The association between clinical parameters recorded at vet gates during Fédération Equestre Internationale (FEI) endurance rides and the imminent risk of elimination

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Authors' declaration of interests

No competing interests have been declared.

Ethical animal research

This work was conducted as part of an agreement with the FEI, who fund EB. The FEI Veterinary Committee approved the study protocol and the FEI gave explicit informed consent for publication of these data.

Owner informed consent

Not applicable.

Data accessibility statement

The data that support the findings of this study are available from the FEI. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the corresponding author with the permission of the FEI.

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Authorship

T. Parkin contributed to study design, data analysis and interpretation, and preparation of the manuscript. E. Bennet contributed to study design, study execution, data analysis and interpretation, and preparation of the manuscript. M. Hayes contributed to study execution and data analysis and interpretation. L. Friend contributed to study execution. All authors gave their final approval of the manuscript.

Summary

Background: Endurance competitions over distances of 80 to 160km are required by Fédération Equestre Internationale (FEI) rules to be divided into between three and six stages, known as “loops”. Veterinary inpections, designed to ensure horse welfare, are conducted at the end of each loop, with details recorded on a separate “vet card” for each horse.

Objectives: To identify risk factors recorded on vet cards that were associated with elimination at subsequent loops.

Study design: Retrospective cohort

Methods: Data relating to 3,213 horse starts worldwide in international (CEI) events during 2014 were analysed. Descriptive statistics and univariable logistic regression to identify risk factors for potential inclusion in the final multivariable logistic regression models. Models were constructed stepwise using backwards-removal and assessed using the Bayesian information criterion.

Results: Risk factors were identified, which would allow an “in-ride” risk profile to be constructed for each horse which evolves as the horse progresses through the ride. Some risk factors such as abnormal gait and high heart rate were found to be repeatedly associated with imminent failure to qualify.

Main limitations: This is a relatively small study in terms of cohort size, based on the data that were available at the time of the study. Although comprehensive ride history data were also available for each horse via the main FEI database, training data was not.

Conclusions: By identifying risk factors observed during the veterinary inspections at the end of a loop that are strongly associated with elimination at the end of the next or subsequent loops, these results provide an evidence-base for educational initiatives and regulatory changes that will inform the way veterinary delegates use veterinary inspections to help identify horses at risk of imminent FTQ.

Introduction

The Fédération Equestre Internationale (FEI) equestrian discipline of endurance is a challenging sport of long-distance riding. At international level (Concours de Raid d'Endurance Internationale [CEI]) single-day rides cover distances between 80km and 160km. The welfare of the horse is the primary focus of the rules and regulations of competition, and one fundamental rule relates to course design: endurance rides must consist of several phases known as "loops", each of which must be between 16km and 40km [1]. The minimum number of loops, determined by the total distance of the ride, is between three and six. Horses are assessed at veterinary inspections before the ride, at the end of each loop and after completion of the final loop. If a horse does not pass a veterinary inspection, they are automatically eliminated from the competition. In those instances, the outcome "Failure to Qualify (FTQ)" is assigned, usually with a subcategory indicating the nature of the FTQ. The subcategories are broad in definition but can be summarised as "irregular gait" (FTQ GA) and "metabolic problems" (FTQ ME) [1].

FTQ GA outcomes generally indicate that the horse was eliminated because it had irregular gait or was observed to be lame during the vet inspection. FTQ ME outcomes indicate that the horse was eliminated because it was showing signs of exhaustion, dehydration, substrate depletion, heat accumulation, or other metabolic problems – symptoms of which would have been detected by vets during clinical investigation of horses' conditions. The intent behind these rules is to protect the welfare of the horse and ensure that early intervention is made, before serious injuries or metabolic problems occur.

