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# Risk factors for lameness elimination in British endurance riding

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## Abstract

**Background:** Horse welfare is a priority in the equine sport of endurance riding. Identification and reduction of risk factors associated with elimination and lameness have been the focus of research to date, however, this has centred on international competition. National federations recognise there is a need to consider risk factors for elimination at a more local level.

**Objectives:** Determine current risk factors associated with horse eliminations, specifically lameness eliminations within British endurance.

**Study design:** Retrospective cohort study.

**Methods:** Data were extracted from the Endurance GB database, for open and advanced horses, competing in rides >64 km in the 2017 and 2018 competitive seasons. Variables were analysed via univariable models which informed subsequent multivariable binary logistic regression modelling. Two models were completed: (A) horse eliminated vs. not eliminated and (B) horse lame vs. not lame.

**Results:** One thousand seven hundred and forty-seven competitive starts were analysed; 542 horses were eliminated. Lameness accounted for 56.1% ($n = 304$) of eliminations. Multivariable analysis identified decreased odds of lameness in graded rides compared with race rides (adjusted odds ratio, OR 0.6; 95% confidence interval, CI 0.4–0.8). There were increased odds of elimination (OR 4.7, CI 3.5–6.5) and increased odds of lameness (OR 1.9, CI 1.2–3.06) when competing in FEI competitions of 2* and above, compared to rides run under national rules. Horses and riders who had not competed as a combination previously had increased odds of elimination (OR 2.2, CI 1.5–3.02).

**Main limitations:** Variables which can influence performance such as speed, environmental and topographical conditions were not recorded in the data set. Only two seasons of data were analysed.

**Conclusions:** Competitive history of horses, including the number of previous starts, previous eliminations and the category of ride entered are significant in establishing the likelihood of elimination and more specifically lameness elimination in British national endurance.

KEYWORDS

elimination, endurance, horse, lameness, risk factor, welfare

## 1 | INTRODUCTION

Endurance is an internationally recognised equestrian sport in which horse and rider combinations compete up to 160 km in 1 day.[1,2] Globally, endurance is governed by the Fédération Equestre Internationale (FEI), whilst in Great Britain, Endurance GB (EGB) governs the sport. Protecting the welfare of the horse is a key strategic priority for both the FEI and EGB. However, repeated incidences of horse injury and fatalities in high profile races have led to a negative public perception of the sport. This has resulted in calls for increased safeguarding of the welfare of the horses that participate in endurance, in order to reduce the risk not only to the horse, but also to the sport of endurance and its social licence to operate.[3–5]

To uphold welfare, prior to each endurance competition, horses are examined by licenced veterinarians who check that each horse is fit to compete by assessing its gait pattern and that it is metabolically fit. If any of these examinations are outside of accepted parameters, the horse is eliminated from the competition.[1,2] This process is repeated after each stage of the ride, which predominantly ranges from 20 to 40 km in length. The horse must also pass a veterinary inspection at the end of the ride before the result is confirmed. If the horse does not pass the veterinary inspection at any stage, it is eliminated from the competition.[1,2]

Previous epidemiological studies in the sport have focussed on FEI competitions and have identified risk factors for elimination, which include higher speeds, multiple competition starts with insufficient recovery periods and historical deleterious competition outcomes of the horse and rider.[6–12] Following the identification of risk factors, positive changes were made to the sport at FEI level, including the duration of mandatory out of competition periods (MOOCP) between competitions being increased following elimination, with additional days being added for multiple eliminations. This has been found to be successful in reducing eliminations in international competition; however, EGB does not mirror the additional days added for multiple eliminations with only eight additional days added for an elimination, regardless of the number of failures. In contrast, FEI regulations require MOOCP increases to 180 days and a veterinary inspection prior to competition return if there have been three lameness eliminations within a year.[1,2,13] The discrepancy between national and international rules on MOOCP may cause competitors confusion and the assumption, due to the reduced MOOCP within EGB rides that national level competition poses less of a welfare risk, which may in turn have a negative impact on horse welfare.

Lameness has been the leading cause of elimination in FEI rides with previous studies reporting 24% to >30% of all horses starting the competition being eliminated for lameness.[6,11] Eighty percent of British endurance riders have reported their horses having at least one episode of lameness within their endurance career.[14] Despite this, there have been no studies identifying risk factors relating to British horses competing at national level and insufficient evidence currently exists to create an accurate profile of risk factors for eliminations and lameness within British Endurance. Therefore, this study aimed to identify risk factors associated with elimination and lameness within horses registered with EGB.

