KINEMATIC ANALYSIS OF TAKE OFF PARAMETERS DURING LOOSE JUMPING IN YOUNG UNTRAINED HORSES

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This study examined the kinematic differences at take off between two groups of young untrained horses. SVHS Video recordings (50Hz.) were obtained of 16 untrained horses loose jumping a parallel fence (Im by 0.50m). Three attempts for each horse were digitised. Eight horses were successful at clearing the fence on each occasion (Group 1) and eight were consistently unsuccessful (Group 2). MANOVA revealed significant between-group differences for centre of gravity (CG) height (p=0.018), and CG distance from the fence at take off (p=0.008). No significant differences were found for trial effect. The practical relevance of these results is discussed.

KEY WORDS: kinematics, hone, loose jumping, take off, multiple trials.

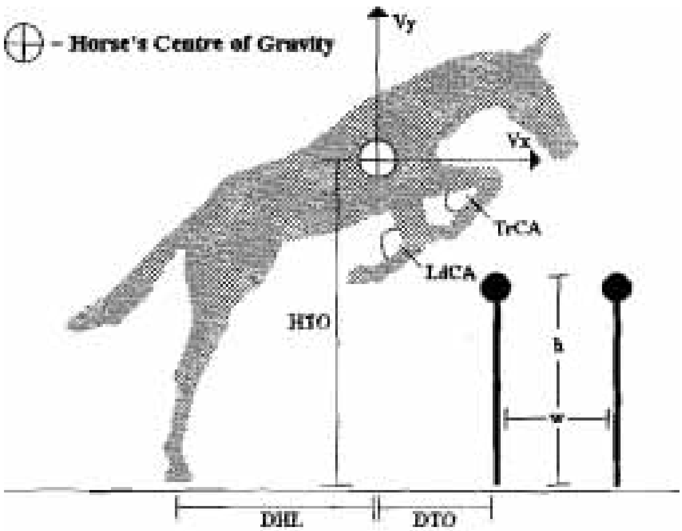
INTRODUCTION: Individual characteristics of movement are considered as one of the primary factors in choosing a successful performance horse (Deuel and Lawrence 1986). When a competition is the source of data collection, researchers are usually limited to capturing a single event such as a jump attempt (Clayton and Barlow 1989, Clayton and Barlow 1991, Deuel and Park 1991, Colbome, Clayton & Lanovaz 1995). Although this can provide valuable insights into the style and techniques used by large numbers of performing horses, relying on single trials fails to account for individual (subject) variation in the analysis. This is particularly important with inexperienced individuals, as the learning of a new skill may be characterised by a large number of errors, and the performance outcome may be highly variable (Fitts and Posner 1967). Loose jumping has long been used as a qualitative method in evaluating technique and ability in both the trained and untrained horse. The horses are free to jump in the manner they choose, and a hone that performs well loose is considered to have 'natural talent'. Nevertheless, no kinematic studies on loose jumping horses have been found.

In any jumping event, there are several phases. These include the approach, the take off and the landing. Typically, the point of take off is considered the most important phase, as it is during this phase that the jump trajectory is determined (Hay 1985). The primary purpose of this study was to examine the kinematic differences at take off during loose jumping between two groups of young horses.

METHOD:

Subjects and Set-up: 16 young horses were used in the analysis (age: 3.7 ± 0.7 years; height 165.5 ± 3.7cm). All horses were untrained, had never been ridden, and had minimal experience with loose jumping. The horse owners signed an informed consent form before filming. A parallel fence measuring 1 m by 0.50 m was set up along one side of a large well-lit indoor arena. The fence dimensions were chosen as the maximum size all the horses would attempt. The fence was approached in an anti-clockwise direction. White markers (40 mm diameter) were stuck to the relevant anatomical reference points on the left side of the horse. Several assistants were available to encourage the horses to attempt to jump the fence.

Data Collection: A Panasonic AG450 camcorder was set up perpendicular to, and approximately 20m from the fence. The field of view measured approximately 11 m wide. A reference pole lying horizontally along the horse's line of motion was filmed for calibration purposes before the trials. All horses had a 10-15 minute warm-up period, during which several practice attempts were made over a smaller fence. SVHS video recordings (50Hz.) were made of the horses attempting the experimental fence. Three attempts for each horse were recorded and digitised.



Where:	h = height of fence	w = width of fence
Vx	Horizontal velocity (ms^{-1}) at take off	
Vy	Vertical velocity (ms^{-1}) at take off	
HTO	Vertical distance (cm) from CG to the around at take off	
DTO	Horizontal distance (cm) from CG to the fence at take off	
DLH	Horizontal distance (cm) from leading hind digit to CG at take off	
LdCA	Relative carpal angle (rads) of leading forelimb at take off	
TrCA	Relative carpal angle (rads) of trailing forelimb at take off	

