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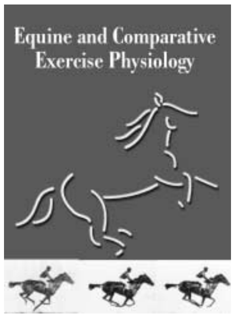

A preliminary investigation of rider position during walk, trot and canter

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Abstract
The purpose of this study was to determine whether significant differences exist in the position of a horse rider when assessed at different points in the horse's stride cycle at walk, trot and canter on the right rein. Video analysis was used to determine the absolute angles of the trunk, thigh and lower leg of five subjects during the walk, rising trot and canter. The range of movement of the trunk, thigh and lower leg during each gait was also determined. At walk significant differences in the rider's trunk angle were found between limb impacts ($P < 0.05$). At trot significant differences were found in all angles between impacts of the horse's diagonal limb pairs ($P < 0.05$). At canter, there were no significant differences in rider position between limb impacts. The range of movement of the trunk was 5.9°, 4.1° and 4.7° for walk, trot and canter, respectively. The corresponding ranges of the thigh and lower leg were 1.9°, 7.3° and 4.4°, and 2.9°, 5.2° and 3.9°, respectively. This preliminary study has demonstrated differences in rider posture between limb impacts in walk and trot. Further work is necessary to investigate the forces acting on the rider during each gait and the postural strategies employed by riders to maintain a balanced position. Such work is a necessary forerunner to the study of rider influence on horse performance.

Keywords: horse-rider; riding; kinematics

Introduction

Riding is a popular recreational and competitive sport. With the exceptions of racing and Western riding, all disciplines require the rider to adopt a posture based on the 'classical seat'. The classical riding position for flat work is described as one in which an imaginary straight line can be drawn through the rider's ear, shoulder, hip and heel, and a second imaginary straight line drawn through the elbow, hand and rein to the bit[1,2]. This position is based on a static image of the rider and does not define any motion that should or does occur when the horse is moving.

A rider's position should enable them to influence and control the movements of their horse in terms of speed and direction without interfering with the horse's balance[1,3]. At novice level this would be the only aim of the rider; however, at a more advanced level, the rider will have the additional aim of positively influencing the horse's gait by the application of appropriate 'aids' or signals to the horse. Effective application of the aids requires considerable postural control on the part of the rider and is dependent upon their training, sporting discipline, conformation and previous injury. To date, researchers have considered the influence of rider weight on horse kinematics[4–6] and the rider's influence on the angular momentum and angular velocity of the jumping horse[7], and a reasonable amount of data is available relating to the physiological demands of riding[8,9].

An analysis of riders with differing levels of ability has shown that, at walk, sitting and rising trot, the posture of more advanced riders can be distinguished from that of novice riders by looking at the position of the trunk, hip and knee angles[10]. However, that study did not consider rider position during the canter. Rider–horse harmony has also been quantified using phase plane diagrams, showing that professional rider–horse combinations have a more consistent motion pattern than recreational rider–horse combinations[11]. Terada[12] investigated differences in rider proficiency by looking at the head movement and electromyogram activity of muscles in novice and advanced riders, and concluded that differences existed in the ability to co-ordinate rider movements between the gaits, with muscle co-ordination at sitting trot being particularly difficult for novice riders. Recently, Terada *et al.*[13] conducted an electromyographic analysis of the rider's trunk muscles during sitting trot. Other studies have considered the effect of the rider's aids on the horse's movement[3,14,15]; these studies, however, tend to show a qualitative rather than a quantitative view.

To improve teaching methods and ultimately to enhance rider–horse performance, an understanding of the rider's position during the stride cycle of various gaits is required. The influence of rider position on horse performance can only be fully understood once the normal range of movement in the rider has been described for all gaits and for the jump sequence. The aims of the present study were to define the position of the rider at different points within the stride cycle in walk, rising trot and right lead canter. The null hypothesis is that there will be no significant difference in trunk, hip and knee angles between limb impacts at walk, trot and canter.

Methodology

Study population

Five female riders aged between 19 and 21 years were selected to take part in this study. All had achieved British Horse Society Stage III or equivalent. Weight of the riders was 63.8 ± 6.38 kg and height was 169.4 ± 6.19 cm (mean ± standard deviation (SD)). One Thoroughbred cross riding horse with a height at the withers of 163 cm was used for each trial. At the time of the trial the horse was competing in elementary dressage competitions and was free from overt lameness. The same dressage saddle and snaffle bridle were used throughout the study.