Recent epidemiological studies of endurance horses have identified several risk factors that in principle could be used to start building a "risk profile" of an individual horse before and even during competition [2-9]. The focus of this study is the identification of intra-ride veterinary inspection related risk factors that may be used to better identify horses at <u>imminent</u> (i.e. during the rest of the current ride) risk of FTQ. This study is the first of its kind in endurance, but a similar study in Thoroughbred racing found an association between pre-race veterinary inspection parameters and likelihood of catastrophic injury [10]

Materials and methods

The data used in this retrospective cohort study were collected as part of a FEI pilot study, then combined and cross-referenced with data from the FEI's global endurance database [11]. The main database is publicly available in a reduced form, but through direct collaboration with the FEI we had access to the full raw database. The pilot study gathered hard copy veterinary cards that were completed during the pre-ride, post-loop, and final veterinary inspections for 3,213 horse starts made by 2,583 horses in 347 CEI rides during 2014. The number of unique riders amongst the cohort was 2,055. These records were digitised and the data for pre-ride, loop 1, loop 2, and loop 3 veterinary inspections extracted. Most rides included no more than four loops and the number of horses completing more than three loops gradually diminished such that any attempt to identify risk factors for imminent FTQ (associated with veterinary inspections after loop 4) were significantly compromised by a lack of statistical power.

At each post-loop veterinary inspection the horse first has to pass through a heart rate (HR) check within 20 minutes of completing the loop. The HR of the horse must be no higher than 64 beats per minute (bpm) to be allowed to pass to the second part of the veterinary inspection. A horse with a HR higher than 64 bpm can take an additional rest and then return again to the vet gate. The total time allowed to pass the HR check is 20 minutes from the end of the ridden loop, apart from the final veterinary inspection for which 30 minutes is permitted. If at that second presentation the HR is still greater than 64 bpm the horse is eliminated with an FTQ ME. Once a horse passes the HR check the following clinical parameters are assessed: gait; mucous membranes; skin turgor; capillary refill time; gut sounds; and girth, back, and withers soreness. Each is graded on a scale from 1-4 (or A-D) with 1(A) representing a horse in 'sound/good health' and 4(D) representing a horse in 'significantly lame/very poor health'. Clear definitions of exactly what each grade for each parameter implies are not readily available. However, guidance and definitions from a course provided for FEI1* endurance vets is included in supplementary item 1 (personal communication Drs Martha Misheff and Sarah Coombs). Horses with a gait score of 3 or 4 at any inspection are immediately eliminated with an FTQ GA. A combination of the scores for the other clinical parameters are used to decide on the metabolic status of the horse, thus informing whether the horse should be subject to an FTQ ME or allowed to continue in the ride.

Towards the end of 2013, FEI veterinary delegates were asked to send all veterinary cards to the FEI Veterinary Department (as required by the rules of Endurance). During 2014, 3,213 (24% of all veterinary cards for that year) were sent to the FEI and subsequently made available for this study. The percentage of veterinary cards returned to the FEI Veterinary Department in 2014, by region group is provided in Table 1. The full records for these 3,213 horse starts in the main FEI global endurance database were identified and reconciled with the data from the veterinary cards.

A total of six multivariable logistic regression models were built, for the following outcomes: FTQ GA at the end of Loop 1, Loop 2, and Loop 3; and FTQ ME at the end of Loop 1, Loop 2, and Loop 3. Each model contained risk factors relating to each horse/rider and "in event" data up to the end of the previous phase of competition. For example, the model for FTQ GA at the end of Loop 2 contained the age and sex of both horse and rider, riding speed during loop 1, and veterinary examination data from the pre-ride and end of loop 1 veterinary inspections. Models were developed to provide a, potentially predictive, risk profile for each horse as it progressed through each ride. Table 2 shows potential risk factors available for inclusion at the start of each analysis.

