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Towards a safer sport: Risk factors for cross-country horse falls at British Eventing competition

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Abstract

Background: Equestrian eventing is a dangerous Olympic sport, with 16 rider and 69 horse fatalities at competition in the last 10 years. Despite this, there is limited research that aims to improve safety within the sport.

Objectives: The purpose of this study was to identify risk factors for horse falls, which are the leading cause of rider fatality within the sport.

Study design: Retrospective cohort study.

Methods: Competition data between January 2005 and December 2015 were analysed. Descriptive statistics followed by univariable logistic regression to identify risk factors for inclusion in a multivariable logistic regression model were conducted. Models were constructed stepwise using a bidirectional process and assessed using the Akaike information criterion. A total of 749 534 cross-country starts were analysed for association with the risk of horse falls.

Results: Sixteen risk factors were identified including: higher event levels, higher dressage penalties and higher number of days since horses' last start. For example, horse and rider combinations competing at BE100 (OR 1.64, confidence interval (CI) 1.37–1.96, $p < 0.001$), novice (OR 3.58, CI 3.03–4.24, $p < 0.001$), intermediate (OR 8.00, CI 6.54–9.78, $p < 0.001$), advanced (OR 12.49, CI 9.42–16.57, $p < 0.001$) and international (OR 4.63, CI 3.50–6.12, $p < 0.001$) all had a higher risk of having a horse fall in comparison to combinations competing at BE90 level. Furthermore, for every additional 10 dressage penalties awarded to a horse and rider combination, there was a higher risk of a horse fall (OR 1.20, CI 1.12–1.28, $p < 0.001$).

Main limitations: The study is not geographically comprehensive (UK only) and does not include any information on training activity of horses and riders.

Conclusions: This is the largest-scale study ever conducted on horse falls during eventing competition. Study results can be used by sport governing bodies to inform policy which has the potential to reduce the risk of injury and fatality to sport participants.

KEYWORDS
epidemiology, equestrian sport, eventing, fatality, horse, injury, risk

1 | INTRODUCTION

Equestrian eventing has been an Olympic sport since 1912. Eventing consists of three phases: dressage, showjumping and cross-country. The phases of eventing and challenges of risk calculation in the sport are described in previous literature.[1] Statistically, the highest risk of injury/fatality to eventing riders is associated with horse falls during the cross-country, defined as when both the horse's shoulder and its quarters touch either the ground, or an obstacle and the ground simultaneously. The risk of serious injury/fatality to the rider is greatest when the fall results in the horse landing on top of them. Horse falls are categorised as rotational or nonrotational. In the instance of a rotational horse fall, the horse somersaults over a solid obstacle. The Fédération Equestre Internationale (FEI) reported that during the 2021 season, 8% ($n = 14$) of nonrotational horse falls and 24% ($n = 7$) of rotational horse falls resulted in serious injury to the rider.[2] Thirty-eight event rider fatalities were reported to have happened during or after eventing competition between 2000 and 2015, with at least 30 of these deaths resulting from a horse fall at a cross-country fence.[1] Additionally, 65 horse fatalities have occurred during or after eventing competition between 2007 and 2015, with limited equine fatality statistics available prior to this date.[3] Of these 65 equine fatalities, 28 were a result of a horse fall at a cross-country fence. News outlets report a further 17 event rider and 39 event horse fatalities in the 6 years since.[3] Research that aims to identify risk factors for horse falls is therefore imperative to highlight potential areas for prevention and set priorities for future research.

Epidemiological studies are required to inform evidence-based policies within the sport of eventing but are currently sparse in the literature, with most studies published more than 15 years ago.[4–6] A recent study investigated risk factors for horse falls at FEI competitions, identifying 13 risk factors including level of competition, horse/rider sex and course length.[7] FEI competitions exclusively encompass international level competition thus the sample is smaller than national-level competition datasets. International competitions are also subject to larger variation such as differing environmental factors and competition format (e.g. temperature, ground condition and order of phases). Furthermore, due to the popularity of the sport in the UK, 34% of recorded event rider fatalities since the year 2000 and 31% of recorded event horse fatalities since the year 2007 occurred on UK soil, highlighting the UK as a location of interest for risk in the sport.[1,3] The aim of the current study was therefore to analyse 11 years of UK 1-day eventing competition data to identify risk factors for horse falls. This approach is the critical next step towards reducing rider injury and fatality and, to our knowledge, encompasses the largest eventing dataset ever analysed for this purpose.

