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1 **EQUINE ENDURANCE RACE PACING STRATEGY AND PERFORMANCE IN**
2 **120km SINGLE-DAY RACES**

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9 **Abstract**

10 Race pace strategy has been extensively studied in human sports such as running, cycling and
11 swimming. In contrast, pacing strategy appears to have been virtually ignored in equestrian sport
12 despite its potential to contribute to performance optimisation. Previously we have demonstrated that
13 there are significant differences in pacing strategy between finishers and non-finishers in 120km
14 single day endurance races [1]. The aim of the present study was to further analyse the same dataset of
15 electronically-timed FEI 120km (single day) CEI** endurance races that took place in Europe and the
16 Middle East in 2016 and 2017. The competition records of 218 horses that finished (average
17 completion rate 56%) in 24 races, each consisting of 4 loops (laps) were evaluated. Final loop speed
18 was significantly increased for horses placed in the top three who recorded 12% faster mean speed
19 ($P=0.011$) compared to horses that finished outside of the top 3. Top 3 finishing horses also
20 significantly increase the speed they complete loop 3 ($p= 0.040$; 3% increase in percentage of loop 1
21 speed) and the final loop ($p=0.008$; 8% increase in percentage of loop 1 speed) of races compared to
22 horses who achieve lower placings and completed loop 1 at a 3% lower percentage of their average
23 race speed ($p=0.008$) compared to those who finished 4th or higher. These results suggest that horses
24 that are placed in the top 3 are ridden more consistently.

25

26 Word Count:

27 **Keywords:** competition; equestrian; completion; failure

28 Introduction

29 On a global basis, equine endurance racing is the second largest Federation Equestre Internationale
30 (FEI) discipline behind show-jumping [2]. The main distances at which high level competition takes
31 place are 120km and 160km. Horses and riders compete at these distances in a single day. The races
32 are broken down into 4-6 loops or laps, with mandatory veterinary inspections for fitness to continue
33 and hold times ranging from 30-40 min between each loop.

34 Pacing strategy has been extensively studied in a number of sports, including marathon running,
35 cycling and long distance swimming and a number of pacing-related factors associated with
36 performance have been identified [e.g. 3 to 12]. The contribution of pacing strategy in equestrian
37 sport has received virtually no attention other the study by Spence *et al.* [13] who found that better
38 performing horses exhibited “race length-dependent pacing strategies” which were “correlated with
39 the fastest racing times”.

40 We [1] recently reported that in horses racing over 120km in a single day: those horses that
41 successfully finished recorded 7% slower average speeds; horses withdrawn at the first veterinary
42 check for “gait” recorded a 36% faster average speed than those withdrawn at the finish; horses
43 withdrawn for “metabolic” reasons between loops 2 and 3 reduced their speed by an average of 17%
44 on the final loop. Overall, horses that failed to finish races appeared to be ridden with a more
45 aggressive race strategy than those which completed. In contrast, horses that finished had a slower
46 loop 1 pace but went on to complete subsequent loops at a higher percentage of their loop 1 speed.

47 The aim of the present study was to re-examine the data from the horses that completed (n=218, 56%
48 of starters) with a view to trying to understand if pacing strategy influenced finishing position.

49

50 Materials and Methods

51 Retrospective competition records for 24, 120km FEI CEI** level single-day global endurance races
52 that took place in the 2016 and 2017 seasons were collated to compare speed related variables
53 between horses that achieved a placing of 1st, 2nd or 3rd in races. All races operated a fully automated
54 electronic timing and had a results service provided by Endurance Team Styria (Hahnhofweg 30,
55 8075 Graz, Austria); an FEI approved timing and results service provider. Races took place in Europe
56 (n=15) or the Middle East (n=9). For each 120km race listed in the online archive, the data were
57 downloaded as a PDF file and converted into a Microsoft Excel spreadsheet. For each horse that
58 started and completed the race, average speed per loop (lap, km/h) and average speed for the entirety
59 of the race were recorded. This enabled individual horses’ racing strategy to be calculated. A strategy
60 marker was calculated by dividing the average speed for sequential loops of the course by the average
61 speed of the horse during loop 1, and multiplying this by 100% to give a percentage marker for each

62 subsequent loop completed relative to loop 1. The significance of the pacing strategy deployed by
63 horses for loop 1 was also evaluated by dividing the average speed for loop 1 by the average speed for
64 the duration of the race, and multiplying this by 100%. This information was used to evaluate how
65 riders used speed strategically throughout the course of a race.

