

Quantifying Show Jumping Horse Rider Expertise using IMUs

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Abstract—Horse rider ability has long been measured using horse performance, competition results and visual observation. Scientific methods of measuring rider ability on the flat are emerging such as measuring position angles and harmony of the horse-rider system. To date no research has quantified rider ability in show jumping. Kinematic analysis and motion sensors have been used in sports other than show jumping to measure the quality of motor control patterns in humans. The aim of this study was to quantify rider ability in show jumping using body-mounted IMUs. Preliminary results indicate that there are clear differences in experienced and novice riders during show jumping.

I. INTRODUCTION

WEARABLE sensor technology is heralding in a new age of data capture which will allow performance metrics to be captured ubiquitously during any type of activity [1]. In this paper we attempt to quantify the performance of horse show jumping riders using 4 body and horse mounted IMUs. Quantifying the ability of a horse rider to perform show jumping can be useful for development in young riders and to identify deficiencies in expert riders.

When horse riding is taught, a huge emphasis is placed on balance and rider position [2]. Rider posture of experienced and less experienced riders can be distinguished objectively in walk, trot and canter by looking at the position of the trunk, hip and knee angles. A rider's ability to maintain a correct position allows them to influence and control the movements of their horse in terms of speed and direction without interfering with the horse's balance [3]. It is the rider's focus on maintaining a correct position that has been regarded as the root of a lot of rigidity, tension and stiff movement in more novice riders. This rigidity manifests itself in the characteristic head-nod seen in many riders [4]. This has been observed but never previously objectively quantified and analyzed.

The aim of this study is to compare rider balance and movement when riders of different experience jump an experienced horse and an inexperienced horse. Previous research has shown that rider experience is not an important factor in an experienced horse's ability to jump well [5]. It is our hypothesis that novice riders will show higher levels of movement during the jump on an inexperienced horse due to being in an unbalanced position.

II. METHODS

Four riders, two novice and two experienced, jumped two horses over a 1.2m upright fence five times in an indoor arena. All riders had competed at least once at a level of 1.2m or higher. Riders were classified as novice or experienced based on their competition experience as evidenced by Showjumping Ireland certificates. Each rider was fitted with three Xsens MTx sensors (Enschede, Netherlands) measuring acceleration on the back of the helmet, the upper arm and the mid-thigh (Fig. 1). These were securely attached to the rider using either Velcro straps or elastic tape. A fourth Xsens MTx sensor was fitted to the front of the saddle to measure movement data from the horse. A Velcro strap was threaded through both D-rings at the front of the saddle providing a secure place for the sensor to sit close to the horse without interfering with its movement. Sensors were connected wirelessly via bluetooth to a laptop computer in the centre of the arena.

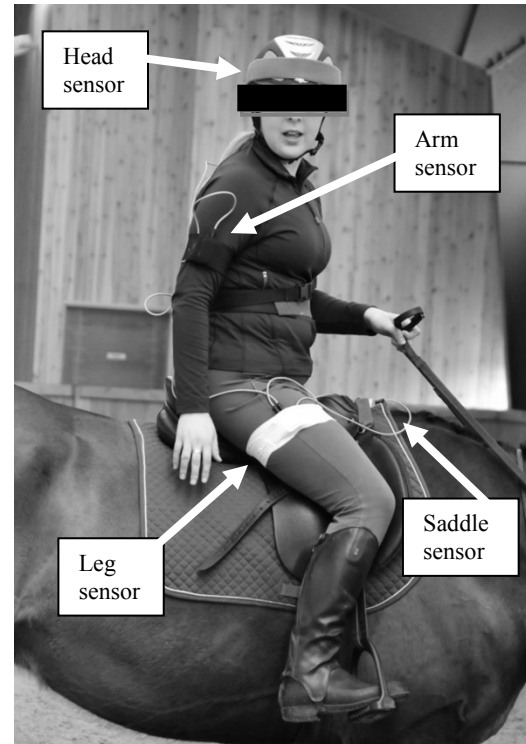


Fig. 1. Sensor set-up on the rider and saddle.

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Two horses were selected for the study. Horse 1 (Gelding, 9 years old, 470kg and 163cm) was classified as an inexperienced horse. He had been jumped over a 1.2m course prior to the study, and thus was competent enough to jump safely, but only had competition experience up to a

1.1m (Showjumping Ireland Grade E). Horse 2 (Gelding, 11 years old, 650kg and 171cm) was classified as an experienced horse. Horse 2 had competition experience up to 1.5m and had 6 years showjumping training and competition experience (Showjumping Ireland Grade C).