Each model was constructed using the same process in a bespoke code written using MATLAB 2018b (MathWorks): a univariable model was created for each outcome for each of the risk factors in Table 2, with a cut-off of $p<0.2$ used to determine candidates for the final model. Multivariable models were built using a backwards-removing iterative process with the Bayesian information criterion used to assess fit at each step. The final models contained only those risk factors with a p-value of less than 0.05. Biologically-plausible interactions were considered at the multivariable stage. Risk factors rejected at both the univariable and multivariable stages were tested for confounding in the final models. Confounding was considered to be present if inclusion of the confouinding variable altered coeeficients of existing variables by more than 30% [12]. Hosmer-Lemeshow goodness of fit tests were used to identify any evidence of a lack of fit of the data to the final models [13]. Residuals were examined to confirm normality and those residuals identified as ouitwith the norm were removed and models refit to identify any excessive influence on final models. Horse- and athlete-level clustering was examined by including horse or athlete ID as a random effect in each of the final multivariable models.

Given that six different models were developed a simple power calculation encompassing all six analyses is meaningless. Nevertheless, once the initial descriptive analyses were conducted which identified as few as 15 cases of FTQ ME at the end of loop 1 and as many as 290 cases of FTQ GA at the end of loop 2 (out of between approximately 2,500 and 3,000 horses at risk at the start of each loop) a series of power calculations were conducted (assuming 20% exposure in the control group): These suggested that for all FTQ GA outcomes these analyses would have sufficient power (at least 80%) with 95% confidence, to identify odds ratios of between 1.5 and 1.7. For the FTQ ME outcomes this sample size is somewhat limited suggesting these analyses would only be able to identify, with confidence, odds ratios of between 2 and 4. In reality the analysis for FTQ ME at the end of loop 1 (15 cases), and possibly loop 2 (43 cases), is underpowered so those results in particular should be interpreted with some caution.

Results

The total number of horse starts included in the analyses was as follows: 3,116 in models for loop 1 outcomes; 2,848 in models for loop 2 outcomes; and 2,438 in models for loop 3 outcomes. The reduction in numbers at each loop reflects the fact that some horses were eliminated before reaching that stage of the ride. At the end of each loop a very small number of horses were voluntarily retired from the ride – these werecounted as controls for the loop in which they retired (as they had successfully completed the loop and passed the vet inspection).A total of 3,172 horses completed loop 1 and were subject to veterinary inspection at the end of that loop. Of these 2,910 (91.7%) passed that veterinary inspection and continued; 56 (1.8%) passed but were voluntarily retired; 167 (5.3%) horses ended the ride at that point with an FTQ GA, 15 (0.5%) horses ended the ride at that point with a FTQ ME, and 24 (0.8%) were either disqualified or eliminated without a specific recorded reason. Of the 2,909 horses that completed loop 2 and were subject to veterinary inspection at the end of that loop, 2,485 (85.4%) passed and continued, 61 (2.1%) passed and retired, 290 (10.0%) ended the ride at that point with a FTQ GA, 43 (1.5%) with FTQ ME, and 30 (1.0%) were either disqualified or eliminated without a specific recorded reason. Of the 2,481 horses that completed loop 3 and were subject to veterinary inspection at the end of that loop, 2,120 (85.4%) passed and continued, 43 (1.7%) retired, 203 (8.2%) horses ended the ride at that point with a FTQ GA,78 (3.1%)

with FTQ ME, and 37 (1.5%) disqualified or eliminated for an unrecorded reason. Results of the six multivariable models are shown in Table 3 (FTQ GA outcomes) and Table 4 (FTQ ME outcomes). For a small minority (<1%) of veterinary cards, some clinical data relating to particular parts of the inspection were absent,and were treated as being in the reference category for the relevant risk factor.

FTQ GA at the end of loop 1

Two significant risk factors were retained in this final model: the first was rider age with an odds ratio (OR) of 1.01 per additional year (95% confidence interval (95%CI) 1.00 – 1.02; p = 0.03). The horses' gait, as assessed at the pre-ride veterinary inspection, was also significantly associated with the likelihood of FTQ GA at the end of loop 1. Compared with horses rated as "1" at that check, horses rated "2" were more likely to be designated FTQ GA at the end of loop 1 (OR 2.09; 95% CI 1.34 – 3.27; p = 0.001).