2 | MATERIALS AND METHODS

2.1 | Cohort

The data set used were the UK governing body's (British Eventing; BE) central database, to which the lead author was given access, to complete the study in collaboration with the governing body. Some of the information within the database is publicly available online such as competition results.[8] Following data cleaning, the study population contained a total of 749 534 starts in the cross-country phase of eventing competition in the UK from 1 January 2005 to 31 December 2015. Data cleaning is described in Data S1. Cross-country starts, which resulted in a horse fall (case starts), were compared with starts that did not result in a horse fall (control starts). A 'start' is any time a horse and rider combination started the cross-country phase in an eventing competition. Study cohort selection included all competition levels except for BE80, which was only introduced in 2009. This was to ensure that the results reflected the full study period for included levels of competition.

2.2 | Data analysis

The relationship between continuous potential risk factors and the outcome horse fall was reviewed by assessment of graphical plots of the log of odds.[9] If a nonlinear relationship was observed, appropriate categorical terms for risk factors were created and were considered. Categorisation was based on quintiles or plausible biological explanations (where possible) on the basis of 'best fit' in a multivariable model using Akaike information criterion (AIC) and log-likelihood, in an attempt to find the most parsimonious model[10,11] (Data S2).

2.3 | Univariable analysis

Univariable logistic regression was performed on all risk factors considered biologically plausible or supported within the literature, to assess the association between potential risk factor and horse fall. Wald p-values were calculated; any risk factors with values of $p < 0.20$ in univariable analysis were deemed eligible for inclusion in a multivariable logistic regression model. A threshold of $p < 0.20$ was chosen to avoid exclusion of a potentially significant risk factor, which only becomes evident when a confounding variable has been controlled for in a multivariable analysis.[10]

2.4 | Multivariable model

A stepwise bidirectional (forwards-adding and backwards-removing) process was used to construct the multivariable model, with each step assessed using the AIC. The AICs for competing models were compared, with the lowest AIC indicating the preferred model. The AIC was relied upon for including risk factors in the final model and no other exclusion criteria based on potential biological interaction was used. A Wald p value of less than 0.05 was required for a risk factor to be retained in the final model.

Risk factors included in the final model were checked for possible collinearity, and correlation coefficients were produced for all pairs with a threshold for inclusion set at $r > 0.7$. Risk factors rejected at

TABLE 1 Multivariable model results for horse falls in British Eventing competition during the 11-year period from 2005 to 2015.

	Cases (%)	Controls (%)	OR	95% CI	*p*-value
Competition level					
BE90[a]	204 (0.1%)	168 452 (99.9%)	1.00	–	–
BE100	365 (0.2%)	183 463 (99.8%)	1.64	1.37–1.96	<0.001
Novice	1153 (0.4%)	268 575 (99.6%)	3.58	3.03–4.24	<0.001
Intermediate	548 (0.8%)	67 165 (99.2%)	8.00	6.54–9.78	<0.001
Advanced	103 (1.2%)	8554 (98.8%)	12.49	9.42–16.57	<0.001
International	237 (0.7%)	33 663 (99.3%)	4.63	3.50–6.12	<0.001
Unknown	23 (0.1%)	19 662 (99.9%)	0.96	0.61–1.51	0.868
Rider—sex					
Female[a]	1906 (0.3%)	596 331 (99.7%)	1	–	–
Male	727 (0.5%)	153 203 (99.5%)	1.25	1.14–1.37	<0.001
Rider—age					
12–21 years[a]	744 (0.3%)	214 229 (99.7%)	1	–	–
22–31 years	911 (0.4%)	240 337 (99.6%)	0.95	0.86–1.06	0.363
32–41 years	634 (0.4%)	170 468 (99.6%)	0.95	0.84–1.06	0.349
42–51 years	285 (0.3%)	95 849 (99.7%)	0.83	0.72–0.96	0.012
Over 52 years	59 (0.2%)	28 651 (99.8%)	0.67	0.51–0.88	0.004
Rider—horse fall in previous start?					
Did not fall	2607 (0.3%)	747 020 (99.7%)	1	–	–
Did fall	26 (1.0%)	2514 (99.0%)	2.39	1.62–3.53	<0.001
Rider—number of starts in previous 90–180 days					
Zero	2167 (0.4%)	588 145 (99.6%)	1	–	–
One or more starts	466 (0.3%)	161 389 (99.7%)	0.83	0.75–0.93	0.001
Rider—number of prior starts in study period					
0–10 starts	460 (0.2%)	188 288 (99.8%)	1	–	–
11–35 starts	639 (0.3%)	189 655 (99.7%)	1.13	0.99–1.28	0.066
36–115 starts	743 (0.4%)	184 447 (99.6%)	1.14	1–1.3	0.056
116 or more starts	791 (0.4%)	187 144 (99.6%)	0.97	0.83–1.12	0.652
Horse—grade					
Grade II[a]	609 (0.5%)	130 401 (99.5%)	1	–	–
Grade I	639 (0.5%)	120 583 (99.5%)	0.78	0.69–0.88	<0.001
Grade III	660 (0.4%)	180 770 (99.6%)	1.12	0.99–1.26	0.062
Grade IV	702 (0.2%)	301 790 (99.8%)	1.25	1.09–1.42	0.001
Unknown	23 (0.1%)	15 990 (99.9%)	1.25	0.79–1.97	0.345
Horse—height					
161–165 cm[a]	945 (0.4%)	267 334 (99.6%)	1	–	–
142–148 cm	121 (0.3%)	40 795 (99.7%)	1.28	1.05–1.57	0.016
149–155 cm	85 (0.3%)	29 617 (99.7%)	1.08	0.86–1.35	0.529
156–160 cm	249 (0.3%)	91 377 (99.7%)	0.9	0.78–1.04	0.149
166–170 cm	971 (0.4%)	252 860 (%)99.6	1.02	0.94–1.12	0.597
More than 170 cm	262 (0.4%)	67 551 (99.6%)	1.09	0.94–1.25	0.25
Horse—sex					
Gelding[a]	1893 (0.3%)	546 424 (99.7%)	1	–	–
Mare	715 (0.4%)	198 258 (99.6%)	1.18	1.08–1.29	<0.001
Stallion	25 (0.5%)	4852 (99.5%)	1.36	0.91–2.02	0.133

