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Original Article

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

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Highlights

- A large epidemiological investigation of Fédération Equestre Internationale (FEI) endurance rides worldwide was performed.
- Significant risk factors for lameness and metabolic problems affecting horses in endurance rides were identified.
- The most notable risk factors for failure to qualify due to lameness were field size, horse sex and horse age.
- The most notable risk factors for failure to qualify due to metabolic problems were ride distance, region group and rider gender.

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 ≥ 9 years, male horse, male rider, field size ≥ 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 ≥ 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.

Keywords: Equine; Endurance; Failure to Qualify; Metabolic; Lameness

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., 2014). 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 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 1 January 2010 to 31 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-IX is a geographical area as defined by the

FEI[1] , 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 1 January 2010 to 31 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.

[1] See: https://data.fei.org/NFPages/NF/Search (accessed 27 July 2017).

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 ± standard deviation (SD) completion rate (i.e. the mean of the nine region group completion rates) was 61.4 ± 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 ± SD rate of FTQ for lameness was 22.7 ± 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 ± SD rate of FTQ for metabolic problems was 5.4 ± 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 ± SD of the completion rates for each of the six years from 2010 to 2015 was 57.8 ± 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 2014-2015 for FTQ LA and from 2013-2015 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 median rider age was 27 years and the interquartile range was 18 years. No significant associations were found between rider age and any of the outcomes studied.

Failure to qualify due to lameness outcomes

Table 2 shows the final significant ($P < 0.05$) results for horse starts resulting in an FTQ LA outcome. Compared to the most recent year studied (2015), associations were found between increased odds (OR 1.1) of FTQ LA and horse starts in 2010. Horse starts in 2014 were associated with reduced odds (OR 0.93) relative to horse starts in 2015. Compared to horse starts in region group I, associations were found between horse starts in region groups IV, VII, VIII and IX, and decreased odds of FTQ LA. Rides in region group II were associated with increased odds of FTQ LA (OR 1.11).

Compared to ride distances of 80 km, an association was found between 90 km rides and reduced odds of FTQ LA (OR 0.81). Ride distances of 120 km were associated with increased odds of FTQ LA (OR 1.08). Compared to field sizes of < 16 horses, field sizes of 31-61 horses (OR 1.17) and > 61 horses (OR 1.27) were associated with increased odds of FTQ LA. Stallions were associated with increased odds (OR 1.12) compared to non-stallions. Compared to horses aged < 7 years, horses aged 7-9 (OR 1.16), 9-11 (OR 1.21) and >11 years (OR 1.3) were associated with increased odds of FTQ LA.

Interactions terms that were significant and retained in the final model were region group VII with ride distance 120 km (OR 1.07), region group VII with field size > 61 (OR 0.84), region group VII with age > 11 years (OR 1.10) and 120 km with male rider (OR 1.18).

Failure to qualify due to metabolic problems

Table 3 shows the final significant ($P < 0.05$) results for horse starts resulting in an FTQ ME outcome. Compared to horse starts in 2015, associations were found between starts in 2010 and 2013, and decreased odds of FTQ ME (OR 0.87 for both years). Compared to horse starts in region group I, an association was found between horse starts in region group VII and increased odds of FTQ ME (OR 2.04). Horse starts in region groups IV (OR 0.6), VIII (OR 0.85) and IX (OR 0.54) were associated with decreased odds of FTQ ME.

In the ride distance category, compared to 80 km ride distances, an association was found between 90 km rides and lower odds of FTQ ME (OR 0.77). All distances > 90 km were associated with greater odds of FTQ ME, i.e. 100 km (OR 1.69), 110 km (OR 1.83), 120 km (OR 1.45) and 160 km (OR 1.76). Horses with male riders were at greater odds of FTQ ME (OR 1.82) compared to horses with female riders.

Five biologically plausible second order interactions terms remained in the final model, providing a range of additional effects for certain combinations of risk factors. Field size was not retained in the final model as a risk factor alone, but interactions between large field size and ride distance were retained, with an OR of 2.1 in 120 km rides and 3.79 in 160 km rides.

Post-model analysis

No significant impact of confounding was found for any of the rejected risk factors. No evidence of a lack of fit to the data for any of the three outcomes was found. In testing the impact of the horse as a random effect, with 22,625 unique horses in the data base and 82,917 horse starts, the median number of horse starts per individual horse was three. The proportion of variance (ρ) associated with individual horses was $\rho = 0.09$, suggesting that individual horses had no significant impact on overall variance in the model.