FTQ GA at the end of loop 2

Compared with horses rated "1" for gait at the veterinary inspection at the end of loop 1, horses rated "2" were at significantly increased odds of an FTQ GA outcome at the end of loop 2 (OR 2.71; 95% CI 2.04 – 3.59; and p<0.001).

FTQ GA at the end of loop 3

Compared with horses whose mucous membranes were assessed at the pre-ride veterinary inspection as '1' horses, with mucous membranes assessed at the pre-ride inspection as "2" or above were at reduced odds of FTQ GA at the end of loop 3 (OR 0.31; 95% CI 0.12 – 0.76; p=0.01). Horses with gut sounds assessed as "2" or above at the veterinary inspection at the end of loop 2 were also at reduced odds (compared with horses assessed as "1") of FTQ GA at the end of loop 3 (OR 0.60; CI 0.43 – 0.84; 0.003). In contrast, horses whose capillary refill time was assessed as "2" or above at the veterinary inspection at the end of loop 1 (compared with horses assessed as "1") were at increased odds of FTQ GA at the end of loop 3, (OR 1.43, CI 1.05 – 1.94, p=0.02). Finally, horses assessed at the veterinary inspection at the end of loop 2 as having a gait score of "2" were more likely to be desigated as FTQ GA at the end of loop 3 compared with horses with a gait score of “1” at the veterinary inspection at the end of loop 2 (OR 2.49; CI 1.82 – 3.40; p<0.001).

FTQ ME at the end of Loop 1

Compared with horses with a ‘girth, back and withers soreness score’ of ‘1’ at the pre-ride veterinary inspection, those with a pre-ride score for their ‘girth, back, and withers soreness score’ of “2” or above were at significantly increased odds of being designated FTQ ME at the end of loop 1 (OR 7.72; 95% CI 2.14 – 27.81; p=0.002).

FTQ ME at the end of Loop 2

Horses with male riders were at increased odds of FTQ ME at the end of loop 2 (OR 2.14; 95% CI 1.12 – 4.11; p=0.022). Horses who initially presented at the veterinary inspection at the end of loop 1 with a heart rate of more than 64bpm were more likely to be designated as FTQ ME at the end of loop 2, compared with those who initally presented with a heart rate of 64bpm or lower at the veterinary inspection at the end of loop 1 (OR 3.6; 95% CI 1.37 – 9.49; p=0.01). Horses with a mucous membrane score of “2” or above at the veterinary inspection at the end of in loop 1 were at increased odds of FTQ ME at the end of loop 2 compared with those with a mucous membrane score of “1” at the end of loop 1 (OR 2.31; CI 1.25 – 4.27; p=0.007).

FTQ ME at the end of Loop 3

Average riding speed in loop 1 was found to be associated with the likelihood of FTQ ME at the end of loop 3. For each additional km/h of average speed, the likelihood of FTQ ME increased by 14% (OR 1.14; CI 1.07 – 1.22; p<0.001). Horses with a gut sounds score of “2” or above at the veterinary inspection at the end of loop 1 were at increased odds of FTQ ME at the end of loop 3 compared to those horses with a gut sounds score of “1” (OR 1.79; CI 1.09 - 2.96; p=0.02). Horses whose average speed in loop 2 increased by more than 20% compared to loop 1 were more likely to end loop 3 with a FTQ ME compared to those horses whose loop 1 and loop 2 speeds were more consistent or those who slowed down in loop 2 (OR 2.86; CI 1.09 – 7.53; p=0.03). Horses that initially presented at the veterinary inspection at the end of loop 2 with a heart rate of more than 60bpm were at increased odds of FTQ ME at the end of loop 3 (OR 1.66; CI 1.05 – 2.63; p=0.03) compared to horses that first presented with heart rate of 60bpm or less. During the initial assessment of this variable a significantly increased risk of FTQ ME was found if the heart rate was between 60 and 64 bpm (OR 1.78; CI 1.11 – 2.85; p=0.002), and there was a non-statistically significant increase in risk for horses with initial heart rate greater than 64bpm (OR 2.08; CI 0.78 – 5.54; p=0.1). Horses with a skin turgor score of “2” or above at the veterinary inspection at the end of loop 2 were more likely to end the ride with an FTQ ME at the end of loop 3 compared with those with a skin turgor score of “1” at the veterinary inspection at the end of loop 2 (OR 1.95; CI 1.23 – 3.09; p=0.005).

