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Maximum and minimum peaks in rein tension within canter strides

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ABSTRACT

Equestrians use reins to communicate with the horse. The aim of this study was to describe the amplitudes of rein tension oscillations at canter. Rein tension data were collected from 8 professional riders each riding 2-3 horses during a normal dressage training session using rein tension meters (128 Hz, logged by an inertial measurement unit sensor). Data were stride-split at the maximal positive vertical poll acceleration. Strides were categorized by canter lead, rider position (sitting/2 point), corners, circles, lateral movements, and stride length (collected/working/lengthened). Changes in head angle were determined from gyroscopic sensor data. Dependent data extracted from each stride and rein were maximal tension (MAX), minimal tension (MIN), and the absolute difference between them (CHANGE). Square-root transformed data were analyzed using mixed models with stride categorizations as fixed effects, and rider and horse included as random effects. Findings for rein tension were considered borderline if $0.05<P>0.001$, but significant if $P < 0.001$. For the rider's position, the magnitudes were higher in sitting canter than 2-point seat ($P < 0.0001$), except for inside rein MIN value ($n = 21{,}548$ strides). For MAX (both reins), MIN (inside), and CHANGE (outside), the right circle had lower values than the left circle or no circle. For the outside rein, MAX and MIN values showed borderline differences with higher values for lengthened strides than working canter ($P = 0.03/0.0014$). Inside rein values in right half pass were significantly or borderline higher than left half pass or baseline, and for MIN values, this was found for both inside/outside reins. Both group effects and all pairwise comparisons evaluated were significant for MAX and CHANGE, except the comparison between inside and outside rein in right canter. MAX/MIN tensions were higher if the nose was moving caudally relative to poll at the MAX/MIN event, respectively. Young horses had the largest MAX and CHANGE values, whereas advanced horses had the highest MIN values. The horse contributed 7%, 27%, and 29% of the variation to MIN, MAX, and CHANGE models, respectively. The rider contributed 19% of the variation to the MIN value models but 0% to the MAX and CHANGE models, suggesting that the horse or the dyad (not statistically separable) is responsible for the basic rein tension pattern at canter. Overall results indicate that asymmetry, of riders and/or horses, plays a role in rein tension.

Introduction

There are many styles of horseback riding that use different equipment and various criteria for assessing performance. One of the features that is common to most riding styles is the use of reins as a means of communicating signals from the rider to the horse. The practice of inserting a bit into the oral diastema has been used as an integral part of a rein-based communication since around 3,500 BC (Anthony and Brown, 1991). Over the intervening years, horseback riding has evolved from the utilitarian needs of transportation and warfare into sophisticated sports in which the bit and the reins offer a means of subtle communication between rider and horse. The effect of rein tension is relevant in relation to equine welfare because it is assumed that excessive tension may be deleterious to the horse's welfare (Ödberg and Bouissou, 1999). Therefore, scientists are interested in measuring rein tension both as a variable that influences success in equestrian sporting performance

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and in relation to the development of oral pathologies (Ödberg and Bouissou, 1999; Tell et al., 2008).

Studies have shown that rein tension varies between riding sessions, riders, horses, reins and other equipment, gaits, exercises, and also between and within-strides (von Borstel and Glißman, 2014; Clayton et al., 2003; Clayton et al., 2005, 2011; Egenvall et al., 2012; Egenvall et al., 2015; Egenvall et al., 2016; Eisersiö et al., 2013; 2015; Heleski et al., 2009; Kuhnke et al., 2010; Warren-Smith et al., 2007). When horses are ridden on the bit, which implies that a contact is maintained between the rider's hand and the bit, rein tension fluctuates considerably over the stride cycle (Clayton et al., 2003; 2011; Egenvall et al., 2015; Egenvall et al., 2016; Eisersiö et al., 2013) and shows a gait-specific pattern of oscillations (Clayton et al., 2003). These oscillations are thought to reflect the cyclic movements of the horse's head and neck relative to the trunk that are characteristic of each gait (Clayton et al., 2011). For example, in trot, the head and neck undergo 2 motion cycles per stride in which they descend under the influences of gravity and inertia to reach their lowest point just after the middle of the diagonal stance phases and are then raised to reach their highest point during the suspension phases (Hobbs et al., 2014). Lowering of the neck coincides with an increase in rein tension (Clayton et al., 2011).

Rein tension during the stride cycle has mainly been studied using average values calculated over multiple strides and using variables such as minimal, maximal, and mean tension to represent the cyclic nature of the data (e.g., von Borstel and Glißman, 2014; Clayton et al., 2011; Warren-Smith et al., 2007). Data presented by Clayton et al. (2011), as well as Eisersiö et al. (2015), suggested that using mean rein tension over the entire stride to discriminate between different experimental conditions may be difficult and that minimal and maximal values could be more useful. A complete description of the oscillations in rein tension should include variables describing the magnitude of the peaks and troughs in rein tension, and the amplitude, duration, and rate of tension change during the rise and fall phases. In addition, summation of the tension values (area under the curve) during the complete oscillation may be useful (Clayton et al., 2011). The timing of these events, for example, when minima and maxima occur, relative to the horse's stride cycle provides relevant information.