Discussion

Our results show that endurance riding distances of 100 and 110 km have increased OR associated with FTQ ME outcomes compared to 80 km rides, despite very low competition numbers in those categories compared to 80, 120 and 160 km ride distances. Associations between longer distances and increased odds of musculoskeletal injury have been demonstrated, for example, in Thoroughbred flat racing in the UK (Parkin et al., 2004), Australia (Boden et al., 2007) and New Zealand (Perkins et al., 2005). Parkin et al. (2004) hypothesised that longer ride distances meant horses spent more time exposed to risk. For all negative outcomes in the present study, ride distances of 120 km were at increased odds compared to 80 km rides. Ride distances of 160 km were associated with increased odds of FTQ ME outcomes, but no significant association was found for FTQ LA outcomes. This suggests that the hypothesis of longer ride being associated with more time exposed to risk factors does not completely explain the results. Some unmeasured risk factor(s) not included in this study may explain why the odds of FTQ LA were increased by distance up to but not beyond 120 km. One example of such a factor could be riding speed, given that the data base shows that the average riding speed in 120 km rides was faster than those in 160 km rides. It could also be hypothesised that the step-up in level of fatigue accumulated over the course of a 160 km ride compared to a 120 km ride could have contributed disproportionately to FTQ ME outcomes. It could even be the case that, regardless of other factors, riding over distances as long as 160 km is beyond the physiological capabilities of some horses, if they were unprepared for the physical demand of riding that distance.

In large fields, horses could be more likely to be pushed harder by their rider to get ahead of the pack or keep up with ride leaders. A subset of horses could experience injury from collision or close proximity to many other horses while riding. This sort of association has been demonstrated previously in Thoroughbred flat racing (Parkin et al., 2004).

Increased odds of FTQ LA for stallions compared to mares and geldings have also been demonstrated previously in Thoroughbred flat racing in Australia (Boden et al., 2007), New Zealand (Perkins et al., 2005) and North America (Estberg et al., 1996, 1998; Hernandez et al., 2001). However, most hypotheses, such as increased levels of testosterone or greater muscle mass, that have been used to potentially explain these results may or may not apply to endurance horses in the same way.

There are several reasons that could contribute to the increased odds of FTQ LA for older horses compared to young horses. Older horses with an extensive ride history could develop subclinical or undetected pathology, which may manifest as an accumulation of bone and tendon damage, increasing the likelihood of bone or soft-tissue related injuries (Estberg et al., 1996, 1998; Williams et al., 2001; Parkin et al., 2005; Henley et al., 2006). Martig et al. (2014) provided a review of accumulated damage over time affecting older Thoroughbreds. Many of the underlying physical processes apply to endurance horses. Older dressage horses have also been found to be at increased risk of lameness compared to younger horses (Murray et al., 2010).

Three major risk factors (or groups of risk factors) stand out for FTQ ME outcomes in particular: (1) region group VII, where horses are more than twice as likely to experience an FTQ ME than horses in region group I; this is likely to be due to particular circumstances of rides in that particular part of the world, for example, the flat terrain and extreme climatic conditions; (2) horses ridden by male riders, who are 84% more likely to experience an FTQ ME than horses with female riders; the reasons for this remain unclear; and (3) ride distances > 90 km; as with FTQ LA outcomes, this is most likely due to the increased time at risk associated with increased distances (Parkin et. al.; 2014).

Previous studies (Nagy et al., 2010, 2014a) also found that horse starts with longer ride distances, larger field sizes and in region group VII were potential risk factors which contributed to the greatest odds of FTQ. Independent studies arriving at the same conclusions enable greater confidence in those particular findings and the likelihood that they are truly associated with the outcomes of interest.

While the FEI endurance data base contains comprehensive details of every horse start in FEI events over the period covered, some limitations apply to the data set. Individual horses must successfully complete at least three National Federation level rides before being eligible to participate in any CEI rides. The data base does not contain information about any National Federation endurance rides. Furthermore, the data base contains no information about training regimens of endurance horses and therefore we were unable to investigate the risk factors related to training, such as those reported by Bolwell et al. (2015).

