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## Original Article

# Fédération Equestre Internationale endurance events: Risk factors for failure to qualify outcomes at the level of the horse, ride and rider (2010–2015)



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## ABSTRACT

An epidemiological study of elite endurance riding was conducted using data from every Fédération Equestre Internationale (FEI) endurance event from 2010 to 2015, comprising 82,917 starts. The aim of the study was to identify risk factors associated with failure to qualify outcomes for horses during FEI endurance rides. The FEI endurance rules state that, during a ride, horses must be assessed by veterinarians several times, giving veterinarians the opportunity to prevent those horses exhibiting signs of lameness or metabolic problems from continuing further. Multivariable logistic regression models were constructed to identify horse, ride and rider level risk factors associated with failure to qualify. Risk factors particularly associated with increased likelihood of failure to qualify due to lameness included age of horse  $\geq 9$  years, male horse, male rider, field size  $\geq 61$  horses and if the ride was held in region group II (Northern and Eastern Europe). Factors associated with increased likelihood of failure to qualify due to metabolic problems included whether the ride was held in region group VII (North Africa and the Middle East), ride distance  $\geq 100$  km and male rider. Some risk factors, such as field size, may be modifiable at the ride level. Other risk factors such as horse age or sex are unmodifiable, but awareness of the risk contributed by these factors can provide veterinarians with additional information while treating horses during endurance rides.

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## Introduction

Amongst equestrian sports, endurance riding has experienced one of the largest increases in popularity in recent years, but there has been anecdotal evidence that rates of horse injuries in this field are rising (Coombs and Fisher, 2012; Nagy et al., 2012). Several attempts to examine the underlying potential causes of horse eliminations have been carried out, including epidemiological studies (Nagy et al., 2010, 2014a,b; Fielding et al., 2011), examination of training regimens (Bolwell et al., 2015) and predictive modelling (Younes et al., 2015). Those in the industry suggest that the nature of some injuries experienced by horses has changed, with severity increasing as average riding speed records continued to be broken, although no in-depth epidemiological study of injuries in relation to riding speeds has been possible to date.

Despite this anecdotal information and reported increasing rates of elimination (Nagy et al., 2012), a study of endurance riding from 2008 to 2011 found no statistically significant increase over time in elimination for lameness or metabolic problems (Nagy et al., 2014a,b). However, the need for further investigation was identified, in particular relating to the average riding speeds of all horses. There is a consensus in the literature regarding the need for a large-scale, worldwide study which would inform targeted, more local studies (Nagy et al., 2010, 2014a,b; Fielding et al., 2011; Bolwell et al., 2015; Younes et al., 2015). The aim of this study was to analyse a global data set to determine risk factors for failure to qualify outcomes that affect endurance horses competing in Fédération Equestre Internationale (FEI) events. The primary hypothesis was that a combination of risk factors at the level of the horse, ride and rider would contribute to the overall risk level of every endurance horse start.

This paper is the first in a series of publications which will present epidemiological analyses of the Fédération Equestre Internationale (FEI) endurance data base and build predictive models for horse eliminations in Concours de Raid d'Endurance International (CEI) endurance rides worldwide. In

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**Table 1**  
Data on ride outcomes by region group.

Region group	Starts	Result	Retired	FTQ Lameness	FTQ Metabolic	Other
I	28,716	17,451	1543	6950	1235	1537
II	5881	3439	237	1522	281	402
III	929	566	40	206	69	48
IV	3050	2130	95	645	89	91
V	549	340	17	129	26	37
VI	12,978	7769	452	3200	873	684
VII	22,149	10,380	1850	5724	2272	1923
VIII	4014	2464	189	805	170	386
IX	4651	3358	142	779	141	231
Total	82,917	47,897	4565	19,960	5156	5339

FTQ, failure to qualify.

this paper, we will focus on risk factors that affect all horse starts recorded in the data base.

## Materials and methods

### Source and classification of data

The FEI Global Endurance data base contains a comprehensive record of every horse start in every CEI event worldwide. This study utilised data collected from 1st January 2010 to 31st December 2015, covering 82,917 horse starts and allowing detailed investigation of a large number of potential risk factors. The endurance data base is publicly available in a limited format; through a direct collaboration with the FEI, the authors obtained the raw data of the full data base, also known as the Global Endurance Injuries Survey (GEIS).