Interactions terms not statistically significant in any of the models nor did they improve the fit of any model. No evidence of significant horse- or athlete-level clustering was found in any of the six models, indicating that the variance in any of the outcomes modelled was not significantly associated with either horse or athete. No evidence of a lack of fit was found for any of the models and reintroduction of potential confounders into final models did not significantly alter coefficients within the models. Assessments of residuals indicated no indication of excessive influence on the variables retained within the final models or their associated coefficients.

Discussion

Minimising the risk to endurance horses is one of the primary goals of the rules and regulations governing the sport. This study is the first to combine detailed veterinary inspection data gathered during a ride with the large-scale global FEI database. A previous study of significantly smaller scale focussed ona single ride of 53 horses to examine which clinical parameters were associated with elimination [3]. The present study examined all clinical parameters recorded as part of end of loop veterinary inspections, along with individual information about both horse and rider and demonstrated that several of those clinical parameters are predictive of imminent FTQ GA or FTQ ME.

Lameness is the most common cause of elimination from endurance competition [6-9]. Several risk factors have previously been demonstrated to be associated with FTQ GA outcomes, including sex of horse and rider, age of the horse, field size, location of the event, and the average riding speed of the horse [6, 7]. Gait scores are assessed by veterinarians who observe the horse trot along a flat, solid surface. The likelihood of FTQ GA at the end of loops 1, 2 and 3, was consistently associated with a horse’s gait score at the previous veterinary inspection. In other words horses with a gait score of “2” at the pre-ride exam were more likely to be eliminated with a FTQ GA at the end of loop 1 than horses with a score of "1" at the pre-ride exam. Very similar associations were found between the end of loop 1 and loop 2 inspections and the likelihood of FTQ GA outcomes at the end of loop 2 and loop 3, respectively. The consistency of this finding from loop to loop is important as it provides greater confidence to veterinary surgeons making decisions about whether to eliminate a horse with an FTQ GA. In particular, the knowledge that horses assessed with a gait score of '2' at the end of one loop are more likely to end the ride at the end of the next loop should encourage veterinary surgeons assessing horses as perhaps border-line '2' or '3' on gait score to err on the side of caution and eliminate them at that earlier veterinary inspection, potentially preventing them from sustaining a more serious lameness-related injury later in the ride. Alternatively, horses assessed with a gait score of '2' could be required to re-present within a certain time limit, similar to the existing rules for horses with high heart rate.

Three further clinical variables (mucous membranes pre-ride, capillary refill time at the end of loop 1, and gut sounds at the end of loop 2) were associated with the likelihood of FTQ GA at the end of loop 3. All three form part of the assessment of the metabolic status of the horse and as such the two variables that demonstrated a reduced risk of FTQ GA if they were scored higher (Pre-ride mucous membranes and end of loop 2 gut sounds) are more easy to understand. Very few horses end a ride with both an FTQ GA and FTQ ME, suggesting that there is some degree of 'competing risk' present in this situation, in that horses at greater risk of FTQ ME may be at lower risk of FTQ GA and vice-versa. This is likely to be the case if the performance or speed of the horse at greater risk of one type of FTQ is compromised such that their risk of sustaining the other type of FTQ is reduced. For example: A horse is at the end of loop 2 and starts to show mild signs of metabolic problems, but the vet passes the horse to go out on the next loop. The horse continues to worsen with perhaps increased, but maybe just mild metabolic signs that do not warrant FTQ ME. However, because it is showing these symptoms it is perhaps not riding to the best of its ability or speed. Because it is not riding at 'top speed' and because we know speed is associated with risk of FTQ, it is therefore less likely to end up with an FTQ GA.