(Continues)

TABLE 1 (Continued)

	Cases (%)	Controls (%)	OR	95% CI	*p*-value
Horse—age					
Per additional 4 years	Median = 9	IQR = 4	1.12	1.04–1.2	0.003
	Min = 4	Max = 29			
Horse—age at first start in study period					
4–5 years[a]	788 (0.4%)	218 445 (99.6%)	1	–	–
6 years	547 (0.3%)	163 926 (99.7%)	0.88	0.79–0.99	0.029
7–8 years	610 (0.3%)	181 236 (99.7%)	0.86	0.77–0.96	0.01
9 year or older	688 (0.4%)	185 927 (99.6%)	0.86	0.75–0.99	0.041
Horse—days since last start					
1–14 days[a]	1189 (0.4%)	289 210 (99.6%)	1	–	–
First start	101 (0.2%)	48 719 (99.8%)	2.06	1.36–3.12	0.001
15–21 days	445 (0.4%)	122 681 (99.6%)	0.88	0.79–0.98	0.025
22–28 days	251 (0.4%)	69 934 (99.6%)	0.94	0.81–1.08	0.382
Over 28 days	647 (0.3%)	218 990 (99.7%)	1.21	0.96–1.54	0.11
Horse—number of starts in previous 30 days					
No starts[a]	669 (0.3%)	251 914 (99.7%)	1	–	–
One start	1070 (0.4%)	295 388 (99.6%)	1.31	1.03–1.66	0.025
Two starts	728 (0.4%)	164 779 (99.6%)	1.44	1.11–1.87	0.006
Three starts	150 (0.4%)	33 964 (99.6%)	1.41	1.05–1.9	0.024
Four or more starts	16 (0.5%)	3489 (99.5%)	1.5	0.86–2.6	0.153
Horse—number of starts in previous 60–90 days					
No starts[a]	1275 (0.3%)	443 924 (99.7%)	1	–	–
One start	674 (0.4%)	163 509 (99.6%)	1.25	1.13–1.37	<0.001
Two starts	515 (0.5%)	108 734 (99.5%)	1.3	1.16–1.44	<0.001
Three starts	149 (0.5%)	29 722 (99.5%)	1.33	1.12–1.58	0.001
Four or more starts	20 (0.5%)	3645 (99.5%)	1.48	0.95–2.31	0.086
Combination—dressage penalties					
Per additional 10 penalties	Median = 35.9	IQR = 7.3	1.2	1.12–1.28	<0.001
	Min = 10.0	Max = 100.0			
Combination—first start					
No[a]	2490 (0.4%)	673 075 (99.6%)	1	–	–
Yes	143 (0.2%)	76 459 (99.8%)	0.69	0.52–0.93	0.014

Note: Cases (%) were starts that recorded a horse fall during the cross-country phase. Controls (%) were starts that did not record a horse fall during the cross-country phase. Odds ratio (OR) and 95% confidence interval (CI) for each level are provided. Risk factors with a *p*-value of less than 0.05 were retained in the final model. For continuous variables, the median, interquartile range (IQR), minimum and maximum are shown in place of the numbers of cases and controls.