Marker placement

Circular skin markers, 3.5 cm in diameter, were placed on the right side of each rider and covered the following anatomical landmarks: the ankle (lateral malleolus); the knee (lateral side of the centre of the flat portion of the condyles of the femur); the hip (greater trochanter of the femur); and the shoulder (glenohumeral joint centre). Each rider wore tightly fitting clothing to minimize displacement of the markers.

Recording equipment

A digital video camera (Canon XL1; Jessops, Leicestershire, UK) mounted on a tripod 1.50 m above the ground was positioned perpendicular to and 10 m away from the track to be followed by the horse and rider. The field of view measured 8.65 m, and data were recorded at a rate of 25 Hz. Two markers, 5.00 m apart, were placed in the field of view to allow the horse's velocity to be calculated for each run through the field of view. The time taken for the horse to travel between the two markers was calculated retrospectively using frame counts. Velocity was then given by the time taken to travel between the two markers divided by 5.00 m.

Data collection

All data were recorded in an indoor arena (50 m × 30 m) with a rolled sand surface. Each rider was given a 5 min warm-up period prior to data collection. Data were collected on the right rein (i.e. in a clockwise direction) at walk, rising trot and canter down the long side of the arena. In rising trot, the rider rises from and sits into the saddle in time with the two-beat rhythm of the gait. In the present study riders were asked to sit when the horse's left forelimb was in contact with the ground. Each rider rode past the camera four times at walk, trot and canter.

Analysis of data

Video recordings of four strides of each gait were analysed for each subject, with data presented being the mean of all four strides. One stride from each pass in front of the camera was selected on the basis of its occurrence closest to the centre of the field of view, thereby minimizing perspective error. The angles at the distal end of the lower leg, thigh and trunk segments were measured to the horizontal in a clockwise direction. The horizontal was determined as a line drawn along the top of the kick boards within the field of view. Each of the angles was measured manually from a print of the first frame picturing the distal hoof in the sand, which was defined as 'initial ground contact'. A single stride was determined as being the time between successive impacts of the right forelimb. The horse's walk is described as a four-beat gait; therefore four points during each stride were analysed. The trot is a two-beat gait and therefore two points during each stride were analysed. For the purpose of this study, impact of the right forelimb and left hind limb was termed the left diagonal and impact of the left forelimb and right hind limb was termed the right diagonal. Each horse was cantered on the right lead so that the sequence of limb placements was left hind, right hind and left fore simultaneously and right fore; therefore three points during each stride were analysed. Standard error was calculated from 20 repeated measures of one frame and was found to be less than 1° for each angle measured.

Statistical analysis

Due to the small sample size, non-parametric tests were used. Differences between angles measured at each limb impact during the walk and canter were

Table 1 Mean (standard deviation) angle and range of movement of the rider's lower leg, thigh and trunk segments during the walk

Segment	Right forelimb (°)	Left hind limb (°)	Left forelimb (°)	Right hind limb (°)	Range of movement (°)
Lower leg	69.6 (5.1)	66.7 (4.8)	68.3 (5.4)	68.2 (5.5)	2.9
Thigh	125.9 (6.0)	125.0 (8.2)	126.9 (8.4)	125.3 (9.0)	1.9
Trunk	87.2 (2.0)	91.9 (2.1)	86.0 (2.0)	91.2 (1.3)	5.9

analysed using the Friedman test for repeated measures. Differences between angles measured at impact of each diagonal pair in trot were measured using the Wilcoxon signed rank test. Analyses were conducted using SPSS® version 10.1 (SPSS Inc., Chicago, IL). The 0.05 level of significance was used.

Results

The walk

The velocity of the walk was $1.84 \pm 0.1\,\mathrm{m\,s^{-1}}$ (mean ± SD). The mean angle and range of movement for each of the measured body segments for walk are shown in Table 1. At hind limb impact the trunk was behind the vertical, whilst at forelimb impact it was in front of the vertical (see Fig. 1), thereby showing an overall range of movement of 5.9° (see Table 1). Much smaller ranges of movement were seen in the lower leg (2.9°) and thigh segments (1.9°). No significant differences were found in the angle of the lower leg or thigh between limb impacts. Significant differences in trunk angle occurred between forelimb and hind limb placements.

