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**Kinematic analysis of the trot in
CCI*** 3-day-event horses.**

A thesis presented in partial fulfilment of the requirements for
the Degree of Doctor of Philosophy at Massey University

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Abstract

Three day eventing is an equestrian sport originally designed to test the capabilities of cavalry horses and riders. An integral component of the sport are the horse inspections to ensure the horse is fit and sound to continue from one phase to the next. This study examined the "in-hand" trot of horses presented at the first and third horse inspections during the CCI*** class at the 1995 New Zealand Horse Trials Championships, Taupo, New Zealand. This study involved five stages.

1. Quantification of the three day event inspection process by use of time motion analysis.
2. Examination of the linear and temporal characteristics of the trot event horses during the first inspection process.
3. Comparison of the temporal gait characteristics between the first and third inspections.
4. Examination of the kinematics of a subset of horses during the first horse inspection and,
5. Comparison of the kinematics of this subset of horses between the first and third horse inspections.

The optimal strategy for both the inspection panel and competitors is to present a horse in a relaxed manner. The time motion analysis revealed that two different approaches to the inspection were used. One third of the class opted to walk their horses rather than trot their horses past the judge's panel on the final section of the return run. Two thirds spent a significantly longer time at the initial walk (4.36 ± 0.94 s vs 3.53 ± 0.91 s, $P < 0.01$), but spent less time during the stationary inspection ($8.77 \pm 2.2.16$ s vs 10.43 ± 2.90 s, $P < 0.05$) and for the total time (42.04 ± 2.50 s vs 45.34 ± 3.38 , $P < 0.01$). A correlation was found between initial walk and the time spent at the stationary inspection ($r^2 = 0.249$, $P < 0.01$). It is concluded that the initial impression gained as the horse is walked toward the inspection panel significantly influences the subsequent inspection.

The trot of 3-day event horses during the preliminary horse inspection of a CCI*** 3-day event was quantified and temporal characteristics defined. A

cross sectional study was made of the kinematics of 24 three day event horses during the first horse inspection. The horses were filmed using a panning lateral S-VHS video camera (50Hz). Video footage was digitised and linear and temporal measurements were made. The horses trotted for an average of 10.44 ± 1.55 strides. Spatial measurements were made on an average of 5.66 ± 0.92 consecutive strides when the horses were within the calibration zone. The horses increased and then maintained a constant velocity within the calibration zone. The relationships between stride length, stride duration and velocity when compared with previously published values. Horse specific differences in stance and retraction time as a percentage of stride were identified that may contribute to each horses unique gait or “kinematic fingerprint”. It is proposed that the initiation of, and completion of, stance by the hind limb first may represent “engagement of the hind quarters” and be a response to dressage training.

Temporal stride parameters between of the trot at the first and third horse inspections were quantified. This provided a repeat sample on 16 horses. Spatial measurements were taken for an average of 5.66 ± 0.92 strides for the first inspection and 5.05 ± 1.27 for the third inspection

The horses trotted with a significantly higher mean velocity during the third inspection ($0.26 \pm 0.05 \text{ms}^{-1}$ $p < 0.001$). During the third inspection the horses trotted with a shorter stride length ($0.193 \pm 0.03 \text{m}$ $p < 0.001$) and stride duration ($31 \pm 42 \text{ms}$ $p < 0.001$). The third inspection was characterised by a significant decrease in retraction percentage for both the forelimbs ($3.69 \pm 2.39\%$ $p < 0.001$) and the hindlimbs ($2.48 \pm 2.16\%$ $p < 0.001$). However, no significant difference was found between the 2 inspections for other temporal parameters when measured as a percentage of stride. It is proposed that the event horses trot with a decreased stride length and duration during the third horse inspection but maintain a consistent temporal relationship.

The kinematics six 3 day event horses presented during the preliminary horse inspection at a CCI*** 3 day event were examined. The six horses trotted with a mean velocity of $3.94 \pm 0.22 \text{ms}^{-1}$. Displacement, velocity and acceleration data

are presented for X, Y and Z axis. Larger than expected vertical displacement values for the central body marker and fore and hind limbs are presented as evidence that during the preliminary horse inspection three day event horses trot with a more animated action. This more animated gait is believed to be due to a combination of the atmosphere of the competition environment and the high level of horse fitness. The significantly greater horizontal ($1.129 \pm 0.103\text{m}$ vs $1.108 \pm 0.05\text{m}$) and vertical displacement of the forelimbs ($0.221 \pm 0.027\text{m}$ vs $0.159 \pm 0.05\text{m}$) to the hind limbs are interpreted as evidence of dressage training.

Comparison of the kinematics of the trot a group of six horses (12.3 ± 2.4 years) during the first and third horse inspections at a CCI*** 3 day event competition was undertaken. The horses trotted with a mean velocity of $3.94 \pm 0.22\text{ms}^{-1}$ during the first inspection and $4.14 \pm 0.15\text{ms}^{-1}$ for the third inspection. During the third inspection a greater range of motion was observed in the hoof trajectories. The horses carried their heads higher during the third inspection ($1.752 \pm 0.090\text{m}$ vs $1.796 \pm 0.091\text{m}$, $P < 0.05$) in an attempt to reduce the minimum vertical acceleration on the forelimbs ($-9.83 \pm 5.28\text{ms}^{-2}$ vs $-9.09 \pm 3.17\text{ms}^{-2}$, $P < 0.05$). Significant differences were found between inspections for most variables. However, the differences were not large, indicating that effect of the exertion of speed and endurance day on the kinematics of this group of event horses was subtle.

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