[a]Among categorical variable levels, this is the reference category.

the univariable and multivariable stages were subsequently tested for confounding in the final model. If the odds ratios (OR) for variables in the final model were altered by >20% by the potentially confounding variable, then the confounder was retained in the final model.[10]

The potential impact of horse and rider clustering was assessed by creating a series of mixed-effects models that included horse and rider as random effects together and separately within the final model.[10] The coefficients associated with each fixed effect were checked after all other model fitting procedures had been completed, which enabled confirmation that the final model was not altered by random effects.

Biologically plausible interaction terms were created to assess whether two or more factors that were associated with the outcome horse fall resulted in an increased or decreased frequency of a horse fall when presented in combination, in the final model.

The final model was tested for goodness-of-fit using the Hosmer-Lemeshow test.[10,12] Statistical analyses and calculations were performed in RStudio V. 1.2.1335 (R Foundation for Statistical Computing). Power calculations indicate that for continuous variables, models have at least 80% power to detect ORs of 1.06 with 95% confidence. For binary categorical variables,

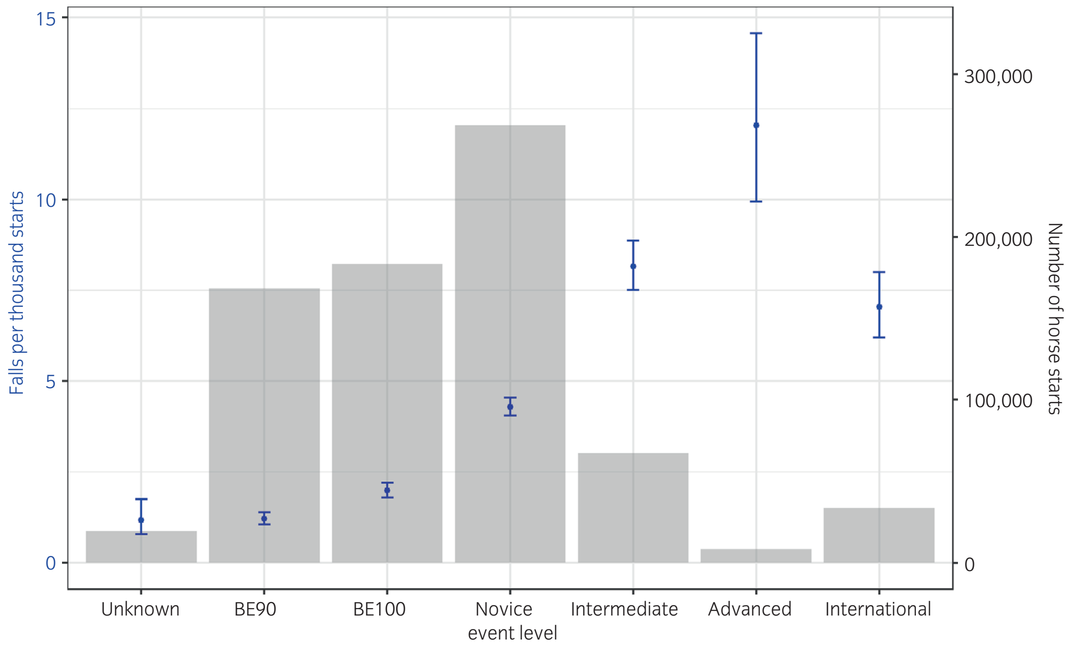

FIGURE 1 Distribution of horse starts by event level (grey bars). The blue points show the falls per 1000 starts for each category of event level. The error bars represent 95% upper and lower confidence intervals on the falls per 1000 starts.

models have at least 80% power to detect ORs of 1.11 with 95% confidence.

For continuous variables, the median, interquartile range (difference between 75th and 25th percentiles), minimum and maximum were produced in place of the numbers of cases and controls (Table 1).

3 | RESULTS

Of 749 534 cross-country starts included in analysis there were 2633 horse falls recorded, with 3.5 falls per 1000 starts. These data included 52 083 unique horses and 23 664 unique riders. There were 81 407 unique horse/rider combinations. Table 1 shows the final multivariable model for the outcome horse falls.