Conclusions

The results of this multivariable model point towards potential underlying causes of elimination due to lameness and metabolic problems experienced by endurance horses. Some risk factors, such as field size, age and distance, may be modifiable if the behaviour of organisers, riders and trainers is also modifiable. Other factors, such as year, region group and rider gender, would be difficult to modify; however, by quantifying the influences these have on the likelihood of deleterious outcomes, we can move a step closer to fully understanding the risks involved for horses during endurance rides.

Conflict of interest statement

None of the authors of this paper have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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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.

Table 2
Data of the multivariable model, with the significant (*P* < 0.05) risk factors affecting all horse starts, for Failure to qualify due to lameness (FTQ LA) outcomes only.

FTQ LA outcomes	Cases	Controls	OR	95% CI	*P* value
Year					
2010	3396	9865	1.1	1.05-1.14	< 0.001
2014	3044	10,447	0.93	0.89-0.98	0.003
2015	3287	10,286	Reference	-	-
Region group					
I	6950	21,766	Reference	-	-
II	1522	4359	1.11	1.05-1.18	0.002
IV	645	2405	0.86	0.76-0.95	0.001
VII	5724	16,425	0.77	0.64-0.89	< 0.001
VIII	805	3209	0.79	0.71-0.88	< 0.001
IX	779	3872	0.59	0.51-0.68	< 0.001
Ride distance (km)					
80	5299	21,593	Reference	-	-
90	1646	6640	0.81	0.75-0.87	< 0.001
120	8518	23,085	1.08	1.03-1.14	0.006
Field size					
< 16	4419	16,617	Reference	-	-
31-61	5219	15,001	1.17	1.13-1.21	< 0.001
> 61	5427	15,381	1.27	1.2-1.34	< 0.001
Horse sex					
Not stallion	18,590	59,180	Reference	-	-
Stallion	1370	3777	1.12	1.06-1.19	< 0.001
Horse age (years)					
< 7	800	3353	Reference	-	-
7-9	6510	21,682	1.16	1.08-1.25	< 0.001
9-11	8051	25,018	1.21	1.13-1.3	< 0.001
> 11	4599	12,904	1.3	1.21-1.39	< 0.001
Interactions terms					
Group VII x 120 km	2990	6647	1.29	1.2-1.38	< 0.001
Group VII x Field > 61	3641	10,471	0.86	0.78-0.95	< 0.001
Group VII x Age > 11	1779	4469	1.1	1.02-1.18	0.025
120 km x Male rider	5463	13,495	1.09	1.02-1.16	0.02

OR, odds ratio; 95% CI, 95% confidence interval.

Table 3
Data of the multivariable model, with the significant ($P < 0.05$) risk factors affecting all horse starts, for Failure to qualify due to metabolic problems (FTG ME) outcomes only.

FTQ ME outcomes	Cases	Controls	OR	95% CI	*P* value
Year					
2010	754	12,507	0.87	0.79-0.95	< 0.001
2013	758	12,732	0.87	0.78-0.95	< 0.001
2015	892	12,681	Reference	-	-
Region group					
I	1235	27,481	Reference	-	-
IV	89	2961	0.6	0.38-0.81	< 0.001
VII	2272	19,877	2.04	1.95-2.13	< 0.001
VIII	170	3844	0.85	0.69-1.01	0.041
IX	141	4510	0.54	0.36-0.72	< 0.001
Ride distance (km)					
80	1283	25,609	Reference	-	-
90	269	8017	0.77	0.63-0.9	< 0.001
100	364	2958	1.69	1.56-1.82	< 0.001
110	29	273	1.83	1.44-2.22	0.003
120	2411	29,192	1.45	1.37-1.54	< 0.001
160	627	8308	1.76	1.6-1.93	< 0.001
Rider gender					
Female	1305	32,642	Reference	-	-
Male	3851	45,119	1.82	1.74-1.91	< 0.001
Interactions terms					
Group VII x Field > 61	1229	12,883	0.68	0.52-0.85	< 0.001
120 km x Field > 61	856	8021	1.45	1.31-1.59	< 0.001
160 km x Field > 61	269	2470	1.87	1.63-2.1	< 0.001
160 km x Male Rider	384	4356	0.73	0.54-0.92	0.001
Field > 61 x Male rider	1315	14,348	0.79	0.62-0.96	0.006

OR, odds ratio; 95% CI, 95% confidence interval.