66 A series of Mann Whitney U analyses identified if significant differences existed between loop speeds
67 and average speed, and the strategy deployed within horses that placed in the top three compared to
68 horses that completed outside of the top three ranks. Subsequent Kruskal-Wallis tests investigated if
69 differences in speed and the strategic approach applied in the race occurred between horses placed
70 first, second and third in FEI CC** single-day 120km races. Significance was set at $P < 0.05$.

71

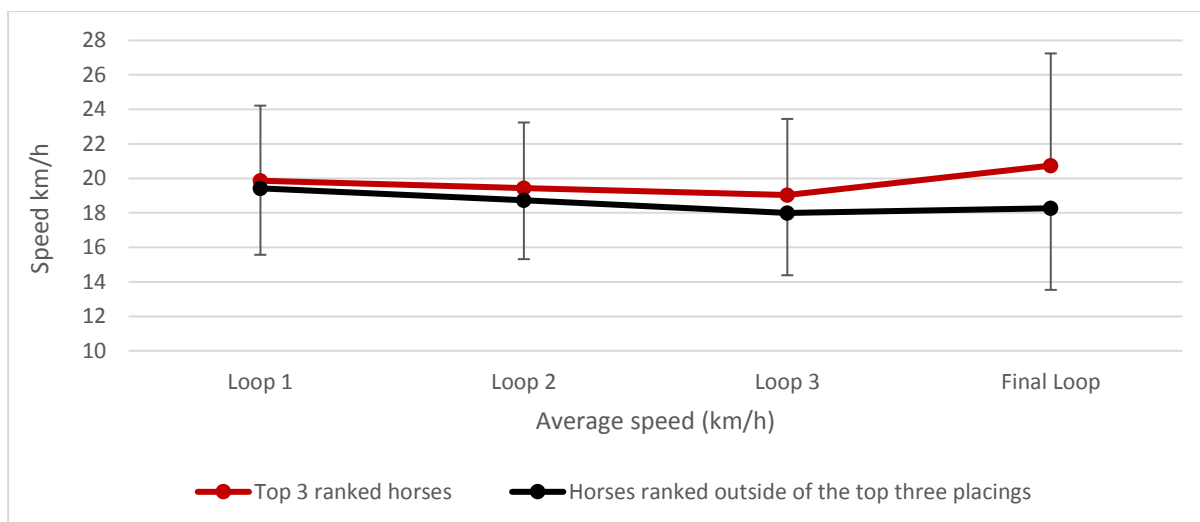
72 **Results**

73 Competition records for 218 horses (56%) that successfully completed the 24 races surveyed were
74 evaluated; the remaining 44% (n=171) were eliminated. Thirty-three percent (n=72) of horses
75 finished races with a top three placing (1st, 2nd or 3rd), with the remaining 67% (n=146) successfully
76 completing the races outside of these ranks (range: 4th to 21st place).

77

78 Race speed

79 Loop speed decreased sequentially throughout races from loop 1 > loop 2 > loop 3 but then increased
80 for the final loop (Figure 1). Horses that went on to achieve a top three ranking completed all loops at
81 a higher average speed than those that finished in the lower rankings, recording a 5% faster average
82 speed across the entire race (Table 1). Despite this, no significant differences in speed were found for
83 loops 1, 2 or 3 ($P > 0.05$), although final loop speed was significantly increased for horses placed in the
84 top three who recorded 12% faster mean speed ($P = 0.011$) compared to the other finishers. Variation
85 in speed on each loop (%CV, Table 1) was always lower in top 3 placed horses, with the exception of
86 loop 3. In both groups the greatest variation in speed was on the final loop (Top 3 31%; Other
87 placings 41%).



88

89 Figure 1: Differences in speed profiles (mean±sd) between endurance horses which successfully
 90 completed races with a top three finish and horses which completed outside of the top three places;
 91 km/h: kilometres per hour; sd: standard deviation.

92

93 Table 1: Race speed profiles for horses that placed in the top three positions and those that completed
 94 but outside of the top three placings to 2 decimal places; km/h: kilometres per hour; sd: standard
 95 deviation; IQR: interquartile range; %CV: coefficient of variation.