3.1 | Event level

Falls per 1000 starts for event level is displayed in Figure 1. Compared with BE90 competitions, BE100 (OR 1.64 [1.37–1.96]), novice (OR 3.58 [3.03–4.24]), intermediate (OR 8.00 [6.54–9.78]), advanced (OR 12.49 [9.42–16.57]) and international (OR 4.63 [3.50–6.12]) were associated with greater odds of a fall.

3.2 | Rider level

Compared with female riders, male riders were associated with greater odds of a fall (OR 1.25 [1.14–1.37]. Older riders were less likely to have a fall than younger riders. Compared with riders aged 12–21 years, riders aged 22–31 years (OR 0.95 [0.86–1.06]), 32–41 years (OR 0.95 [0.84–1.06], 42–51 years (OR 0.83 [0.72–0.96]) and over 52 years (OR 0.67 [0.51–0.88]) were associated with lower odds of a fall. Riders that have had 1 or more starts in the previous 90–180 days (OR 0.83 [0.75–0.93]) are less likely to fall than those that have not had any starts during this period. Riders that had a horse fall during their previous start (OR 2.39 [1.62–3.53]) were more likely to fall during their current start. Riders with a higher number of starts in the study period were more likely to have a horse fall than riders with less starts. This finding was not statistically significant, but its inclusion improved the overall fit of the model according to the AIC therefore it was retained in the final model.

3.3 | Horse level

Compared with Grade II horses, Grade I horses (OR 0.78 [0.69–0.88]) were less likely to fall. Grade IV (OR 1.25 [1.09–1.42]) horses were more likely to fall in comparison with Grade II horses. Horses competing in their first start (OR 2.06 [1.36–3.12]) were more likely to have a horse fall than horses that had started in the previous 1–14 days. Grade I horses are considered 'Elite' having gained 500 or more grading points, whereas Grade IV horses have zero points and are the least experienced. Grading points are awarded for 'good' performance such as being placed in the top 10 (Table 2). However, horses that had started in the previous 15–21 (OR 0.88 [0.79–0.98]) days were less likely to have a horse fall than horses that had started in the previous 1–14 days. In comparison with horses that had zero starts in the previous 30 days, horses that had started once (OR 1.31 [1.03–1.66]), twice (OR 1.44 [1.11–1.87]) and three times (OR 1.41 [1.05–1.9]) were associated with greater odds of a fall. Horses that had started once (OR 1.25 [1.13–1.37]), twice (OR 1.3 [1.16–1.44]) or three times (OR. 1.33 [1.12–1.58]) during the previous 60–90 days all had greater odds of a fall than horses that had not started during this period. Ponies (of height 142–148 cm) (OR 1.28 [1.05–1.57]) were more likely to have a horse fall than horses that were 161–165 cm in height. Mares (OR 1.18 [1.08–1.29]) were more likely to have a horse fall in comparison to geldings. Horses that start competition later in the study period are less likely to have a horse fall. Compared with horses that were 4–5 years of age at their first start in the study period, horses that were 6 years (OR 0.88 [0.79–0.99]), 7–8 years (OR 0.86 [0.77–0.96]) and 9 years or older (OR 0.86 [0.75–0.99]) were associated with lower odds of a fall. Older horses were more likely to fall than younger horses. For every four unit increase in horse age, the odds of a horse fall increased (OR 1.12 [1.04–1.20]). Horses at or above the 75th percentile of age (11 years of age) were at OR 1.12 (1.04–1.20) compared with horses at or below the 25th percentile (7 years of age).

TABLE 2 British Eventing horse grade descriptions.

Grades	Descriptions
1 (Elite)	500 or more grading points
2	61 or more grading points
3	21–60 grading points
4	Zero points

Note: Horses are awarded points for completing the showjumping and cross-country phases of a competition without incurring any jump-penalties, or time-penalties in the showjumping phase ('double clear' round). Horses also gain points by being placed in the competition. The number of points awarded, and to what 'placing' are dictated by the number of competitors in the class and the competition level.

3.4 | Combination level

Horse and rider combinations that scored a high number of penalties in dressage were more likely to have a horse fall than those who scored a low number of penalties. For every 10 unit increase in dressage penalties, the odds of a horse fall increased (OR 1.2 [1.12–1.28]). Falls per 1000 starts for dressage penalties is displayed in Figure 2. Combinations at or above the 75th percentile for dressage penalties (39.8 penalties) were at OR 1.13 (1.08–1.18) compared with combinations at or below the 25th percentile (32.5 penalties). Horse and rider combinations that were competing in their first start as a partnership (OR 0.69 [0.52–0.93]) were at decreased risk of a horse fall compared with combinations who were not competing in their first start.