The trot

The velocity of the trot was $3.78 \pm 0.13\,\mathrm{m\,s^{-1}}$ (mean ± SD). The mean angle and range of movement for each of the measured body segments for trot are shown in Table 2. The position of each segment varied with the impact of each limb pair (see Fig. 2). The thigh segment showed the greatest range of movement (7.3°), compared with the lower leg (5.2°) and the trunk (4.1°). At impact of the right diagonal limb pair, all body segments were closer to the vertical than at impact of the left diagonal pair ($P < 0.05$).

The canter

The velocity of the canter was $4.82 \pm 0.28\,\mathrm{m\,s^{-1}}$ (mean ± SD). The mean angle and range of movement for each of the measured body segments for canter are shown in Table 3. The position of each segment varied between limb impacts (see Fig. 3), although these differences were not found to be significant. The trunk segment showed the greatest range of movement (4.7°), compared with the thigh (4.4°) and the lower leg (3.9°).

At impact of the left hind limb the trunk segment was close to the vertical (86.1°). At impact of the left forelimb and right hind limb the trunk angle was

Table 2 Mean (standard deviation) angle and range of movement of the rider's lower leg, thigh and trunk segments during the trot

Segment	Right forelimb and left hind limb (°)	Left forelimb and right hind limb (°)	Range of movement (°)
Lower leg	73.8 (2.6)	68.6 (4.1)	5.2
Thigh	124.9 (4.1)	117.6 (3.1)	7.3
Trunk	80.7 (6.2)	84.8 (4.5)	4.1

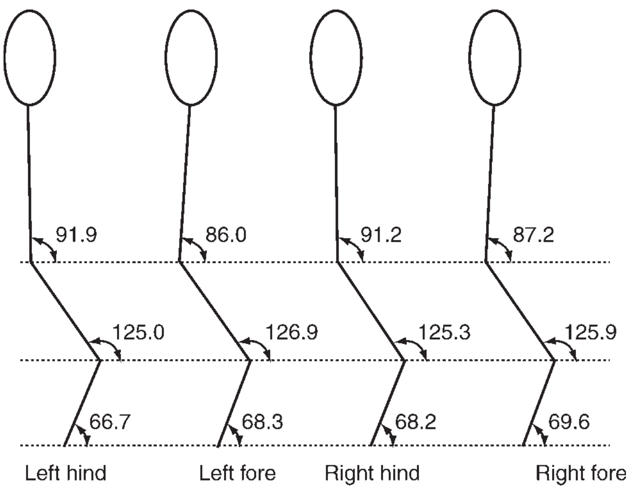

Fig. 1 Mean angles (°) for riders measured at impact of each of the horse's limbs during walk

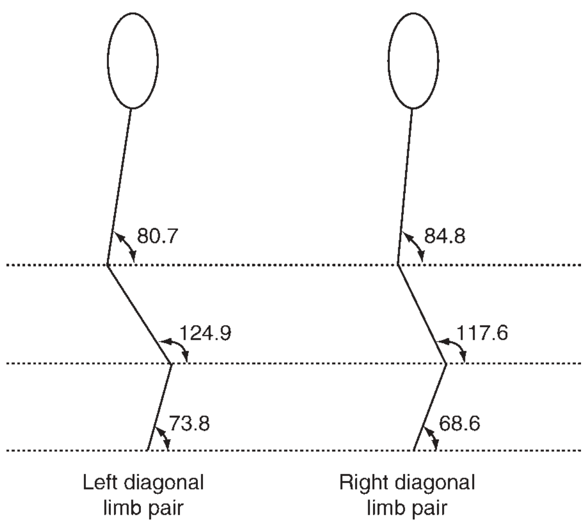

Fig. 2 Mean angles (°) for riders measured at impact of the horse's limb pairs during trot

Table 3 Mean (standard deviation) angle and range of movement of the rider's lower leg, thigh and trunk segments during the canter

Segment	Left hind limb (°)	Left forelimb and right hind limb (°)	Right forelimb (°)	Range of movement (°)
Lower leg	69.6 (1.8)	69.4 (2.4)	73.3 (5.0)	3.9
Thigh	123.1 (6.5)	123.2 (7.5)	127.5 (5.3)	4.4
Trunk	86.1 (6.7)	81.4 (8.2)	82.1 (5.6)	4.7