## 2 | MATERIALS AND METHODS

### 2.1 | Participants

Endurance GB provided the data for all rides with a veterinary inspection (rides of ≥64 km) that had been recorded on their central database for the competitive seasons from March to October of 2017 and 2018. The majority of these data were publicly available. Horses that had a competitive history detailing that they were appropriately qualified in accordance with the EGB rules (had completed novice level and were at open or advanced level) to compete in rides of 64 km and above were included in the study. No external intervention was required by participants and all data were anonymised.

A total of 1747 single day ride entries were recorded, representing 512 unique horses and 385 unique riders, all were appropriate for inclusion. Frequency analysis of risk factors was completed. As all the data met nonparametric assumptions, the data are reported as median ± interquartile range unless otherwise stated.

For each ride entry, the database had eight possible outcomes, (1) completion (C), the horse successfully completed and passed the final veterinary inspection; (2) eliminated, the horse did not successfully complete the competition; this was split further into (a) eliminated due to lameness, (b) eliminated for metabolic reasons (MET), (c) retired (RET), the horse successfully passed the veterinary inspection but was subsequently withdrawn by the rider, (d) disqualified (DSQ), a breach of the rules resulted in disqualification, (e) out of time (OOT), the course was not completed within the maximum-minimum time requirements, (f) withdrawn (WDN), the horse was entered but was not presented to the initial veterinary inspection.[1,2]

### 2.2 | Risk factors

Previous literature findings and anecdotal experience within EGB competitions were used to identify potential risk factors to be considered at horse, rider and ride-level that were included in the initial stage of modelling.[6–8,10–12] Fifty-eight factors were identified including the level of ride (FEI or national), competitive history such as the number of times a horse had been eliminated and whether the horse and rider combination had competed together previously. All factors are provided in Table S1.

### 2.3 | Data collection and analysis

The data are publicly available; however, EGB provided the raw data from their full database. The database provided the competition details and outcome for every competition entered within the horse/rider career. All analyses were completed using Statistical Product and Service Solutions software (Version 26, IBM, United Kingdom Limited, Portsmouth, Hampshire, UK).

Whilst the study cohort contained horse starts in only the 2017 and 2018 competitive seasons, the data for the entirety of the horse

career were available from the archive history of EGB. However, in multiple cases, the reason for historical elimination was not specified and only listed as 'Fail' or 'Eliminated'.

A series of Spearman's rank correlations ($p < 0.05$) examined the relationship between the number of times a horse had been eliminated in their entire career and the following variables: age of horse, career length (years), number of rides attempted, number of rides completed, distance attempted and distance completed.[15] A separate series of correlations examined the relationship between the same variables and the number of times a horse had been eliminated due to lameness in the entire career.

The data were translated to binary or categorical data where required, prior to coding (Table S1).

### 2.4 | Univariable and multivariable analysis

Binary logistic regression modelling was used to identify risk factors.[16] Two deleterious outcomes were considered: (A) Eliminated (any reason) and (B) eliminated due to lameness. For each of the two outcomes, univariable analysis of each of the risk factors was completed. Risk factors with a $p$ value ≤0.1 were included in the final multivariable models.[16] Additional variables which did not meet the significance level for inclusion but were considered biologically plausible based on previous research were also included. Multivariable logistic regression models were constructed using a backwards-stepwise process, with an Omnibus test of model coefficients applied at each step. The Hosmer-Lemeshow goodness-of-fit test was used to assess each stage of the models.[17]

The predictive ability of the models was assessed using receiver operating characteristic (ROC) curve analysis.[18,19] Risk factors with $p$ value ≤0.05 in the final multivariable models were considered significant.[6–8,10–12]

## 3 | RESULTS

### 3.1 | Descriptive statistics

Of the 1747 competitive horse starts, 91.5% of riders were female ($n = 1598$) and the majority of riders, ($n = 1625$; 93.0%) were in the senior age (over 21 years old) category. Median horse age was 11 ± 4 years. Most of the entrants to the rides ($n = 1571$; 89.9%) had ridden as a horse and rider combination previously within the 2017–2018 competitive season. The experience of the horses ranged from horses being in their first competitive season to having competed for 15 years. The number of previous competitive starts ranged from 2 to 112 (median 19 ± 19). The number of previous eliminations ranged from 0 to 16 (median 2.1 ± 2); 23% of horses ($n = 404$) had never been eliminated and 31% ($n = 547$) had never had a lameness elimination outcome. The number of previous lameness eliminations ranged from 0 to 14 (median 1 ± 3).