		Loop1 km/h (%CV)	Loop 2 km/h (%CV)	Loop 3 km/h (%CV)	Final Loop km/h (%CV)	Average whole course km/h (%CV)
Horses with a top 3 placing	mean±sd	19.9±4.4 (22%)	19.4±3.8 (20%)	19.0±4.4 (23%)	20.7±6.5 (31%)	19.5±4.4 (23%)
	median±IQR	18.7±7.4	18.8±5.7	17.9±7.2	20.2±11.0	18.0±7.6
Horses placed outside the top 3	mean±sd	19.4±3.9 (35%)	18.7±3.4 (30%)	18.0±3.6 (20%)	18.3±4.7 (41%)	18.5±3.5 (35%)
	median±IQR	19.3±6.7	18.6±5.5	17.7±5.1	17.7±7.3	18.1±6.3

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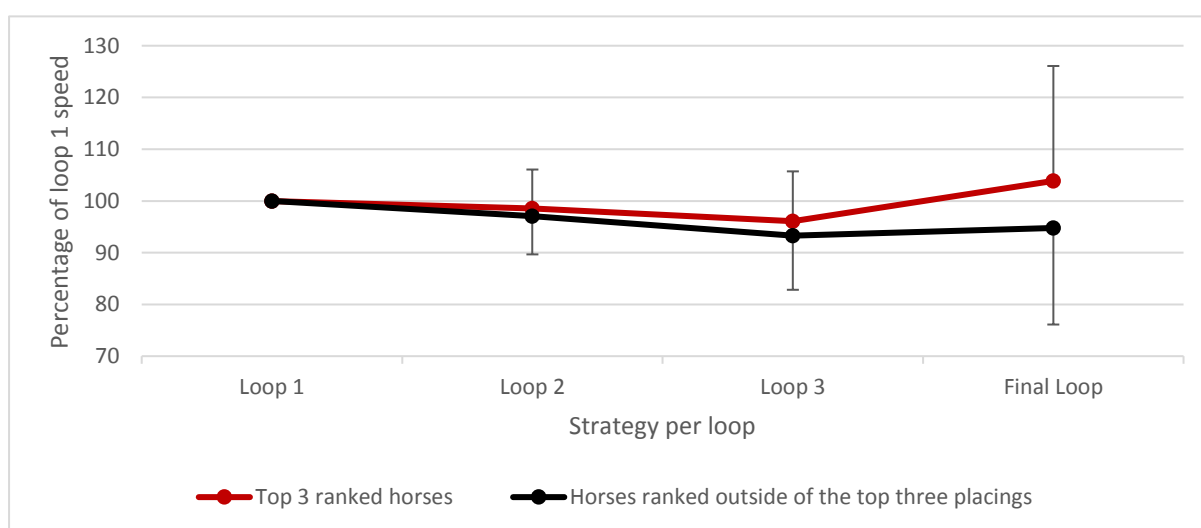
98 Race strategy

99 Horses that successfully finished 120km CEI ** races appeared to adopt a similar pacing strategy,
 100 however those that go on to attain a top three finishing position maintain a faster average racing speed
 101 (as a % of their Loop 1 speed) throughout the duration of the race (Figure 2; Table 2). These better
 102 performing horses also complete loop 3 faster ($p=0.040$; 3% increase in percentage of loop 1 speed)
 103 and the final loop faster ($p=0.008$; 8% increase in percentage of loop 1 speed) compared with horses
 104 who achieve lower placings. Additional differences in pacing strategies were also apparent in the
 105 earlier stages of races. Top 3 finishing horses reduced the speed they completed loops 2 and 3 (1.4%
 106 and 3% reduction in percentage of loop 1 speed, respectively) approximately 50% less on the first
 107 loop and 25% less on loops 2 and 3, than their less successful competitors (3% and 4% reduction in
 108 percentage of loop 1 speed, respectively). On the final loop, 57% of top 3 placed horses completed
 109 faster than their loop 1 speed compared with 47% of lower placed horses. In comparison, on the final
 110 loop only 9% of top 3 placed horses completed at <75% of their loop 1 speed compared with 18% of
 111 lower placed horses. The greatest variation in speed as a % of loop 1 speed was seen in both groups
 112 on the final loop.