However, the association between an increased score on capillary refill time at the end of loop 1 and an increased risk of FTQ GA at the end of loop 3 is more difficult to explain. Although not a particularly satisfactory conclusion, it may be that this is genuinely a 'chance' finding. As such it is important that this, alongside all other findings in this study, are replicated in a larger-scale analyses once an easier system to collect veterinary inspection data from all FEI endurance rides is established. The authors view this initial study as important evidence that should be used to demonstrate the true potential value of collection and analysis of these veterinary gate data by the FEI for all Endurance rides in the future.

Finally, older riders were more likely to end a ride with a horse designated as FTQ GA at the end of loop 1. The risk of FTQ GA at the end of loop 1 increased by approximately 1% for every extra year of age. Given that an association between rider age and elimination was not identified in the previous much larger scale analysis of risk factors (that did not include veterinary inspection parameters), it may be the case that this finding is peculiar to this particular data set alone [6, 7].

The association between heart rate at the previous veterinary inspection and FTQ ME outcome at the end of loops 2 and 3 is important in that it suggests that it may be possible to identify horses at greater risk of a metabolic problem well before they actually end up with an FTQ ME. These results have been used as evidence to design new regulations for Endurance linked to heart rate at initial presentation at the veterinary gate. From the first veterinary gate after the half-way point in a ride or from the third veterinary gate onwards (which ever comes first) a horse presenting with an initial heart rate over 68 beats per minute will be compelled to undergo a further veterinary inspection before being allowed to start the next loop. These rules werevoted upon at the FEI General Assembly in November 2019, and will be coming into force by July 2020.

Clinical assessment of mucous membranes, gut sounds, skin turgor, and girth, back, and withers soreness all form part of the veterinary inspection to decide whether a horse should be eliminated with an FTQ ME. The results reported here suggest that these clinical assessments are all somewhat indicative that a horse will at some point further on during the ride end up being designated with an FTQ ME. This shows the value of measuring these parameters and should be further motivation to encourage much better compliance with the current regulations that require the return of veterinary cards to the FEI at the end of an FEI Endurance competition – along with specific definitions of severity for each clinical measure and guidance to ensure consistency in completion of the vet cards across all events. Having said that, the current format of these veterinary cards (i.e. on card or paper) is not conducive to their further use once at the FEI HQ. It is therefore important that the FEI Veterinary Department consider ways in which these data can be collected in digital format and immediately uploaded to an FEI database. It has previously been reported that skin turgor is not a reliable indicator of dehydration in horses [14] which suggests that any change in data collection protocol should follow a review of which parameters should be included and how they are graded.

The FEI Endurance rules [1] specify that the pre-ride veterinary exam must take place either on the day of the ride or the day before. The vet cards used in this study did not record the date of the pre-ride exam, but we would suggest that the time and date of this exam would be a useful addition to the data recorded.

Associations between high average riding speeds (and male riders) and the odds of FTQ ME have been reported previously in larger scale studies [7, 8, 9] and the potential reasons behind these associations are well-rehearsed. The present results also found that if riding speed in loop 2 increased compared to loop 1, FTQ ME outcomes at the end of loop 3 were more likely. This indicates that sub-optimal pacing strategies potentially contribute to an increased risk of FTQ ME. Further work identifying optimal pacing strategies for successful completion of rides will be a focus of future work with these data.

