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Original Research

Kinematic Analysis of the Rider According to Different Skill Levels in Sitting Trot and Canter

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ABSTRACT

The purpose of this study was to analyze and compare the kinematics of a group of 10 professional riders (PROs) and a group of 10 beginners (BEGs) in sitting trot and canter. Therefore, the relative joint angles of the knee and elbow as well as the absolute segment angles of the riders' pelvis, trunk, and head were measured using a full-body inertial measurement system under field conditions. Two further sensors were attached to the horse and collected the motions and steps of the horses. The waveform parameters of each rider–horse combination were statistically and qualitatively analyzed over 30 gait cycles. At sitting trot, the ranges of motion of the left elbow and left knee were significantly higher in the BEG group. Furthermore, the BEGs' heads tilted notably more anterior than PROs' heads in sitting trot. In canter, BEGs moved their trunks significantly more over the mediolateral axis than PROs. Statistical differences in the ranges of motion of the riders' elbows and knees could be found in canter. Considering this, it can be presumed that a smaller range of motion in the elbows and knees and a more upright head are indicators for a more skilled rider in sitting trot. Furthermore, the results of canter pointed out that a more stable and calmer trunk could be important for a good riding performance. Based on these quantitative findings, the performance of inexperienced riders could be improved in the future.

1. Introduction

In horseback riding, the skill of the rider has an influence on the movements of the horse and the harmony of such horse–rider systems. It was found out that proficient riders are more in harmony, more stabilized, and more consistent than beginners [1–3]. Novices or less-skilled riders probably cannot follow the movement of the horse because they are stiff or asymmetries in their musculoskeletal system prevent a better performance [2,4]. A good riding performance is based on a correct rider posture and the interaction between the rider and the horse. In the literature, the ideal dressage seat is described as the following: The rider's posture is balanced, elastic, and upright. In the sagittal plane, the rider's ear, shoulder, hip, knee, and ankle must be on the same vertical axis. In the frontal plane, the rider should be sitting in a central position on the horse [5–7].

These mainly theoretical considerations of horseback riding are difficult to understand for judges, horsemen, and researchers. The results of Blokhuis et al [5] investigation show that the ideal seat of the rider is difficult to define. Therefore, they give a suggestion to analyze the rider's posture with a comprehensive approach.

By using infrared cameras, it is possible to collect and analyze the kinematics of riders and horses with a high accuracy [8–11]. But such systems are expensive, require a dedicated laboratory, and also need a skilled horse that was trained to walk on a treadmill. Several studies have already shown that there are differences in stride characteristics

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between treadmill and overground locomotion [12–14]. Furthermore, the rider's posture and movement was analyzed with video-based measurement techniques under field conditions [15–19]. These studies concluded that the rider's position on a horse and the postural variations in the upper and lower body are different according to the rider's skill level [1,2,15]. However, video-based measurements have a number of drawbacks: (1) these measurements have a limited field of view and small sample sizes [9] and (2) there are limitations concerning the quantification of acceleration data [20,21]. Because of the fast locomotion of canter, there are difficulties to analyze the rider's kinematics by using those systems. Up to present, the rider's posture in canter was investigated only in preliminary studies with the limitations of video-based systems explained previously [17,18].

Biomechanical analyses of the rider [22,23] and the horse–rider interaction in dressage [24] have shown that inertial measurement units are suitable for collecting the rider's kinematics showing results with a high reliability and repeatability under field conditions in all equine gaits. Nonetheless, the rider's postural variations and horse–rider interactions are not fully analyzed and understood yet.

Thus, the aim of this study was to investigate whether significant differences exist between the kinematics of a group of 10 professional riders (PROs) and a group of 10 beginners (BEGs) by using a full-body inertial measurement system under field conditions during sitting trot (ST) and left-lead canter (CL).

2. Materials and Methods

2.1. Subjects and Horses

Ten high-level riders (PROs: eight women, two men; mean age ± standard deviation [SD]: 23.4 ± 5.3) with a body mass index of 21.5 ± 2.5 kg/m^2 and 10 beginners (BEGs: seven women, three men; mean age ± SD: 20.2 ± 5.7) with a body mass index of 21.6 ± 2.6 kg/m^2 participated in the study. The PROs were experienced riders (mean of experience ± SD: 33.9 ± 11.9 years) and riding instructors of the German National Equestrian Federation (FN). The BEGs were students of a riding school with limited riding experience (mean of experience ± SD: 3.2 ± 1.9 years). Both groups (PROs and BEGs) rode their own horses and used their own dressage saddles and bits. The ridden warmblood horses belonging to the PRO (eight geldings, two mares; mean age: 7.9 ± 4.2 years; mean height at withers: 170 ± 3.5 cm) had been trained by the FN. The BEGs' warmblood horses (seven geldings, three mares; mean age: 10.8 ± 3.7 years; mean height at withers: 173 ± 6.5 cm) were exercised in a riding school. None of the investigated horses showed any sign of lameness.

2.2. Testing Procedure

In the middle of an indoor riding hall, the subjects rode with constant working speed four times in ST and four times in CL. They rode a straight line on a 30-m sand track. In accordance to the method described by Eckardt et al [22], the kinematics of each rider (PROs and BEGs) was recorded with a six-degrees-of-freedom full-body inertial measurement system (MVN; Xsens Technologies BV, Enschede, The Netherlands). To investigate the horses' trunk movements simultaneously, an additional six-degrees-of-freedom inertial measurement unit (MTx; Xsens Technologies BV) was placed centrally on the saddle girth next to the sternum of the horses [23] (Fig. 1). To identify one gait cycle of the horses, one wireless 3D accelerometer (RFTD-A01; myon AG, Baar, Switzerland) was fixed laterally onto the cannon bone of the left front limb. All measurement systems were

Fig. 1. Experimental setup: rider (MVN suit) and horse (acceleration sensor on the cannon bone) with the applied measurement systems: Rotation axes of the riders' segments are shown as arrows: red arrows indicating roll angles; green arrows indicating pitch angles [22].