113 The significance of the pacing strategy deployed for loop 1 was also investigated; horses which
 114 achieved a top 3 rank completed loop 1 at a 3% lower percentage of their average race speed
 115 ($p=0.008$) compared to those who finished 4th or higher, suggesting consistency is a more successful
 116 strategy to enhance performance in CEI** endurance races.

117

118



119

120 Figure 2: Differences in strategic profiles between endurance horses which finished in the top 3 and
 121 horses finished outside the top 3; %: percentage of loop 1 mean speed selected loop completed at; L1:
 122 Loop 1; L2; Loop 2; L3: Loop 3; Finish: final loop.

123

124 Table 2: Race strategy profiles (mean±sd) for horses that finished in the top three compared to those
 125 completing outside of the top three places; %: percentage of loop 1 speed selected loop completed at.

126

127

		Loop1 %	Loop 2 %	Loop 3 %	Final Loop %	Average whole course %
Horses with a top 3 placing	mean±sd	100±0.0	98.6±7.5	96.1±9.6	103.9±22.2	102.2±8.0
	median±IQR	100±0.0	98.3±9.5	98.4±10.4	104.9±26.9	100.2±8.4
Horses placed outside the top 3	mean±sd	100±0.0	97.1±7.4	93.3±10.5	94.8±18.7	105.0±8.5
	median±IQR	100±0.0	97.2±9.0	95.3±11.9	98.5±23.7	102.9±8.3

128

129 Discussion and conclusions

130 Within endurance races, riders must continuously adapt and maintain the horse's gait and speed to
 131 optimise performance [14]; in effect applying a pacing strategy. We have previously reported that
 132 competitors in FEI CEI** 120km single day races who applied consistent pacing strategies delivering
 133 sustainable speeds were less likely to be eliminated [1]. Analysis of race finishers further suggests that
 134 pacing strategy influences competitive success. Similar patterns in race completion were observed for
 135 both groups of finishers investigated, with a sequential decrease in speed from loop 1 through to loop
 136 3, followed by an increase in speed for the final loop. The average speed of the horses who recorded a
 137 top three rank in races was consistently higher than the other combinations who completed the races.
 138 Differences in race pacing strategy also occurred between the groups; top three horses completed
 139 loops 1 to 3 at a more consistent pace (5% variation from loop 1 speed) compared to horses placed
 140 fourth and above (7% variation from loop 1 speed). Interestingly, although both groups increased their
 141 speed during the final loop, the top three ranked horses recorded speeds which were higher than what
 142 they had used for loop 1 (>100%) whilst the lower ranked horses did not attain their loop 1 speed
 143 (95%). The pacing strategy adopted for loop 3 and the final loop appear to be significant in predicting
 144 which horses are more likely to achieve success, with superior performers able to complete these at a
 145 higher percentage of loop 1 speed than their peers.

146 Our results suggest that combinations who adopt a higher average speed throughout races but manage
147 this through a more consistent pacing strategy are more likely to achieve a top 3 rank in FEI CEI**
148 120km single day races. The association between performance and higher average race speed
149 identified here reinforces the importance of appropriate preparation and training to ensure endurance
150 horses possess suitable fitness levels to meet the demands of competition. The use of appropriate
151 pacing strategies during racing is also key to maintain optimal performance during racing. Consistent
152 pacing strategies for loops of the track are associated with superior performance in human athletes
153 competing in endurance running [7 -9]. Our results suggest adopting a similar approach could
154 optimise the performance of combinations in endurance racing. Endurance trainers and riders should
155 also consider how the training regimens implemented are preparing horses for races. Regular
156 monitoring of fitness parameters, such as heart rate, evaluation of speed and pacing work are
157 recommended to ensure horses are suitably prepared for races and to support the application of pacing
158 strategies during competition [1]. Furthermore, it appears that for many horses that fail to complete,
159 this may be due to riding too fast on the first loop for the horses ability and level of fitness. Use of
160 heart rate monitors in training to establish the heart rate and velocity relationship or use in races could
161 reduce eliminations and help identify optimal race strategy. Further studies investigating how pacing
162 strategies are used across different levels of competition and to identify optimal pacing strategies to
163 enhance performance in endurance racing are warranted.

164

165 Conflicts of interest: none

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167 commercial, or not-for-profit sectors.

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