A significant positive correlation was found between the distance a horse attempted within its career and the number of times it had been eliminated ($r = 0.73$, $p < 0.001$, $n = 1747$). The number of rides attempted in the horse's career had a significant positive correlation with the number of times the horse had been eliminated ($r = 0.67$, $p < 0.001$, $n = 1747$) as did the distance completed in the horse's career ($r = 0.62$, $p < 0.001$, $n = 1747$) the number of years the horse had been competing ($r = 0.64$, $p < 0.001$, $n = 1747$). Weaker correlations were found between the number of eliminations in a horse's career and the number of rides completed in the horse's career ($r = 0.57$, $p < 0.001$, $n = 1747$), and the age of the horse and the number of times it had been eliminated ($r = 0.47$, $p < 0.001$, $n = 1747$).

A significant, positive correlation was found between the number of lameness eliminations in a horse's career and the distance it had attempted within its career ($r = 0.72$, $p < 0.001$, $n = 1747$). The number of lameness eliminations were also significantly associated with the rides attempted within the horses career ($r = 0.66$, $p < 0.001$, $n = 1747$), the length of the horse's career (years) ($r = 0.63$, $p < 0.001$, $n = 1747$), the distance the horse had completed in its career ($r = 0.62$, $p < 0.001$, $n = 1747$), the number of rides the horse had completed in its career ($r = 0.57$, $p < 0.001$, $n = 1747$) and to a lesser extent the age of the horse ($r = 0.46$, $p < 0.00$, $n = 1747$).

The data for each of the horse starts and the subsequent outcomes for the 2017–2018 rides are shown in Table 1.

Across the sample, 69% ($n = 1205$) of horse and rider combinations successfully completed the competitions they entered. The remaining 31% were eliminated. The most common reason for elimination was due to lameness with ($n = 304$). The reasons for elimination are shown in Figure 1.

### 3.2 | Model A: Elimination outcomes

A total of 42 variables from the univariable analysis were significant at $p \leq 0.1$ and were taken forward to multivariable analysis, additionally all previous distance attempted and completed, and number of starts and completions were included as biologically plausible factors. Seven variables remained in the final model multivariable model with five demonstrating they were significantly associated with an elimination outcome (Table 2), the remaining two variables improved the model fit. Horse and rider combinations who had not competed together previously were at increased odds of elimination, compared with combinations that had competed together previously (Adjusted Odds Ratio, OR 2.2, 95% confidence interval, CI: 1.5–3.02). Compared with rides that were run under EGB rules, those competing in FEI 1* competitions had increased odds of an elimination outcome (OR 1.7, CI 1.3–0.2.3) and those in FEI 2* and above had increased odds of elimination compared to those competing under EGB rules (OR 4.7, CI: 3.5–6.5). Horses that had two competitive starts within the previous 60 days were at increased odds of elimination compared to those who had not competed in the last 60 days (OR 1.8 CI: 1.3–2.5). Previous elimination results impacted the odds of an elimination outcome, with horses having more than one elimination within the last 365 days have increased odds (OR 2.2, CI: 1.3–3.7) compared with horses who had no elimination results in the previous 365 days.

**TABLE 1** Number of horse starts and outcomes in 2017–2018 competitions

| Category | Entrants | Successful completion *n* (%) | Eliminated any reason *n* (%) | Eliminated lame *n* (%) |
|---|---|---|---|---|
| Year | | | | |
| 2017 | 937 | 663 (70.8) | 274 (29.2) | 152 (16.2) |
| 2018 | 810 | 542 (66.9) | 268 (33.1) | 152 (18.8) |
| Ride category | | | | |
| GER | 999 | 757 (75.8) | 242 (24.2) | 115 (11.5) |
| CER (EGB) | 193 | 141 (73.1) | 52 (26.9) | 38 (19.7) |
| FEI | 555 | 307 (55.3) | 248 (44.7) | 151 (27.2) |
| FEI ride | | | | |
| No | 1192 | 898 (75.3) | 294 (24.7) | 153 (12.8) |
| Yes | 555 | 307 (55.3) | 248 (44.7) | 151 (27.2) |
| FEI level | | | | |
| Not FEI | 1192 | 898 (75.3) | 294 (24.7) | 153 (12.8) |
| 1 star | 328 | 212 (64.6) | 116 (35.4) | 77 (23.5) |
| 2 star+ | 227 | 95 (41.9) | 132 (58.1) | 74 (32.6) |
| Distance (km) | | | | |
| 64–79 | 612 | 473 (77.3) | 139 (22.7) | 69 (11.3) |
| 80–119 | 906 | 635 (70.1) | 271 (29.9) | 161 (17.8) |
| 120+ | 229 | 97 (42.4) | 132 (57.6) | 74 (32.3) |

*Note*: The number of horse starts and the outcomes for horses registered with Endurance GB, competing in rides of >64 km, during the competitive seasons of 2017–2018.
Abbreviations: CER, competitive endurance ride (no capped speed); EGB, Endurance GB; FEI, Fédération Equestre Internationale; GER, graded endurance ride (capped speed).
*Source*: Data from Endurance GB's database.