Data collection took place over 1 day. Rider order was controlled to minimise the effect of fatigue on the horses. Rider order was set as novice-experienced - (Rest period) - experienced-novice. In each case, the inexperienced horse was ridden first followed by the experienced horse. Riders and horses had sufficient jumping experience; thus the learning effect was likely to be small. Each horse was jumped 5 times by each rider, resulting in a total of 20 recorded jumps. Horses were warmed up appropriately and provided with rest periods if necessary. Neither horse was deemed to be over-tired at any part of the study.

A. Data Analysis

For this study we were interested in identifying movement where each sensor was placed, so only the acceleration data from the MTx sensor was analyzed. Accelerometer data from each sensor was RMS transformed to get a measure of dispersion of the data relative to zero, as done in previous studies analyzing human movement [6]. This is referred to as total acceleration and tells us when a segment is accelerating, but not in what direction. The calculation to find the total acceleration was performed by taking x, y and z acceleration values and inserting them into Equation 1.

$$\text{Total Acceleration} = \text{sqrt}(Ax^2 + Ay^2 + Az^2) \quad (1)$$

A total acceleration curve was generated for each jump that each rider performed. A custom algorithm was developed using MATLAB R2009b (Natick, Massachusetts) in which the stride before the jump was manually identified as well as when the jump began and ended and when the initial loading spikes after landing dissipated. The forward lean of the rider from the back sensor was used to confirm when in the recording the jump occurred, since all riders clearly had a large forward lean during the jumps.

Peak saddle total acceleration was calculated on the stride before take-off. This value gave an indication of how much a horse was changing their velocity close to the jump. A horse changing velocity just before the jump will have a higher peak total acceleration value.

Mean total acceleration during the jump was collected for the head and arm sensors. These factors indicate how much movement was occurring at each segment throughout the jump. Higher levels of movement during the jump would indicate that the rider is in a more unbalanced position.

Peak acceleration at landing was also collected. These values indicate how hard a horse is hitting the ground, how the impact is being transferred into the rider and how they absorb it. A novice rider who is in a more unbalanced position during the jump would likely experience higher levels of acceleration throughout their body as opposed to an experienced rider who can maintain a stable position

throughout the jump, allowing them to maintain balance through-out the impact force at landing.

III. RESULTS

The results from the sensor analyses indicate that the experienced rider group had less total head acceleration during the jump (Fig. 2). Novice riders had higher mean arm total accelerations while riding the inexperienced horse. When these same riders rode the experienced horse their mean arm total accelerations were slightly lower (Fig. 3). All riders had lower mean arm total acceleration on the experienced horse, compared to the inexperienced horse.

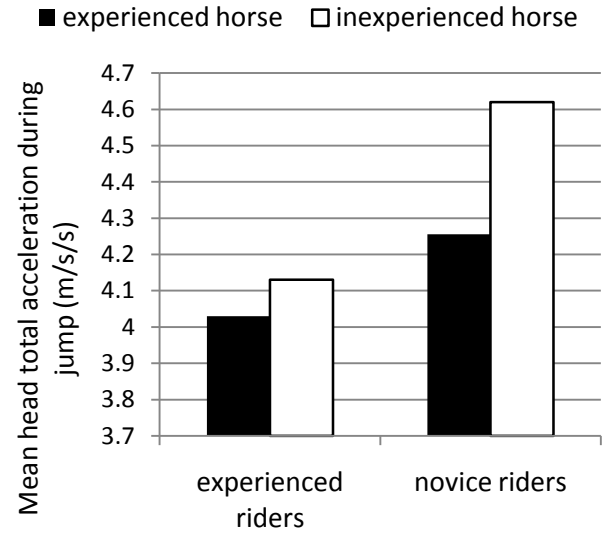


Fig. 2. Mean head total acceleration during the jump was consistently higher in novice riders. This effect was enhanced when riding the inexperienced horse. This is likely due to the novice riders being more unbalanced during the jump.