3.5 | Collinearity, confounding, random effects and model fit

No evidence of collinearity was found. No second-order interactions terms were found to be significant in the final model. None of the risk factors, which were rejected at any stage of model-building, were found to be confounded with any of the retained risk factors. There were no meaningful changes in p values and <10% change in ORs compared with results obtained with the model that did not include random effects, so the single level model was retained as the final model. With the horse included as a random effect, <1% of the variance as measured by the R-squared was due to the horse ID. With the rider included as a random effect, <14% of the variance as measured by the R-squared was due to the rider ID. No evidence of a lack of fit

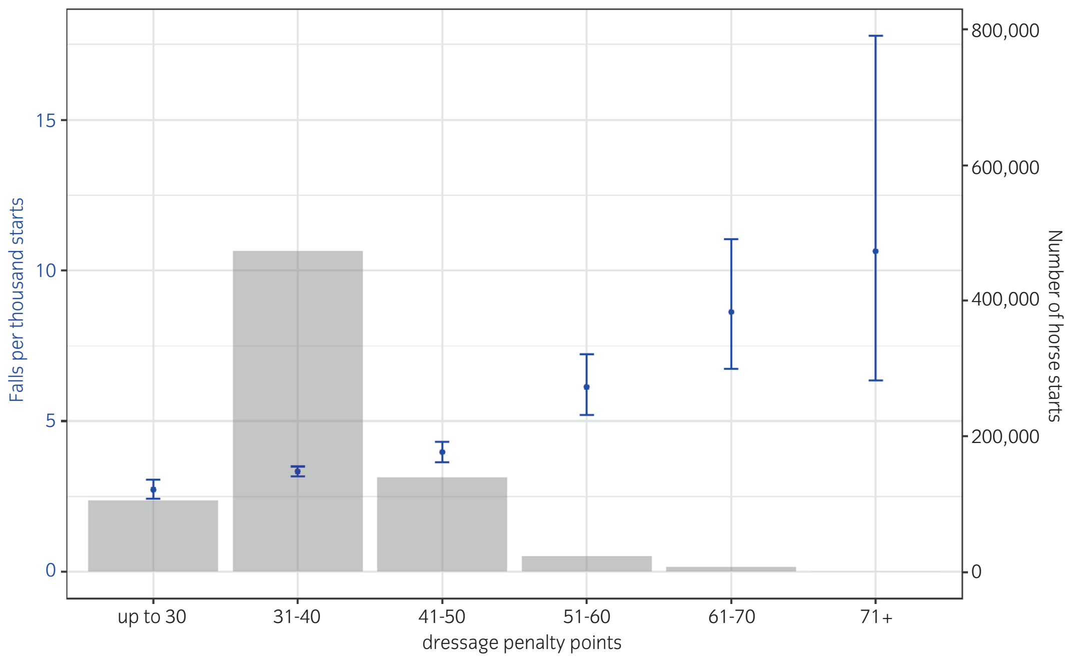

FIGURE 2 Distribution of horse starts by dressage penalty points (grey bars). The blue points show the falls per 1000 starts for each category of dressage penalty points. The error bars represent 95% upper and lower confidence intervals on the falls per 1000 starts.

was found with the Hosmer-Lemeshow goodness-of-fit test (p-value = 0.96).

4 | DISCUSSION

The purpose of this study was to determine risk factors that are associated with horse falls during cross-country at 1-day eventing competitions in the UK. Sixteen variables at the level of event, rider, horse and rider/horse combination were retained in the final model, demonstrating that they have a significant effect on the risk of a horse fall.

Prior to data cleaning, the data set included an incidence of 4.3 falls per 1000 starts, which is in line with previously reported incidence rates. For example, BE reported 4.4 falls per 1000 starts at competition for the period 2004–2015.[13] For FEI (international) eventing competitions, 14.3 horse falls per 1000 starts for the period 2008–2018 were reported.[7] It is important to note that FEI competitions typically have higher horse fall incidence than 1-day (national) competitions as they consist of 1-, 2- and 3-day competitions and do not encompass lower levels of eventing.