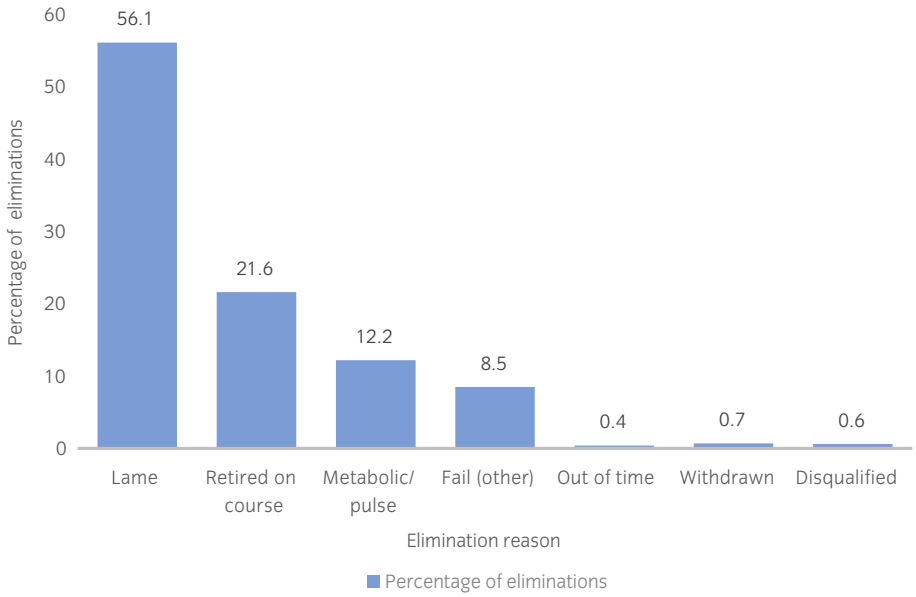


**FIGURE 1** The reasons horses registered with Endurance GB were eliminated from competitions of >64 km, during the 2017–2018 competitive seasons. Displayed as percentages of eliminated horses. *Source*: Data from Endurance GB's database

## 3.3 | Model B: Failure to qualify due to lameness outcomes

A total of 40 variables related to horse starts were significantly associated with elimination due to lameness outcome at univariable level at $p \leq 0.1$, all variables relating to distance attempted and completed and the number of rides started and completed were included in the model as biologically plausible, regardless of whether they met the significance level. Nine variables remained in the final multivariable model with four being significantly associated with a

**TABLE 2** Model A: Multivariable model results showing the significant risk factors impacting ride entries for 2017–2018, for all elimination reasons

| Risk factor | Cases: Eliminated *n* (%) | Controls: Pass *n* (%) | Adjusted OR | 95% CI | *p* value |
|---|---|---|---|---|---|
| Returning combination | | | | | |
| Yes | 467 (29.7) | 1104 (70.3) | Reference | - | <0.001 |
| No | 75 (42.6) | 101 (57.4) | 2.15 | 1.53–3.02 | <0.001 |
| FEI level | | | | | |
| Not FEI | 294 (24.7) | 898 (75.3) | Reference | - | <0.001 |
| 1* | 116 (35.4) | 212 (64.6) | 1.71 | 1.31–2.25 | <0.001 |
| 2*+ | 132 (58.1) | 95 (41.9) | 4.74 | 3.48–6.46 | <0.001 |
| Distance attempted in 365 days | | | | | |
| 0–100 km | 47 (29.7) | 111 (70.3) | Reference | - | 0.05 |
| 101–200 km | 121(31.2) | 267 (68.8) | 1.12 | 0.73–1.72 | 0.6 |
| 201–300 km | 150 (32.7) | 309 (67.3) | 1.11 | 0.73–1.71 | 0.6 |
| 301–400 km | 117 (30.3) | 269 (69.7) | 0.88 | 0.56–1.38 | 0.6 |
| 401–500 km | 69 (27.6) | 181 (72.4) | 0.63 | 0.38–1.04 | 0.07 |
| >500 km | 38 (35.8) | 68 (64.2) | 0.75 | 0.40–1.38 | 0.4 |
| Number of starts in 60 days | | | | | |
| 0 | 121 (27.9) | 313 (72.1) | Reference | | 0.002 |
| 1 | 253 (30.9) | 567 (69.1) | 1.15 | 0.87–1.52 | 0.3 |
| 2 | 139 (37.7) | 230 (62.3) | 1.78 | 1.28–2.47 | 0.001 |
| 3+ | 29(23.4) | 95 (73.4) | 1.01 | 0.61–1.67 | >0.9 |
| Eliminated last 60 days | | | | | |
| No | 466 (29.5) | 1114 (70.5) | Reference | - | - |
| Yes | 76 (45.5) | 91 (54.5) | 1.33 | 0.90–1.96 | 0.2 |
| Eliminated last 365 days | | | | | |
| 0 | 282 (27.0) | 764 (73.0) | Reference | - | 0.02 |
| 1 | 175 (33.0) | 355 (67.0) | 1.31 | 0.88–1.92 | 0.2 |
| 2+ | 85 (44.5) | 106 (55.5) | 2.15 | 1.25–3.68 | 0.005 |
| Eliminated lame last 365 days | | | | | |
| No | 340 (28.0) | 876 (72.0) | Reference | - | - |
| Yes | 202 (38.0) | 329 (62.0) | 1.03 | 0.70–1.52 | 0.9 |