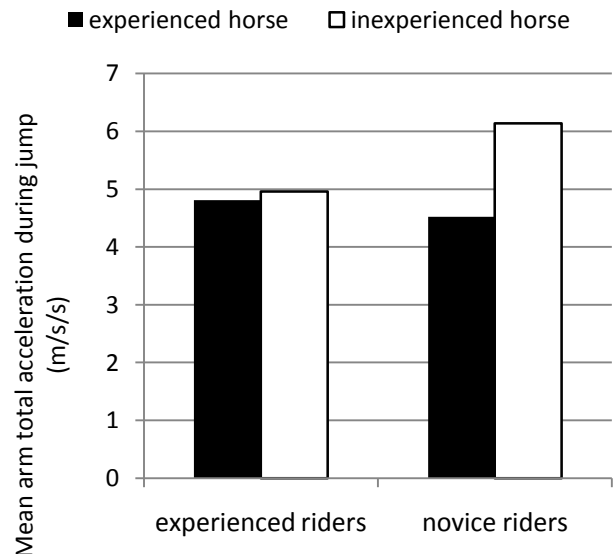


Fig. 3. Mean arm total acceleration during the jump was similar in both groups of riders while riding the experienced horse. Novice riders showed higher values while riding the inexperienced horse.

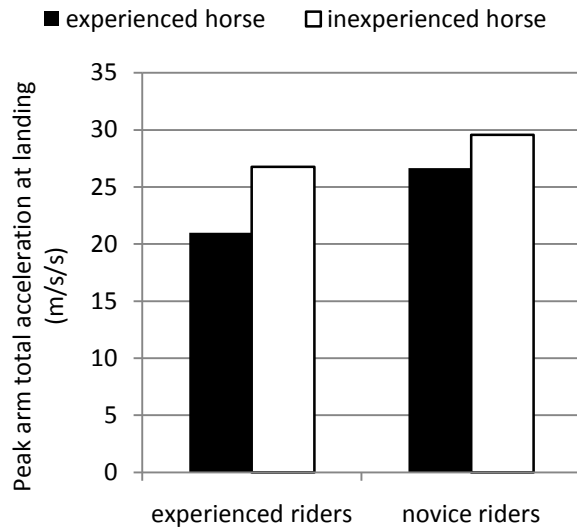


Fig. 4. Novice riders displayed higher peak arm total acceleration at landing on both horses, indicating that they were in a more uncontrolled position at landing.

Novice riders had higher peak arm and leg total acceleration at landing on both horses. All riders had lower peak arm and leg total acceleration at landing on the experienced horse (Figs. 4, 5).

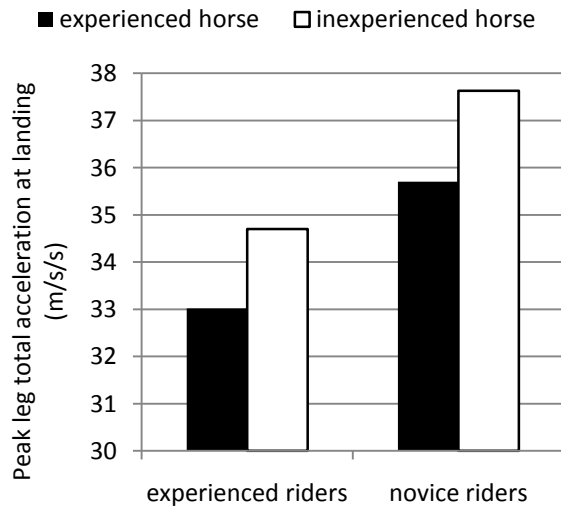


Fig. 5. Novice riders displayed higher peak leg total acceleration at landing on both horses, indicating that they were in a more uncontrolled position at landing.

Both horses had lower peak saddle total acceleration on the stride before take-off with the experienced riders. The inexperienced horse also showed a smaller difference in peak saddle total acceleration between rider groups than the experienced horse (Fig. 6).

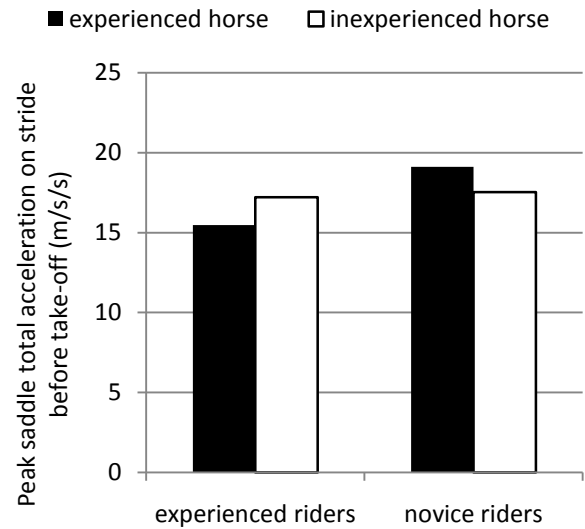


Fig. 6. On average novice riders displayed higher peak saddle total acceleration values on the stride before take-off. This indicates that horses were adjusting their speed more with novice riders just before the fence.