4.1 | Event level

Previous studies into the risk of horse falls during the cross-country phase of national-level (BE) competitions have not reported class of competition to be associated with the risk of horse falls.[4,6] In the current study, the risk of horse falls increased through higher levels of national competitions. Two-, three-, and four-star international competitions have previously been associated with increased risk of a horse fall in comparison to one-star international competitions, indicative of the increasing challenge of international competition as the levels ascend.[7,14] Regardless of whether the competition is at national (i.e. BE) or international (FEI) level, the difficulty of the competition increases as the competition levels ascend. For the cross-country phase, characteristics that can change the difficulty of the competition include length of the course, height/spread of the fences, number of jumping efforts and speed at which the horse and rider combination must complete the course to achieve the optimum time. Many of these variables have been previously identified as risk factors for horse falls.[4–7,14,15]

For international competition, risk of falls was lower than the highest national level (advanced). The international category included international levels one-, two- and three-star, which are comparable to novice, intermediate and advanced level national competitions, the finding that the international category of competition does not carry a higher risk of horse falls in this data is therefore not unexpected. Due to event level encompassing many competition characteristics, it is challenging to identify modifiable changes to improve safety as a result of this finding. However, the minimum eligibility requirements (MERs) for each level of competition should continue to be carefully reviewed to minimise the risk to riders progressing through higher levels of competition. Advanced level competition specifically was associated with a high OR, begging the question as to whether the higher levels of competition are overstepping a 'line' in terms of distance, speed and fence design; with these variables all having been previously identified as risk factors for horse falls.[4–7,15] Further research is needed to investigate these factors however, to enable valid recommendations to be made in relation to MERs and their suitability for maximising safety.

The cohort of riders competing at higher levels may be more likely to include professional athletes. Pressures on professional athletes have been reported to increase due to the size or importance of the competition,[16] which may compromise performance and increase risk-taking behaviours.[17]

4.2 | Rider level

Previous studies reported that male riders were at an increased risk of horse falls at FEI events than female riders, thus the current study supports these findings for 1-day events in the UK.[7,14] Males have been reported to score higher in self-efficacy than females in sports such as parkour (free running),[18] and rock climbing.[19] Self-efficacy is described as an individual's 'belief in one's capabilities to organise and execute the courses of action required to produce given attainments'.[20] Indeed, self-efficacy and sex-differences (higher in males) have been previously identified as important predictors of risk-taking in dangerous sports such as rock climbing.[19] This could suggest that males are more likely to take risks during sports such as eventing (e.g. riding at faster speeds), due to their greater belief in their ability to deal with risky situations. Additionally, it is reported that males take greater risks than females in sports such as skiing and snowboarding[21] and parkour[18] and score higher in sensation seeking.[22,23] It is possible therefore that gender differences in attitudes to risk could affect likelihood of falling.

Comparable to the current study, previous studies have reported that older riders were less likely to have a fall during FEI competition.[7] Risk taking is reported to decline with age in people[24] and it has been found that risk taking decreases with age specifically in sports such as skiing and snowboarding,[21] parkour,[18] skateboarding,[25] and eventing.[26] Eventing riders could be at a decreased risk of horse falls at older ages because they have a lower willingness to take risks. Alternatively, older riders may benefit from extensive experience of participating in eventing. Unlike other sports, equestrian sport does not experience a decrease in sport participation as participants get older.[26,27] Riders continue to participate in equestrian sport into advanced age, even at a professional level. It is possible that older eventing riders harness extensive experience that equips them with well-developed coping mechanisms, allowing them to manage sport related anxiety, and to focus their performance and skill to completing the cross-country course accurately and safely.

Results of the current study indicate that it is beneficial to be well-practised at competing. The frequency of competition may also be indicative of the level and status of the rider, as professional riders are expected to compete more often.

The finding that riders who had a fall during their previous start were more likely to fall could indicate that these individuals were competing at a level above their skill and therefore were at a heightened risk, further highlighting the importance of continually reviewing MERs.

4.3 | Horse level

Horses that have achieved Grades I and II status have done so through good performance and obtaining clear rounds, whereby they have not incurred any showjumping or cross-country jumping penalties. Additionally, being placed in the top 10 in previous competitions awards points to horses and indicates a high level of skill/athletic ability. An explanation of the grading system for BE horses can be viewed in Table 2. The findings of the current study indicate that horses with the most experience in eventing (Grade I) are at a decreased risk of a horse fall compared with those that are least experienced (Grade IV).