*Note*: Model fit was good: Omnibus $p < 0.001$, Hosmer-Lemeshow $p = 0.43$. ROC = 0.68. Risk factors associated with elimination for horses registered with Endurance GB, competing in rides of >64 km during the 2017–2018 competitive seasons.
Abbreviations: 95% CI, 95% confidence interval; FEI, Fédération Equestre Internationale; OR, adjusted odds ratio.
*Source*: Data from Endurance GB's database.

lameness outcome, the remaining five remained as they improved the model fit (Table 3). Riders and horses who had not competed as a combination before were at a higher likelihood (OR 2.3, CI: 1.5–3.4) of being eliminated with a lameness outcome than those who had competed together. Rides categorised as GER were associated with reduced odds of lameness compared to CER rides (OR −0.6, CI: 0.4–0.8). Horses competing at FEI 2* and above had an increased likelihood of lameness (OR 1.9, CI: 1.2–3.06) when compared to horses competing under EGB rules. Weak collinearity was found between the risk factors 'distance completed in 365 days' and 'eliminated lame in previous 365 days'.

Significant associations were found between the outcome of elimination due to lameness and previous lameness eliminations, with horses being 0.5 times less likely to be eliminated lame if their previous lameness was 91–365 days ago, compared with horses that had a lameness elimination within the last 45 days. There was a decreased likelihood of a lameness elimination outcome (OR 0.4, CI: 0.3–0.8) when the horse's previous lameness was over a year ago and a decreased likelihood of a lameness elimination if the horse had never been eliminated for lameness (OR 0.3, CI 0.2–0.6) when compared with horses who had a lameness elimination in the past 45 days. Weak collinearity was found between the risk factors 'starts in 60 days' and 'starts in 90 days'.

Biologically plausible interactions terms were tested in both the final models. No statistically significant interactions terms were found.

**TABLE 3** Model B: Results of the multivariable model for all horse starts for the elimination due to lameness outcome only