By its nature this study is a pilot and the results provide strong motivation to design data collection protocols to carry out a larger scale study. This would overcome several of the limitations of the present study, in particular the low sample size in later loops. A new data collection protocol should be accompanied by clear and consistent definitions of severity at the point of collection and training (or at least some sort of guidance) would be useful for FEI veterinary delegates. The present study is limited by potential inconsistencies in the data given the current lack of such clear guidance. Despite the small-scale nature of the present study which only had access to a relatively small number of vet cards, and no prior input into the collection protocol, these results have already proved useful for informing regulatory change, and demonstrate the almost unique opportunity amongst equestrian sports of in-competition risk prediction that is available in endurance.

Conclusion

As a whole these results provide plenty of evidence to suggest that further collection and routine analysis of veterinary card data could provide significant reward in terms of being able to predict, before and during a ride, which horses are at greater risk of FTQ GA or ME. An initial effort to establish a mechanism by which these data can be more readily collected from all FEI Endurance rides could provide, within one year, approximately four times as many veterinary cards as were analysed in this study. This analysis could then be extended to include individual horse and rider histories to develop risk profiles for each rider/horse combination, that evolve in real-time over the course of an endurance competition, to reflect the findings of clinical examinations recorded at each veterinary inspection. The next step would be to develop algorithms that inform an automated risk calculator which would be available to veterinary delegates at the veterinary gates at the time each horse arrives for its inspection at the end of a loop. This information could then be used, alongside clinical judgement, to enable vets to make evidence-based decisions about which horses to eliminate earlier in rides before more serious FTQs were incurred, thus providing significant benefit to equine welfare.

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Table 1

Number and percentage of starts by region group for which veterinary cards were returned to the FEI Veterinary Department in 2014.

Geographical area (FEI designated Region Group)[1]	Number of vet cards	Starts in 2014	% of starts, in that region, for which a vet card was returned
Western/Southern Europe (Group I)	1778	5128	34.7
Northern/Eastern Europe (Group II)	393	870	45.2
Russia/Caucasia (Group III)	120	162	74.1
North America (Group IV)	203	415	48.9
Central America (Group V)	32	95	33.7
South America (Group VI)	73	2194	3.3
North Africa/Middle East (Group VII)	380	3745	10.1
East/South Asia and Oceania (Group VIII)	152	391	38.9
Sub-Saharan Africa (Group IX)	82	491	16.7
Total	**3213**	**13491**	**23.8**

[1] Groups I and II are now known as the European Equestrian Federation (EEF)

Table 2

The full list of risk factors included at the beginning of the model-building process of six multivariable models investigating six different outcomes for horses during endurance rides: FTQ GA[2] in loop 1, 2, and 3, and FTQ ME[3] in loop 1, 2, and 3. A "Y" indicates the variables which were candidates for inclusion in each multivariable logistic regression model.

Risk factors			Included FTQ GA outcome in loop…			Included FTQ ME outcome in loop…		
Name	Categorisation	Notes	1	2	3	1	2	3
Horse sex	Categorical	Four categories: mare, gelding, stallion, male unknown.	Y	Y	Y	Y	Y	Y
Horse age	Continuous		Y	Y	Y	Y	Y	Y
Rider sex	Binary		Y	Y	Y	Y	Y	Y
Rider age	Continuous		Y	Y	Y	Y	Y	Y
Loop 1 riding speed	Continuous	Average riding speed during Loop 1		Y	Y		Y	Y
Loop 2 riding speed	Continuous	Average riding speed during Loop 2			Y			Y
Change in speed between loop 1 and loop 2	Continuous	Change in speed was the percentage difference between the horse's average riding speed in loop 1 and that in loop 2			Y			Y
Heart rate at first presentation	Categorical	Categories: under 60bpm, 60-64bpm, greater than 64bpm	Y	Y	Y	Y	Y	Y
Cardiac recovery index	Continuous			Y	Y		Y	Y
Mucous membranes	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Capillary refill	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Skin turgour	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Gut sounds	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Girth, back and withers soreness	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Muscle tone	Binary	Records are categorical 1-4; grouped into "1" and "2 or above"	Y	Y	Y	Y	Y	Y
Gait	Binary	Records are categorical 1-4; grouped into "1" and "2"[4]	Y	Y	Y	Y	Y	Y

[2] FTQ GA – Failure to qualify due to irregular gait
[3] FTQ ME – Failure to qualify due to metabolic problems
[4] According to the rules, any horse whose gait was assessed as "3" or "4" at any veterinary inspection would automatically be eliminated with a FTQ GA outcome. Therefore no horse assessed as a "3" or "4" for gait could continue to the next loop.