IV. DISCUSSION

Novice riders appear to be in a more unbalanced position during the jump. On average for both horses, mean head total acceleration during the jump is higher for novice riders (Fig. 2). Mean head total acceleration gives an indication of the amount of movement occurring at the head during the jump. The observed difference is primarily due to the greater level of head movement seen in the novice riders while riding the inexperienced horse. This suggests that experienced and novice riders can produce good jumps on an experienced horse, which has already been reported by Powers and Kavanagh [5]. The larger difference in head movement for both groups of riders while riding the inexperienced horse suggests that novice riders were not in a balanced position while jumping the inexperienced horse.

The reduction in head movement in the experienced riders suggests that the experienced riders have better functioning motor control patterns working to stabilize their field of vision and vestibular system. Previous work on human movement with accelerometers shows that humans minimize head accelerations in order to allow visual and vestibular processes to function more efficiently [7]. These same processes work more efficiently in experienced riders; which gives them an advantage when jumping consecutive fences, since they are able to always take in spatial feedback to correct their position on the horse and to correct the horse's movements. This coincides with previous research on novice horse riders which showed that increased head movement was a result of an unbalanced position and would lead to an inability to control the horse [8].

Novice riders had slightly less arm movement during the jump than their experienced counter-parts while riding the experienced horse. Again, this suggests that novice riders are capable of producing good jumps on experienced horses.

However, on the inexperienced horse the novice riders displayed much more arm movement (Fig. 3). This increase in arm movement is likely due to the fact that the novice riders had to move their arms during the jump to maintain balance on the horse, which would have been a result of their inability to control their position on the horse leading up to and during the jump. This is in line with the head movement data that also suggests the novice riders were unbalanced while jumping the inexperienced horse.

Figs 4 and 5 show that novice riders had higher levels of arm and leg movement at landing, which is likely due to the fact they were not able to maintain a balanced position and absorb the sharp forces transmitted up from the horse.

Experienced riders are trained to maintain a still leg position against the horse during the jump with knees and lower leg closed, knees bent, heels down. Their legs should be kept closed on landing for security. Experienced riders are also trained to open the hand on landing and to keep it still so that control can be regained quickly [2]. The high peak leg and arm total accelerations at landing suggest that the novice riders had difficulty maintaining balance during the landing. This would lead to a decreased amount of control over the horse just after landing, which is a critical factor in competitions when horses have to jump consecutive fences. There are added dangers to this high level of leg movement at landing because it suggests a low level of security in the saddle; increasing the risk of a fall. Furthermore, the horse may be injured by unintentional rider leg movement if a rider is wearing spurs.

These higher landing total accelerations for the novice riders were consistent across both horses. Despite movement during the jump being consistent for both rider groups while riding the experienced horse, the novice riders technique broke down at the landing – leaving them in a more unbalanced position with less control over the horse at this point.

Experienced riders had lower peak saddle total accelerations on the stride before take-off than novice riders (Fig. 6). This difference is likely due to the fact that the novice riders had less control of their horses on the approach and thus horses were changing velocity at a greater rate on the stride before take-off compared to when the horses were ridden by experienced riders. This suggests that experienced riders made adjustments to the horse's speed long before the jump, whereas the novice riders had less control leading into the jump causing the horses to have to make greater changes in velocity on the stride before take-off. This variable may give an indication of the level of rider control over the horse on the approach to the fence.

The main limitation of this study is the limited number of riders on whom data was collected. Since this was the first time IMU data was collected on show jumping riders, we wanted to test the feasibility of using these sensors to measure rider performance.

V. CONCLUSION

We were able to quantify show jumping horse rider expertise by measuring the rider's ability to maintain a balanced position during and following the jump.

Preliminary data suggests that novice riders seem to be in a more unbalanced position during the jump as evidenced by increased head and arm movement while jumping the inexperienced horse. This confirms our hypothesis. As previous research also states, both rider groups had similar movement during the jump on the experienced horse. However, we found that novice riders had poor ability to maintain balance when absorbing the landing impact on both horses. This may lead to a fall or at least make the horse and rider less prepared for the next jump in a competition setting.

To our knowledge this is the first study using IMU's to identify expertise in show jumping riders. Future work on this topic should be focused on testing these variables with a wider group of riders and creating a more ubiquitous sensor system, so that no extra time is needed to collect this data. The development of standard values for the variables described in this paper may one day lead to a better understanding of how to develop show jumping riders and the fine adjustments more experienced riders need to make to improve their performance.

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