| Risk factor | Cases: Lame *n*-per category (%) | Controls: Not lame *n*-per category (%) | Adjusted OR | 95% CI | *p* value |
|---|---|---|---|---|---|
| Returning combination | | | | | |
| Yes | 261 (16.6) | 1310 (83.4) | Reference | - | <0.001 |
| No | 43 (24.4) | 133 (75.6) | 2.26 | 1.52–3.37 | <0.001 |
| Class code | | | | | |
| CER | 189 (25.3) | 559 (74.7) | Reference | - | <0.001 |
| GER | 115 (11.5) | 884 (88.5) | −0.54 | 0.35–0.81 | 0.003 |
| FEI level | | | | | |
| Not FEI | 153 (12.8) | 1039 (87.2) | Reference | - | 0.02 |
| 1* | 77 (23.5) | 251 (76.5) | 1.21 | 0.76–1.91 | 0.4 |
| 2*+ | 74 (32.6) | 153 (67.4) | 1.90 | 1.18–3.06 | 0.008 |
| Distance attempted last 30 days (km) | | | | | |
| 0 | 167 (16.9) | 824 (83.1) | Reference | - | 0.6 |
| 1–55 | 54 (15.4) | 296 (84.6) | 0.93 | 0.62–1.38 | 0.7 |
| 56–79 | 31 (17.7) | 144 (82.3) | 1.12 | 0.69–1.84 | 0.6 |
| 80–100 | 41 (22.4) | 142 (77.6) | 1.23 | 0.78–1.92 | 0.4 |
| >100 | 11 (22.9) | 37 (77.1) | 1.71 | 0.76–3.87 | 0.2 |
| Distance change from previous ride | | | | | |
| Distance decrease | 39 (13.3) | 254 (86.7) | Reference | - | 0.2 |
| Equal distance | 60 (22.7) | 204 (77.3) | 1.56 | 0.98–2.50 | 0.1 |
| Increase ≤55 km | 205 (17.2) | 985 (82.8) | 1.22 | 0.80–1.88 | 0.4 |
| Rides completed previous 180 days | | | | | |
| 0 | 33 (13.3) | 216 (86.7) | Reference | - | 0.4 |
| 1 | 83 (17.4) | 395 (82.6) | 1.00 | 0.55–1.81 | >0.9 |
| 2 | 83 (19.2) | 349 (80.8) | 1.25 | 0.66–2.37 | 0.5 |
| 3+ | 105 (17.9) | 483 (82.1) | 1.44 | 0.73–2.81 | 0.3 |
| Starts last 60 days | 83 (17.4) | 395 (82.6) | | | |
| 0 | 83 (19.2) | 349 (80.8) | Reference | - | 0.04 |
| 1 | 105 (17.9) | 483 (82.1) | 1.05 | 0.64–1.71 | 0.9 |
| 2 | 79 (19.9) | 290 (73.2) | 1.61 | 0.83–3.15 | 0.2 |
| 3+ | 16 (12.9) | 108 (87.1) | 0.74 | 0.29–1.89 | 0.5 |
| Starts last 90 days | | | | | |
| 0 | 31 (10.8) | 256 (89.2) | Reference | - | 0.03 |
| 1 | 114 (19.6) | 468 (80.4) | 1.64 | 0.81–3.30 | 0.2 |
| 2 | 92 (17.2) | 442 (82.8) | 0.92 | 0.40–2.14 | 0.9 |
| 3 | 116 (28.1) | 297 (71.9) | 1.03 | 0.39–2.72 | >0.9 |
| Days since previous lameness | | | | | |
| Within 45 days | 25 (34.2) | 48 (65.8) | Reference | - | <0.001 |
| 46–90 | 31 (34.1) | 60 (65.9) | 1.15 | 0.57–2.30 | 0.7 |
| 91–365 | 70 (19.4) | 291 (80.6) | −0.51 | 0.28–0.92 | 0.03 |
| >365 | 109 (16.4) | 554 (83.6) | −0.44 | 0.25–0.78 | 0.005 |
| No previous lameness | 69 (12.5) | 484 (87.5) | −0.33 | 0.18–0.59 | <0.001 |

*Note*: Model fit was good: Omnibus $p < 0.001$, Hosmer-Lemeshow $p = 0.24$. ROC = 0.72. Risk factors associated with lameness eliminations for horses registered with Endurance GB, competing in rides of >64 km during the 2017–2018 competitive seasons.

Abbreviations: 95% CI, 95% confidence interval; CER, competitive endurance ride (no capped speed); FEI, Fédération Equestre Internationale; GER, graded endurance ride (capped speed); OR, adjusted odds ratio.

*Source*: Data from Endurance GB's database.

## 4 | DISCUSSION

The results of this study demonstrate that the competitive history of a horse, the combined competitive experience of the horse and rider and ride specific factors such as whether a competition is classified as a CER or GER, are specific risk factors for horses to elimination and more specifically elimination due to lameness within British endurance rides.

### 4.1 | Returning combinations

Horses ridden by a rider that they had never previously competed with were more than twice as likely to be eliminated and be eliminated due to lameness compared to horses ridden by a rider that they had previously been partnered in competition. Therefore, it could be assumed that riders who had previously partnered with the horse would be more likely to adapt their riding strategy as necessary throughout the competition, compared to an individual who had not ridden the horse previously. The partnership between horse and rider has been discussed from a biomechanical perspective with previous studies identifying that a horse adapts to the riders positioning which can impact gait.[20–23] Riders respond to the horses' movement and adopt their individual postural strategies and responses differently to other riders.[21–24] Therefore, if a horse has been trained, or is normally competed by one individual and then ridden in the next competition by another individual the horse would have to adapt its movement patterning to compensate for the change in each riders' position. Over the course of the long distance and time frame within endurance riding it is possible that the horse may adopt compensatory muscle patterning which may result in altered biomechanics, abnormal loading and increased fatigue, which could potentially manifest as gait abnormalities resulting in the increased elimination and lameness outcomes observed in new combinations.[23,25]