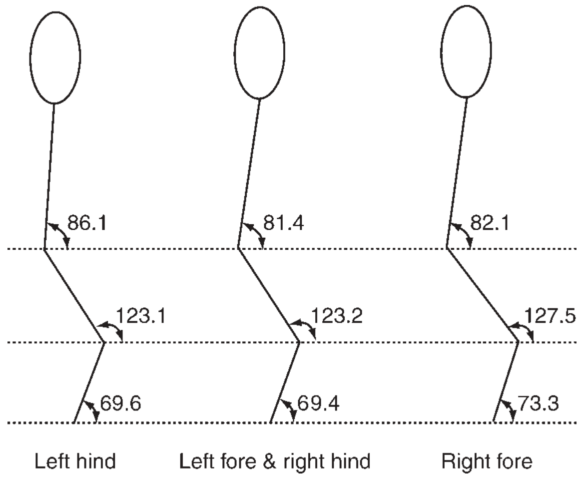

Fig. 3 Mean angles (°) for riders measured at impact of the horse's limbs during right lead canter

smaller (81.4°) and maintained a similar position at impact of the right forelimb (82.1°). Both the thigh and lower leg segments maintained a similar position at each point in the stride, with the largest angles seen at impact of the right forelimb.

Discussion

The classical position described in equestrian literature is based on a single, static posture and does not take into account any movement that may occur during each stride. Our findings have shown that significant changes in rider position occur during walk and rising trot. From the work of Schils *et al.*[10], each of the riders in the present study could be classified as being at intermediate standard on the basis of their lower leg position and advanced standard on the basis of their trunk position. This cross-classification may be caused by the smaller sample size used in the present study or may be related to actual differences in riding styles seen between the two groups, as 39% of riders in the study by Schils *et al.*[10] rode predominantly in a Western style. Further comparison with Schils *et al.*'s work[10] is difficult because their data were reported as an average of angles measured at different points during the stride and did not consider any changes in rider position throughout the stride cycle.

The sampling frequency of 25 Hz is relatively low, with the result that the actual initial ground contact with the sand may have occurred between frames. Whilst increased accuracy would be gained by use of a higher sampling frequency, there would still be limitations in defining the exact moment of initial ground contact due to the variable height of the sand surface. While the sampling rate was considered sufficient to address the aims of this preliminary study, it should be noted that the accuracy in limb impact identification is greater for walk and trot than for canter.

The velocity of the walk in the present study was comparable to the velocity of the extended walk reported by Clayton[16] for horses competing at national level. The walk is a symmetrical gait in which the pattern of limb movement on one side of the horse is repeated half a stride later by the limb pair on the contralateral side. At the walk, significant difference between limb impacts was only seen in the angle of the trunk segment. At impacts of the hind limbs the trunk segment was slightly behind the vertical and at forelimb impacts the trunk was in front of the vertical. Possible influences on the rider's trunk position include flexion–extension movements of the horse's back, changes in orientation of the horse's trunk or inertial forces resulting from the propulsive forces generated by the horse's limbs. At walk, it has been shown that the height of the horse's withers and *tuber sacrale* is lowest at the beginning of the stance phase and highest at approximately mid-stance of both thoracic and pelvic limbs[17]. It is therefore likely that the hip joints act as a fulcrum around which the trunk segment pivots in relation to forelimb and hind limb stance phases. Further work is required to determine the strategies riders use to control movement of their upper body during walk and the influence of different horse types, as such information would be valuable for training novice riders.

During rising trot the rider rises and sits in the saddle according to the two-beat rhythm of the gait. The velocity of the trot was comparable to that of the working trot reported previously[18]. During the present study, the riders sat on the right diagonal, meaning that as the left forelimb entered mid-stance the rider was seated in the saddle, and as the right forelimb entered mid-stance the rider was raised out of the saddle. In agreement with Schils *et al.*[10], the trunk segment was seen to be in front of the vertical throughout the trot stride, showing that the rider adopts a different position in the trot compared with the walk.

At the point of initial ground contact of the left forelimb the rider's seat was returning to the saddle, while at the point of initial ground contact of the right forelimb the rider' seat was moving away from the saddle. The significant difference in rider position between impact of diagonal pairs may reflect the differences in balance and co-ordination required between the sitting and rising phases of rising trot. Schils *et al.*[10] also reported two distinctive positions during rising trot, dependent upon whether the rider was seated or raised from the saddle. Continuous analysis of the rider's movements through an entire trot stride would be required to determine when the change in position occurs, and to identify if riders adopt different strategies depending on the type and movement of the horse they are riding. Identifying differences between the movements of beginner and advanced riders may also be of use in developing teaching techniques for beginners.