Each horse start in the data base has one of nine potential outcomes recorded: (1) result (R); the horse completed the ride safely, i.e. it passed the final veterinary gate (one of the 4–7 veterinary examinations that horses are subject to during an endurance ride); (2) retired (RET); the rider/trainer elected not to continue after successfully passing any veterinary gate during the ride; (3) disqualified (DSQ); the rider was disqualified for breach of rules; (4) eliminated (EL); the horse was eliminated during a loop (i.e. before a veterinary gate), usually accompanied by a reason and treated as a failure to qualify (FTQ) in the data base; (5) finished, not ranked (FNR); the horse completed the ride but took longer to finish than the specified time limit; (6) withdrawn (WD); the horse withdrew before the event start, or did not show up to the event; and (7) FTQ; the horse failed to pass a veterinary gate (usually accompanied with a subcategory indicating the nature of the FTQ; a small number of horses cannot be subcategorised, including horses eliminated for reasons such as saddle sores, minor cuts or injuries); (8) FTQ due to lameness (FTQ LA); a subcategory for FTQ, indicating that the reason for failure to qualify was an irregular gait observed while trotting, or other musculoskeletal injury discovered at a veterinary gate; and (9) FTQ due to metabolic problems (FTQ ME); a subcategory of FTQ, indicating that the reason for failure to qualify was a metabolic problem discovered at a veterinary gate e.g. heart rate above the limit set for the ride, dehydration, decreased intestinal activity or other clinical signs as specified by the FEI endurance rules. Reflecting the relative frequency of each outcome, the data were grouped into four categories: 'Result', 'Retired', 'Eliminations' and 'Other'. The category 'Eliminations' was split into two subcategories: 'Lameness' and 'Metabolic'. The category 'Other' included the outcomes DSQ, FNR and WD.

In addition to the ride outcomes described above, the data base records a wide variety of horse, rider and ride level factors. Potential risk factors included in the model were: (1) year (2010–2015); (2) region group; each group from I to IX is a geographical area as defined by the FEI,<sup>1</sup> approximately corresponding to Western/Southern Europe (I), Northern/Eastern Europe (II), Russia/Western Asia (III), North America (IV), Central America (V), South America (VI), North Africa/Middle East (VII), Oceania/Asia (VIII) and Sub-Saharan Africa (IX); (3) ride distance; the current endurance rules allow for a range of event distances, from 80 to 160 km; (4) field size; the number of horses starting each ride are not currently limited by regulations; four categories were used, corresponding to quartiles of the data (this approach was selected after testing different models with field size as a continuous and categorical variable); (5) horse sex; four are recorded (stallion, mare, gelding and male unknown); (6) horse age; defined as age on the day of the ride, with horses' deemed under FEI rules to have their birthday on 1 January; (7) rider gender; and (8) rider age.

### Model building and statistical analysis

A bespoke model building code was written in MATLAB 2016b (MathWorks) to fit a multivariable logistic regression to the data. The cohort examined was every

horse start in FEI competitions worldwide from 1st January 2010 to 31st December 2015, representing a total of 82,917 horse starts. Two deleterious outcomes were assessed: (1) FTQ due to lameness (FTQ LA); and (2) FTQ due to metabolic problems (FTQ ME).

The first stage in model building was to fit univariable models for each potential risk factor. Risk factors with a *P* value < 0.2 were considered for inclusion in the final multivariable model. These risk factors were allowed to progress into a forward adding multivariable model using Akaike's Information Criterion to determine acceptance or rejection into the final model. Risk factors with *P* values < 0.05 in the final multivariable model were considered to be significant and were retained for analysis.

Risk factors rejected at the univariable and multivariable stage were tested for confounding in the final model. The goodness-of-fit of the model was assessed using the Hosmer–Lemeshow test. Biologically plausible combinations of risk factors were tested for second order interaction and were included in the final model. The final model was tested with horse starts as a random effect to examine any potential for horse-level clustering.

## Results

### Descriptive statistics

Table 1 shows the elimination data for each of the nine region groups. The global mean  $\pm$  standard deviation (SD) completion rate (i.e. the mean of the nine region group completion rates) was  $61.4 \pm 7.1\%$ . Two thirds of region groups had a completion rate within 1 SD of the global mean; the exceptions were region groups IV (69.8%), VII (46.9%) and IX (72.2%).

The global mean  $\pm$  SD rate of FTQ for lameness was  $22.7 \pm 3\%$ ; most region groups were within one SD of the mean, the exceptions being regions II (25.9%) and VII (25.8%). The global mean  $\pm$  SD rate of FTQ for metabolic problems was  $5.4 \pm 2.4\%$ ; seven region groups were within one SD of the global mean, the two exceptions being region groups IV (2.9%) and VII (10.3%).

The mean  $\pm$  SD of the completion rates for each of the six years from 2010 to 2015 was  $57.8 \pm 0.8\%$ . Therefore, variations between region groups were proportionately much larger than variations by year. The region groups with the largest variation by year (III, IV and V) were also those with the fewest horse starts per year. The completion rates for region group VII were consistently above the mean, while region group IX were consistently below it. For each of the last three years studied (2013–2015), rates of elimination by FTQ increased and the associated odds ratio (OR) also increased (from 2014 to 2015 for FTQ LA and from 2013 to 2015 for FTQ ME); these increases were statistically significant according to the *t* test, with *P* < 0.05.

Ride distances were predominantly one of three categories; 32% of horse starts were in 80 km rides, while 38% of starts were in 120 km rides and 11% were in 160 km rides. There was large variation in the field sizes recorded, from a minimum of one (a single horse competing in the ride) to a maximum of 284. The median field size was 30 horses and the interquartile range was 47. The only statistically significant difference for horse sex was found between a binary coding of 'stallion' and 'not stallion'. The median horse age was 9 years and the interquartile range was 3 years. The

<sup>1</sup> See: <https://data.fei.org/NFPages/NF/Search> (accessed 27th July 2017).

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