Factors that affect rein tension include the horse's gait, the rider's ability to follow the movements of the horse, the rein aids given by the rider to communicate with the horse, and the horse's response to the rein aids (von Borstel and Glißman, 2014; Clayton et al., 2003; Egenvall et al., 2012; Egenvall et al., 2015; Eisersiö et al., 2013, 2015; Heleski et al., 2009). Oral lesions can be due to abrasion of soft tissues, such as the cheeks or tongue, by contact with sharp edges of the teeth or pressure applied by the bit to the oral tissues (Björnsdottir et al., 2014; Tell et al., 2008). However, the susceptibility of different oral tissues to pressure of different magnitudes and durations is not known. Because increased pressure on the oral tissues is a direct consequence of an increase in rein tension, studies of rein tension during riding are required to provide normative values as a prerequisite to seeking information regarding the magnitude and effects of excessive rein tension.

This study analyzes rein tension within strides of canter performed by professional riders mounted on horses in their own training. The long-term goal is to further our understanding of how the interaction between the horse and riders affects forces between the rein and the bit, and the bit and the mouth, to improve both equine welfare and riding pedagogy. The aim is to quantify the patterns and magnitudes of the applied rein tension by measuring variables that describe the minima, maxima, and the absolute difference between them together with the horse's sagittal-plane head rotation. These variables were analyzed in relation to rein (inside/outside), the rider's position in saddle (sitting, 2-point seat), passing through corners, circling, performing lateral movements, and riding with shorter or longer strides (collected/working/lengthened). Our hypotheses were that rein tension is equal in the left and right reins regardless of direction of travel or movements performed and that rein tension differs when shortening versus lengthening the stride, and rein tension differs when the rider uses a 2-point seat versus sitting in the saddle.

Materials and methods

Riders and horses

Rein tension data were collected from 8 professional riders (mean ± STD height 173 ± 6 cm and weight 65.5 ± 10 kg) riding horses they had trained regularly over a period of one month to 22 years (median 24 months). The horses were classified according to their level of training as advanced, medium, basic, or young. Seven riders rode 3 horses each and 1 rider rode 2 horses ($n = 23$). All horses wore their own well-fitting saddle (as assessed by the riders) and a bridle with a snaffle bit. Fifteen of the snaffles were double jointed, 2 of which had fixed rings and 1 had a small port. Six bits were single jointed, 2 of which were full cheek. Two bits were unjointed, 1 with rigid rings and 1 with rubber rings. One rider was left handed, the others were right handed. When asked the riders assessed 7 horses as being easier to bend to the left, 15 horses were easier to bend to the right, 1 horse was equally easy to bend left and right, and 1 horse was easier to bend right at the trot and left at the canter.

Equipment

Data collection took place at each horse's current stable in an outdoor ($n = 4$ riders, gravel-based, the smallest 23 × 62 m and the largest 40 × 80 m) or indoor ($n = 4$ riders, 2 sand-fiber arenas and 2 sand-wood chip arenas, the smallest 20 × 50 m and the largest 24 × 62 m), riding arena depending on the weather conditions. Before mounting by the rider, custom-made rein tension meters (sampling rate: 128 Hz; measuring range: 0-500 N; resolution: 0.11 N), were fitted onto leather reins. A cable from each tension meter ran forward along the rein and up the cheek piece of the bridle, to an inertial measurement unit (IMU, x-io Technologies Limited, UK) fastened at the browband of the bridle using hook and loop fasteners. The rein tension meter (Eisersiö, 2013) was successfully tested in a tensile test machine for stability and repeatability (e.g., see Egenvall et al., 2016) and was calibrated before starting the riding sessions for each rider by suspension of 13 known weights ranging from 0 to 20 kg. It took about 10 minutes to fit the equipment onto the horse and synchronize the rein tension meters with the videos. Video recordings (Canon Legria HF200, 25 Hz) of the entire riding session were made from the middle of one of the long sides of the arena. All horses were judged to be free from lameness by a veterinarian who visually evaluated the videos.

Study design

The riders were asked to perform a flatwork/dressage training session that was appropriate for the educational level of each horse including periods of walk, trot, and canter. The whole riding arena was used, and the duration of the riding session and the exercise performed was determined by the rider.

Synchronization of equipment

After the rider had mounted at the start of the session and before dismounting at the end, the rein tension meter was synchronized with the video recordings by pulling the right rein to apply the