From a welfare perspective the horse and rider relationship within competition, should also be considered. If the rider has an awareness of the typical movement behaviour and physiological responses of the horse, it is likely that they would be more competent to recognise fatigue or changes to the gait pattern and implement strategic changes such as changing pace, change of tactics, or where necessary considering retiring the horse before it requires additional veterinary attention.[26] The individual experience of the horse and rider may be considered as a contributing factor in the ability to adapt in ride tactics throughout the competition, as has been found in racing, where less falls were associated with more experienced jockeys.[27,28] However, as limited information was available surrounding the riders, this study limited inclusion to horses and riders who had successfully completed their novice qualifications and therefore were deemed eligible to attempt rides of 64 km and above and had some experience within the sport. Further research could consider novice horses and riders, to identify whether there is a difference in eliminations and specifically lameness eliminations in lower levels, which could impact the success and welfare of the horse as it progresses through the distances.

### 4.2 | Rider age and gender

This study did not find a significant difference between rider age and elimination/lameness elimination or between rider gender and elimination/lameness elimination in the final modelling. Rider age had no significance at univariable analysis stage, which is in contrast to previous research which identified young riders were less likely to be eliminated as lame; however, this was only at univariable level and should not be over interpreted.[6] Previous research at international level competition has identified male riders are more likely to have a horse which is eliminated for metabolic compromise.[11] This study did not look specifically at metabolic eliminations, however, at univariable analysis, male riders were significantly more likely to be eliminated overall but were less likely to be eliminated for lameness. This did not carry significance in the final multivariable models and cannot be overinterpreted.

### 4.3 | Class categories

Whilst speed data were not available, horses competing in CER classes with no upper speed limit were more likely to be eliminated than horses in GER where a defined upper speed limit is enforced. This pattern was repeated for horses competing in FEI rides with no upper speed limit compared to national rides, where the majority (83.8%) had speed restrictions in place. Concerns within the sport regarding increasing speeds and the increased likelihood of a negative outcome have been documented by veterinarians who have officiated at the highest level.[29] Additionally, other studies have found that increased speeds in the initial phases of the race, or sudden changes within the pace have been found to increase the likelihood of a deleterious outcome.[10–12,30] This information was not available in the data set analysed however, anecdotally, a change in pace is more likely within a CER competition where the riders are racing another combination and are perhaps more likely to push the horse's physiological capabilities, compared to a GER where other horses competing have no impact on their final result. This highlights the complexity of the sport and consideration should be given to tactical riding including pacing strategies and awareness of the negative impact speed may have. Maximum speed limits have been introduced for FEI qualifications; however, these are not echoed for riders who have no desire to compete at international level.[1,2] Tactical training and race management strategies are anecdotally shared with riders who have aspirations to compete at an international level during team training days, however it is not given to riders competing at national level. Further consideration should be given to increased education for riders changing from GERs to CERs such as pacing strategies and care of the horse within the vet hold, with perhaps an upper speed limit imposed for their first attempts at CERs.

A higher incidence and increased odds of elimination and lameness were identified in FEI rides, whilst this could be associated with international competitors perhaps riding at a higher speed, it is also plausible that the veterinary scrutiny may differ between rides run under EGB

rules and those run under FEI rules. The veterinary parameters remain the same for both EGB and FEI, but different veterinarians, with differing levels of experience, particularly experience within the sport specifically, may account for some of the higher incidence of eliminations within the FEI category rides. Additionally, a horse can be eliminated with two veterinarians viewing the trot for a EGB GER, whereas three are required to view any questionable trot ups in EGB CERs and all FEI rides. It should be noted, however, the incidence of elimination and lameness elimination in British FEI rides was slightly less in this study (44.7% and 27.2%), compared to previous findings (49.8% and 39.4%).[6]

## 4.4 | Number of competitions

Multiple rides within the previous 60 days were found to increase the odds of elimination; this potentially could be linked to a lack of recovery time between competitions. The benefit of longer rest periods between competitions has been demonstrated at international level, where an analysis of competition starts from 2010 to 2017 found 2.3% of eliminations could have been prevented if the mandatory rest period rule instated in 2014 had been implemented in 2008.[13] By extending the mandatory rest period by 7 days, and a further 7 days if the horse was ridden over 20 kmph, 10.7% of eliminations could be prevented.[13] Research in racehorses has associated accumulative repetitive loading combined with insufficient recovery from micro trauma with a higher incidence of lameness and catastrophic injuries.[31–33] The significant positive correlation between the distances attempted in the horse's competitive career and the number of eliminations as well as the number of eliminations due to lameness in the horse's career, would indicate that endurance horses also experience the impact of repetitive microtrauma. The correlation identified between the increased number of rides attempted and the number of eliminations and eliminations in the horse's career supports this theory. Endurance horses undergo similar physical loading patterns, although work/exercise occurs predominately at lower speeds the repetition of strides will be increased, not only in competition, but also in training. It is plausible that horses competing may have a subclinical issue that is not apparent until exposed by the increased physical demands of competition. The details surrounding the training of the horses in the data set were not available, however research into training of endurance horses and subsequent impact on competitive success or failure needs to be considered in greater detail and may be advantageous in reducing injuries.[33,34]