Figure 1 - Variable definitions and abbreviations

Data Analysis: The study was concerned with take off variables only. The take off is the first phase of the jump stride and encompasses the stance phase of the two hind limbs (Clayton 1989). For each jumping attempt 15 frames were digitised (7 frames before the point of take off, and 7 frames after). This number of frames was required in order to reduce the effect of end point distortion on the kinematics of take off. End point distortion is known to occur when using a 4th Order Butterworth filter (Winter 1990). The recordings were digitised manually using Peak Motus and the zoom facility was used at all times to increase the digitising accuracy. A total of 22 points defining the body segment parameters of the horse were digitised using the centre of gravity (CG) data published by Sakuraoka, Amano & lshii (1991). Optimised cut-off frequencies were determined automatically by Peak Motus using the Jackson Knee Method (Jackson 1979). Seven variables were examined. These are defined and illustrated in Figure 1. The terms 'leading' and 'trailing' as defined by Leach, Ormrod & Clayton (1984) were used to identify these limbs. On the stride before take off, the leading limb is the one nearest to the fence. However, at the point of take off, the leading limb normally ends up behind the trailing limb as depicted in Figure 1. Horses that were successful at clearing the fence on each attempt were designated to Group 1, while hones that consistently hit the fence (2 out of 3 attempts) were designated to Group 2. From this qualitative assessment 8 horses were assigned to Group 1 and 8 horses to Group 2. The data was analysed in Minitab using a GLM Multivariate ANOVA. The design was as follows: 2 independent variables (factors), i.e. Group and Trial, and the interaction Group*Trial; and 7 dependent variables as listed in Figure 1.

RESULTS AND DISCUSSION: The descriptive statistics are shown in Table 1. The MANOVA revealed significant between-group differences for HTO and DTO. Group 2 horses had a greater mean horizontal velocity, but a lower mean vertical velocity than the horses in Group 1, however neither of these differences were significant. This is interesting, since these variables together with HTO and DTO are the primary determinants of the CG flight path in the jump, so it appears somewhat contradictory that only two of the four determinants were significant in this experiment. This is probably due to the relatively small group sizes. These results indicated that the horses in Group 1 had increased ability to position themselves appropriately in front of the fence. The Group 1 horses had smaller mean carpal angles than Group 2 horses, but again this was not found to be significant. It appears that the horses in Group 2 had several problems compared to the horses in Group 1. They had an increased horizontal velocity at take off, a decreased vertical velocity, an inability to raise their CG high enough and they took off too close to the fence. The fact that they had a higher Vx may have reduced the time necessary to flex their carpi sufficiently at take off. There was little difference in the variable DHL between the groups. Previous research (Colborne, Clayton & Lanovaz 1995) has revealed significant between group differences for DHL in successful and unsuccessful horses attempting a water jump in competition, however the fact that elite horses and a completely different fence type were examined probably explains the difference in findings. In the present study, not all of the results were significant at the 0.05 level. The practical significance, however, may be more important, particularly in applied, exploratory studies such as this.

Table 1 Descriptive statistics for between-group variables including p-values for group and trial effects

Variable	Group 1 Mean ± SD	Group 2 Mean ± SD	Group Effect p-value	Trial Effect p-value	Group*Trial pvalue
Vx	6.68 ± 0.89 ms^{-1}	6.95 ± 0.84 ms^{-1}	0.284	0.983	0.979
Vy	2.50 ± 0.54 ms^{-1}	2.29 ± 0.51 ms^{-1}	0.171	0.767	0.241
HTO	1.86 ± 0.09cm	1.80 ± 0.08cm	0.018	0.402	0.853
DTO	0.54 ± 0.24cm	0.34 ± 0.26cm	0.008	0.655	0.498
DHL	1.11 ± 0.21cm	1.07 ± 0.10cm	0.451	0.476	0.846
Ld CA	1.03 ± 0.18 rads	1.13 ± 0.13 rads	0.091	0.999	0.873
Tr CA	1.26 ± 0.17 rads	1.38 ± 0.30 rads	0.093	0.249	0.189

Trial effect and the interaction between group and trial were also examined (Table 1), and revealed no significant differences, this implied that no learning or fatigue effect was present within or between the groups.

An ANOVA was conducted on the Group 2 data, comparing the successful jumping attempts (n=8) with the unsuccessful jumping attempts (n=16) within the group. No significant differences were found for any of the take off variables. (There was, however, a similar trend to that found in the Group 1 and Group 2 comparison). This rejects the hypothesis that there were differences in the take off kinematics of the successful and unsuccessful attempts of the group 2 horses and indicated that these horses were of a lower standard, regardless of whether they hit the fence or not. The times that they hit the fence may be due to poor limb movements during the flight phase of the jump. This suggests that future studies should examine some of the kinematics during the flight phase as determinants of success.

By highlighting some of the deficits in unsuccessful jumping horses, the horse rider or coach is better informed to choose and adopt suitable training procedures. Training techniques that help horses take off at a more suitable distance from the fence, such as the use of placing poles, could be used. Procedures encouraging horses to sharpen their limb movement reactions may supervene in quicker/greater flexion of the carpi at take off. The main application of this research is to help those purchasing and training young horses identify the most important characteristics of performance that may predict jumping potential. Having identified these factors through quantitative biomechanical analysis, it is expected that qualitative inspection of jumping technique (perhaps using video replay facilities) would be sufficient for selecting horses with show jumping potential.

CONCLUSION: The use of motion analysis has allowed identification of the most important factors at take off that determine success in loose jumping horses. Horses which were successful at loose jumping had a CG at take off that was higher and farther from the fence compared to less successful horses. Successful horses tended to have lower horizontal velocities, greater vertical velocities, and greater flexion of the carpi than unsuccessful horses. Within the less successful group of horses, the trend differentiating successful attempts from the unsuccessful attempts was similar to that present between the two principal groups. It is anticipated that the unsuccessful horses could be improved using relevant training applications.

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