Analysis of the position of the individual segments during the rising trot indicates that the thigh segment shows a greater range of movement in the rising trot than during the walk, which can be related to the rider's efforts to rise from and sit into the saddle. The lower leg segment is positioned more caudally as the rider moves into a seated position and is closer to the vertical position as the rider rises. This movement of the lower leg may be related to the application of a forward driving aid. However, it is more likely that it provides the rider with a stronger base from which to rise and allows better mechanical efficiency of the rising movement as the knee extensor muscles would remain closer to their mid-range[19]. As only the rider's right side was assessed, no comment can be made on the symmetry of movement between the rider's left and right sides.

The velocity of the canter recorded in the present study was comparable to the velocity of medium canter in horses competing at national level[20]. The results for the canter show that the lower leg and thigh segments maintain similar angles to those seen during the walk and trot, and undergo relatively small changes in position through the canter stride cycle. As in the walk, the largest range of movement was seen within the trunk segment although there was no significant difference in trunk position seen between limb impacts.

In canter as in walk, the rider's upper body is likely to be influenced by the longitudinal ground-reaction forces of the limbs and flexion–extension movements of the horse's back. However, in canter, the changes in orientation of the horse's trunk are greater than in walk owing to there being an aerial phase. The range of movement of the trunk in canter is comparable to that seen in walk. Since the ground-reaction forces during canter are greater than during walk, and the change in orientation of the trunk is also greater, the fact that the rider's trunk shows a comparable range of movement to that of the walk suggests that the rider uses a greater degree of muscle activity to maintain the position of their trunk during canter. Westerling[8] found heart rates and oxygen uptakes of riders during canter to be $172 \pm 18\,\text{beats min}^{-1}$ and $30.6 \pm 3.3\,\text{ml kg}^{-1}\,\text{min}^{-1}$, compared with $108 \pm 13\,\text{beats min}^{-1}$ and $9.4 \pm 1.4\,\text{ml kg}^{-1}\,\text{min}^{-1}$ for walk. Further study is required to determine the effect of the rider's muscles on maintaining postural stability throughout the stride during various gaits. Comparing rider position and muscular activity on both trained and untrained horses would go some way towards understanding the influence of the rider's posture on the quality of the horse's gait.

Conclusion

This pilot study has quantified the range of movement of body segments seen in walk, rising trot and right lead canter and has related these movements to the horse's stride cycle. Greater understanding of the rider's movements will provide a sounder basis from which to teach both novice and advanced riders. There is tremendous scope for further study relating the movements of the horse and rider to the forces that produce them.

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A preliminary investigation of rider position during walk, trot and canter. T. Lovett, E. Hodson-Tole, Kathryn Nankervis. Medicine. 1 May 2005. The purpose of this study was to determine whether significant differences exist in the position of a horse rider when assessed at different points in the horse's stride cycle at walk, trot andâ€¦ Expand. 50. Comparative analyses of rider position according to skill levels during walk and trot in Jeju horse. Human Movement Science, Vol. 29, Issue. 6, p. 956.Â Rein tension during canter. Comparative Exercise Physiology, Vol. 11, Issue. 2, p. 107.Â A comparison of the position of elite and non-elite riders during competitive show jumping. Comparative Exercise Physiology, Vol. 11, Issue. 2, p. 119. Trot for a few strides; then come back to walk before you start to fall apart. If, as you increase your number of sitting strides, you find you're losing your position, getting tired or starting to get out of phase, immediately walk and reorganize. The only way you learn to do a movement well is by doing it well. If you press on after your position begins to degrade or you start bouncing, you won't learn to sit well. While walking is a slow movement that is used at the beginning and end of rides, trotting is a little faster and cantering is a little faster still. With some practice of how to position your body and how to give clear directions to your horse, you can learn to ride a horse at walk, trot, and canter. Steps. Method 1 of 3: Walking a Horse.Â Distinguish the canter from the walk and the trot. The canter is three-beat gait with a rocking motion. This is a quicker speed than walk and trot that also requires greater balance on the riderâ€™s part, so it should only be done after you have mastered the walk and the trot.[10] X Research source. During the canter, the horse moves its right rear leg, then its left rear and right front legs, and then the left front leg. The right rear leg will move again a moment later.