## 4.5 | Previous eliminations

Endurance GB requires horses to have MOOCP based on the distance completed and an additional 8 days are added if the horse is eliminated by the veterinary panel regardless of the number of previous eliminations. As this study has identified that horses are at a decreased likelihood of lameness eliminations if there is >90 days since their previous lameness elimination, consideration should be given to extending these rest periods within national competition dependent on the elimination reason. Adopting this approach has been successful in decreasing the likelihood of elimination in FEI competitions.[13]

## 4.6 | Recommendations

Equestrian sport is recognised in the literature to have inherent risks, but within the context of social licence to operate, there is a need to define a framework to limit risks, reduce injury and optimise the welfare of competing horses.[3] The results of this study demonstrate reasons for lameness may be multifactorial and therefore complex to remove entirely from endurance. Veterinarians within the sport also report identification of lameness within competition is challenging and is considered a clinical sign rather than a diagnosis.[35] The findings of this study demonstrate that following a lameness elimination, there is a higher likelihood of another lameness elimination, however, little is known about the causality, diagnosis and rehabilitation prior to return to competition post lameness elimination. In order to manage endurance horses effectively, it would be beneficial to have greater details of lameness such as which limb(s) and at what stage of the competition lameness and elimination is occurring, to be able to determine prophylactic management strategies. The current data do not indicate which limb(s) of the horse(s) are considered to be the lame limb and therefore it is not possible to evaluate whether the horse(s) with repeated lameness elimination results are being eliminated with the same limb each time, which would be indicative of a return to competition prior to full recovery. Identification of reoccurring injuries and/or compensatory patterns which may be detrimental to the welfare of the horse would allow stakeholders to act upon it, to improve the welfare and ultimately performance outcomes. Increasing the mandatory rest periods between competition and education for riders surrounding the importance of appropriate and maximal recovery could improve equine welfare and increase the longevity of the horse's career. It may also be of benefit to restrict the number of competitive starts within one competitive season to reduce the possible impact of microtrauma from a cumulative distance.

## 4.7 | Limitations

This study highlights gaps in the current data recorded at ride level, such as the terrain and ground conditions of the ride, the weather conditions, the speeds, point of elimination, and if lame, the limb(s) which were identified as lame which would enable further information surrounding lameness eliminations to be considered for the improvement of welfare within the sport. Some eliminations (8.5%) on the database were documented only as elimination without further classification, which may explain the lower percentage of lameness eliminations in comparison to other studies. It is assumed that some of these eliminations without further classification may indeed have been lameness eliminations, but of course could not be considered as, which will have some impact on the accuracy of the results. This also

prevented detailed modelling on other elimination reasons such as metabolic eliminations which have identified different risk factors for lameness.[6–13] Additionally, 21.6% of eliminations were a result ofriders retiring their horses on course, further information as to the reasons behind their retirement were not available. Whilst FEI rides and EGB use the same vetting parameters, it is plausible that there may be a differing level of veterinary scrutiny across competitions, which may impact results. It is also acknowledged that weak collinearity between variables in the final models was found and is recognised as a limitation but is inevitable in studies of this nature.

## 5 | CONCLUSION

This study of British endurance horses has shown that multiple competitive starts, previous veterinary eliminations and ride categories are significant risk factors associated with elimination from the competition. Additionally, it demonstrated that horses and riders who had not previously competed as a combination were significantly more likely to be eliminated from the competition.

### AUTHOR CONTRIBUTIONS

Fiona Bloom, Stephen Draper, Euan Bennet and Jane Williams contributed to study design, study execution, data analysis and interpretation, preparation of the manuscript and final approval of the manuscript. David Marlin contributed to study design, interpretation of the data, preparation of the manuscript and final approval of the manuscript. Fiona Bloom had full access to all of the data in the study and is responsible for data integrity and accuracy of analysis.

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### CONFLICT OF INTEREST STATEMENT

No competing interests have been declared.

### PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/evj.13875.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Endurance GB. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available from the authors with the permission of Endurance GB.

### ETHICS STATEMENT

The ethics committee at Hartpury University approved this study and Endurance GB board of directors gave consent for retrospective analysis of the raw data from the Endurance GB results database.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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