggarwal et al., 2010; Kneebone, 2009; Royal Aeronautical Society). The unpredictable nature of horses combined with the energetically costly and visually unstable 'martini glass' position adopted by modern racing jockeys (De Cocq et al., 2013; Pfau et al., 2009) has led to the common use of racehorse simulators to facilitate jockey training. Simulators support objective assessment of a rider's position (Longhurst and Lesniak, 2013), allow physical correction and can improve confidence or aid rehabilitation.

The first horse simulators were developed in 1980 and interactive simulators were introduced in 2007 (Racewood Equestrian Simulators). Anecdotally, the movement of a simulator differs from that of a real horse, but no studies have quantified this difference or considered the effect on jockey position. Greater physical effort has been reported when riding a real horse compared to a simulator, however in many cases the novelty of riding a simulator has been held responsible for higher stress levels, suggesting movements are indeed different (Ille et al., 2015).

Despite the inherent differences, many benefits of simulator training of inexperienced jockeys have been reported. These include economical intensive training sessions, reduced risk of injury to the horse or rider falls and greater scope to physically correct technique while improving muscle and movement-specific fitness (Bailey et al., 1997; Hitchens et al., 2012; Kang.et al., 2010). On the other hand, if the differences between a simulator and a real horse are substantial, extensive simulator use may be contraindicated despite safety and practical benefits.

In contrast to walk and trot, gallop is an asymmetrical gait, with asymmetrical movements throughout the stride cycle influencing the interaction between horse and rider (Greve and Dyson, 2013; Robilliard et al., 2007). Such asymmetrical movement can be

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difficult to simulate and is currently not programmed into racehorse simulators. The implications of the absence of movement asymmetry on the training of jockeys are unknown.

Aim: Quantify and compare rotation and displacement vectors for a racehorse simulator and a real galloping horse.
Objectives: Quantify displacement of the horse and simulator in three axes.
Record the roll and pitch of the sacrum in the horse and simulator throughout a stride.
Objectively compare the difference in parameters recorded from the horse and simulator.
Hypothesis: Kinematics of a racehorse simulator differ significantly from those of real horses.

2. Materials and methods

2.1. Data collection

Twelve jockeys were assigned a category based on their experience (Table 1), 1 Elite, 8 Experienced and 3 Intermediate. All jockeys completed a consent form which had undergone review by the Royal Veterinary College's Ethics Committee.

2.2. Simulator

An MK9[1] racehorse simulator set at the highest speed level was used for all simulator testing. An MTw[2] inertial measurement unit (IMU), containing three axis 16g accelerometers, 1200°/s gyroscopes and 1.5 Gauss magnetometers, was attached to the sacrum area of the simulator.

Inertial data were collected with an update rate of 30 Hz. Data were collected from twelve jockeys (six were also recorded on a real horse) using a set protocol with three 30 s trials in the normal riding position.

2.3. Real horse

Data were collected from eight jockeys using six Thoroughbred racehorses from the British Racing School. Two ran twice with different jockeys on different days. The MTw[2] IMU was attached to the sacrum of the horse.

Inertial data were collected with an update rate of 30 Hz. Horses galloped the length of an all-weather seven furlong (0.88 mile) track routinely used at the British Racing School.

2.4. Data processing

Acceleration data were calibrated and exported using commercial software (Xsens 'MT manager'). Data were filtered (Butterworth 4th order 0.5 Hz high pass) to remove drift. Accelerations in 3 axes were integrated to velocity and again to displacement using numerical integration in custom written Matlab[3] scripts. Positive displacements are dorsal, cranial and left with negative being ventral, caudal and right for the three axes. Displacement data were segmented using minima in dorso-ventral sacrum displacement to represent mid-stance of the cycle.

Cycles were interpolated allowing trials to be combined for analysis. Frame numbers for the start and stop of each cycle were saved and used to extract corresponding filtered roll and pitch data.

2.5. Data analysis

Mean and standard deviation values for each horse-jockey combination were analysed using a linear mixed model in SPSS[4] with condition (simulator or horse) and experience level as fixed factors and jockey as a random factor. The cut off for significance was $P \leq 0.05$.

3. Results

Cycle displacement magnitude, shape and phase of the sacrum differed between the movement of the simulator and that of real horses in all three axes. Shape and phasing of dorso-ventral displacement were similar but the real horses exhibited greater (P=0.014) dorso-ventral displacement within a stride (Figs. 1, 3 and 5, Table 2) and variation (P=0.004) between strides than the simulator (Figs. 1 and 5, Table 2).

A fundamental difference exists between the simulator and a real horse in the magnitude and phasing of cranio-caudal displacement within a stride (Figs. 2, 3 and 5). Horse displacement is smaller (P=0.000) than simulator, although a significant difference in variation between strides was not found. Simulator displacement is in the opposite direction to the horse. The horse moves upward and backward, then downwards and forward (clockwise) while the simulator moves upward and forward, then downward and backwards (anticlockwise) (Fig. 3).

Medio-lateral displacement of the simulator is smaller than the real horse (P=0.000) with less variability (P=0.004) presumably as a result of the simulators stationary nature. Despite the greater variation in a real horse, a clear and consistent pattern throughout the stride can be seen between left and right lead gallop (Fig. 4).

No significant difference in pitch amplitude was found although differences in phasing were visible between the simulator and real horse and also between left and right lead gallop (Fig. 6). In contrast a significant difference was found in roll amplitude (P=0.001) between simulator and real horse and a consistent but opposite movement was recorded between left and right lead gallop (Fig. 7).

4. Discussion

The racehorse simulator is a simplified model of the movement of a real horse. Powered by a 1.5 kW (2 horsepower) motor, it is restricted mechanically due to hinged joints and its permanent location. A real horse's musculoskeletal system has a multitude of complex joints, muscles and tendons that all interact to support the horses mass and enable locomotion.

Displacement of the simulator sacrum is different to that of a real horse. The simulator has a smaller dorso-ventral and medio-lateral displacement in conjunction with greater cranio-caudal displacement amplitude compared to that of a real horse. Further to magnitude differences, phasing differs with the cranio-caudal displacement being around 180° out of phase between the simulator and horse (Fig. 6) resulting in opposite trajectories. Due to the fixed nature of the simulator, and therefore inability to roll, a significant difference in sacrum roll was recorded between the simulator and real horse trials. Further differences were seen between left and right lead gallop initially rolling away from the

Table 1
Jockey experience categories.

Level	Name	Description
1	Beginner	Working full time for less than 1 yr or possibly still at the BRS under Foundation Training.
2	Novice	Working full time for over 1 yr but not had any race rides.
3	Intermediate	Working full time for over 1 year, holds a licence but less than 20 rides – recently got licence e.g. done Apprentice licence course in last yr.
4	Experienced	Riding over 3 years, has held licence for more than one year, had over 20 rides and ridden up to 20 winners raced 21 or more times and won 20 or less in the last year – corresponding to Apprentice Continuation Course.
5	Elite	Has held a licence for over 3 years, ridden over 20 winners and riding on a daily basis.

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