Table 3

Results of three different multivariable logistic regression models for failure to qualify due to irregular gait (FTQ GA) outcomes for horses during FEI endurance rides. Outcomes studied were FTQ GA in loop 1, loop 2, and loop 3.

Risk factor	FTQ GA in loop 1			FTQ GA in loop 2			FTQ GA in loop 3		
	Odds ratio	95% confidence interval	p-value	Odds ratio	95% confidence interval	p-value	Odds ratio	95% confidence interval	p-value
Rider age									
Per year	1.01	1.00 – 1.02	0.026						
Pre-ride Gait									
1 (n=2831)	Ref.	-	-						
2 (n=282)	2.09	1.34 – 3.27	0.001						
Loop 1 Gait									
1 (n=2536)				Ref.	-	-			
2 (n=584)				2.71	2.04 – 3.59	<0.001			
Pre-ride mucous membranes									
1 (n=2965)							Ref.	-	-
2-4 (n=194)							0.31	0.12 – 0.76	0.011
Loop 1 Cap refill time									
1 (n=2178)							Ref.	-	-
2-4 (n=963)							1.43	1.05 – 1.94	0.023
Loop 2 Gut sounds									
1 (n=1786)							Ref.	-	-
2-4 (n=969)							0.6	0.43 – 0.84	0.003
Loop 2 Gait									
1 (n=2051)							Ref.	-	-
2 (n=837)							2.49	1.82 – 3.4	<0.001

Table 4

Results of three different multivariable logistic regression models for failure to qualify due to metabolic problems (FTQ ME) outcomes for horses during FEI endurance rides. Outcomes studied were FTQ ME in loop 1, loop 2, and loop 3.

Risk factor	FTQ ME in loop 1			FTQ ME in loop 2			FTQ ME in loop 3		
	Odds ratio	95% confidence interval	p-value	Odds ratio	95% confidence interval	p-value	Odds ratio	95% confidence interval	p-value
Pre-ride Girth, back, and withers soreness									
1 (n=2764)	Ref.	-	-						
2-4 (n=104)	7.72	2.14 – 27.81	0.002						
Rider sex									
Female (n=1722)				Ref.	-	-			
Male (n=1491)				2.14	1.12 – 4.11	0.022			
Loop 1 Heart rate									
64bpm or less (n=2406)				Ref.	-	-			
Greater than 64bpm (n=75)				3.6	1.37 – 9.49	0.01			
Loop 1 Mucous membranes									
1 (n=2226)				Ref.	-	-			
2-4 (n=908)				2.31	1.25 – 4.27	0.007			
Loop 1 average riding speed									
Per additional km/h							1.14	1.07 – 1.22	<0.001
Loop 1 Gut sounds									
1 (n=2260)							Ref.	-	-
2-4 (n=707)							1.79	1.09 – 2.96	0.022
Speed change between Loop 1 and Loop 2									
Same, decrease or increase by no more than 20% (n=2393)							Ref.	-	-
Increase greater than 20% (n=88)							2.86	1.09 – 7.53	0.033
Loop 2 Heart Rate									
60bpm or less (n=1648)							Ref.	-	-
Greater than 60 bpm (n=933)							1.66	1.05 – 2.63	0.029
Loop 2 Skin turgour									
1 (n=1993)							Ref.	-	-
2-4 (n=885)							1.95	1.23 – 3.09	0.005