The findings regarding the number of days since the horse's last start may indicate that after the first competition of the season there is an optimal time (in days) between competition starts for horses. In addition, horses that had more starts in recent months were more likely to have a fall, highlighting the importance of a carefully managed competition schedule. Research in racehorse training reported that a greater number of rest periods were associated with greater prize money, indicative that frequent rest periods may be beneficial for equine performance.[28]

The finding that ponies were more likely to fall than horses that were 161–165 cm in height could be due to the increased difference between pony height and the height of the fences. Mares were at increased risk of a fall, which is consistent with findings reported for FEI eventing competitions.[7] Previous research has reported that stallions and gelding's peak performance is better than mares at all levels of BE.[29] Findings of the current study indicate that horses starting competition later in life is beneficial, however it is important to note that the study cohort does not definitely include the first start of every horse's career.

4.4 | Combination level

Poor performance in dressage increased the risk of a horse fall, supporting findings of previous studies for FEI competitions.[7] Horse and rider combinations who are awarded poor scores in the dressage phase may not be competing at the most suitable level of the sport for their respective level of ability. These combinations may benefit from moving down a level until they are at a skill-level where they will achieve better scores. Alternatively, a penalty cap could be implemented to eliminate combinations who achieve a high dressage penalty score, which would prevent these combinations from starting the cross-country, comparable to the cap on showjumping penalties, which is currently implemented by governing bodies. For example, for combinations with a dressage penalty score of 70 or more, there were 11 falls per 1000 starts in comparison to 3.5 falls per 1000 starts for combinations with a score of <70. Implementing a cap of 70 penalties therefore has the potential to reduce the incidence of horse falls. At competitions where the showjumping penalty restriction is not in place before the cross-country phase (i.e. competitions run in the order of dressage, cross-country then showjumping), a dressage penalty restriction may be beneficial to restrict high-risk horse and rider combinations from starting the cross-country. Previous studies have reported that horse riders are not always aware of lameness in their horses; a study of 506 sports horses reported that 47% of the horses that were believed to be sound by riders were lame or had pain-related gait abnormalities.[30] As symmetry, ease of movements and suppleness are evaluated during a dressage test, gait abnormalities/lameness will negatively affect a horse and rider's dressage score during competition and subsequently their risk of a horse fall during the cross-country.

Combinations competing in their first start as a partnership may have included experienced individual riders and horses who have not competed together before. These combinations may be more likely to exercise caution during their first event together due to a lack of familiarity. This highlights the potential importance of a well-established relationship between horse and rider, which riders have previously attributed to increased performance and reduced risk.[31]

5 | CONCLUSION

The study has identified 16 risk factors for horse falls during the cross-country phase of eventing in the UK. Eventing regulators and those in charge of safety at events are faced with a challenging task of mitigating horse falls and improving rider safety. Whilst it will be impossible to eliminate the risk of horse falls entirely, key recommendations can be drawn from this study. For example, a cap on dressage penalties or altered qualification requirements for progression through the competition levels may be beneficial for minimising the risk of horse falls. Further research on the time between starts is needed, as a mandatory out-of-competition period (such as used in equestrian endurance sport) could reduce the risk of horse falls, and subsequently the risk of injury/fatality. We propose that research in this field continues to adopt a 'marginal gains' approach to improving safety in the sport. Many small reductions to the risk of a horse-fall could ultimately be the difference between life and death.

6 | LIMITATIONS

A number of issues were noted with the quality of the data as outlined in Data S1. The study is limited by this loss of data with the reduction in cases likely having the largest effect on the results. It is therefore a possibility that risk factors presented in this study are underestimated. The study is not geographically comprehensive and thus aspects of horse/rider competition history may be absent from the data set. The data does not include any information on training activity of horses or riders, which may be beneficial to investigate in future in the context of horse falls.

AUTHOR CONTRIBUTIONS

Heather A. Cameron-Whytock contributed to study design, study execution, data analysis, interpretation, had full access to all the data in the study, responsible for data integrity and accuracy of the data analysis and wrote the article with input from all authors. Tim D. H. Parkin contributed to study design, study execution, data analysis and interpretation. Sarah J. Hobbs contributed to study design and study execution. Charlotte V. Brigden contributed to study design. Euan D. Bennet contributed to study execution, data analysis, interpretation and wrote the article with input from all authors.

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CONFLICT OF INTEREST STATEMENT

No competing interests to declare.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/evj.13934.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from British Eventing. Restrictions apply to the availability of these data, which were used under licence for this study.

ETHICS STATEMENT

The study was approved by UCLan Science, Technology, Engineering, Medicine and Health (STEMH) ethics committee, reference: STEMH 483. Date approved: 15.08.2016.

INFORMED CONSENT

Consent from riders and explicit owner informed consent for inclusion of animals in this study is not required by this journal. British Eventing supplied competition data.

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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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