Preventive Veterinary Medicine xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Risk factors for equine fractures in Thoroughbred flat racing in North America

Stamatis Panagiotis Georgopoulos*, Tim D.H. Parkin

School of Veterinary Medicine, College of Medical, Veterinary and Life Sciences, University of Glasgow, 464 Bearsden Road, Glasgow G61 1QH, UK

ARTICLE INFO

Article history:
Received 18 April 2016
Received in revised form 5 December 2016
Accepted 7 December 2016

Keywords:
Risk factor analysis
Logistic regression
Horse racing
Equine epidemiology

ABSTRACT

The aim of this paper is to identify risk factors associated with equine fractures in flat horse racing of Thoroughbreds in North America. Equine fractures were defined as any fracture sustained by a horse during a race. This was a cohort study that made use of all starts from the racecourses reporting injuries. The analysis was based on 2,201,152 racing starts that represent 91% of all official racing starts in the USA and Canada from 1 st January 2009–31 st December 2014. Approximately 3,990,000 workout starts made by the 230,034 Thoroughbreds that raced during that period were also included in the analysis. During this period the incidence of equine fractures was 2 per 1000 starts. The final multivariable logistic regression models identified risk factors significantly associated ($p < 0.05$) with equine fracture. For example, horses were found to have a 32% higher chance of sustaining a fracture when racing on a dirt surface compared to a synthetic surface; a 35% higher chance if they had sustained a previous injury during racing and a 47% higher chance was also found for stallions compared to mares and geldings. Furthermore, logistic regression models based on data available only from the period 2009–2013 were used to predict the probability of a Thoroughbred sustaining a fracture for 2014. The 5% of starts that had the highest score in our predictive models for 2014 were found to have 2.4 times (95% CI: 1.9–2.9) higher fracture prevalence than the mean fracture prevalence of 2014. The results of this study can be used to identify horses at higher risk on entering a race and could help inform the design and implementation of preventive measures aimed at minimising the number of Thoroughbreds sustaining fractures during racing in North America.

1. Introduction

This study is based on equine fractures in flat horse racing of Thoroughbreds in the USA and Canada during the period 2009–2014. More than 80% of equine fatalities in this period were the result of a fracture. As such, they are a primary focus of epidemiological analyses of existing racing data aimed at maximising the welfare of the racehorse.

Recent studies investigating equine injuries across different countries and jurisdictions have identified associations between them and plausible risk factors. Horse-related risk factors, such as the age, the sex, and the prior racing history of the horse, have been shown to be associated with injuries: age (Estberg et al., 1996a; Estberg et al., 1998a,b; Williams et al., 2001; Parkin et al., 2005; Henley et al., 2006; Lyle et al., 2012) has been shown to be a significant risk factor with older horses having a higher risk of injury. Male horses have also been shown to have a higher risk of injury (Estberg et al., 1996a; Estberg et al., 1998a,b; Hernandez et al., 2001; Hernandez et al., 2005). The prior racing history of a horse was also found to be associated with injuries (Estberg et al., 1995; Hernandez et al., 2001; Hernandez et al., 2005; Parkin et al., 2005; Henley et al., 2006; Boden et al., 2007; Lyle et al., 2012). If there was an extended interval since the last race the risk for catastrophic injury was higher (Hernandez et al., 2001; Hernandez et al., 2005). Lyle et al. (2012) found that the more starts a horse had within the last 60 days the less the risk of injury. Henley et al. (2006) also found a decrease in risk of injury the more starts a horse had during the year prior a race but Boden et al. (2007) looking specifically at the starts in the 31–60 days period prior the race, found a higher risk for fatal injuries if the horse had a start. The risk of fracture was also higher for horses that did no gallop work during training (Parkin et al., 2005) but horses that accumulated an excess timed work distance within a 2 month period prior a race were at higher risk as well (Estberg et al., 1996a). Exercise history (Estberg et al., 1996a,b; Estberg et al., 1998a,b) (Cohen et al., 2000) (Hernandez et al., 2005; Parkin et al., 2005) and specifically the distance galloped in training

Abbreviations: AIC, Akaike's information criterion; CI, confidence interval; EID, equine injury database.

* Corresponding author.
E-mail address: s.georgopoulos.1@research.gla.ac.uk (S.P. Georgopoulos).

http://dx.doi.org/10.1016/j.prevetmed.2016.12.006
0167-5877/

(Estberg et al., 1995; Estberg et al., 1996a,b; Estberg et al., 1998a,b; Cohen et al., 2000; Parkin et al., 2004a) have also been associated with injuries.

Furthermore, prerace condition of a horse; horses that were reluctant to start a race, (Parkin et al., 2006) inspection by regulatory veterinarians (Cohen et al., 1997) and shoe characteristics have been identified to be associated with equine injuries (Kane, 1996; Kane et al., 1998).

Finally, there seem to be risk factors directly related to the race course. The racing surface and its conditions have been shown to be associated with injuries (Hernandez et al., 2001) (Williams et al., 2001; Parkin et al., 2004a,b; Parkin et al., 2005; Henley et al., 2006), the distance of the race (Peloso et al., 1994; Parkin et al., 2004b; Henley et al., 2006; Boden et al., 2007; Lyle et al., 2012), the field size (Parkin et al., 2004b; Parkin et al., 2005; Lyle et al., 2012), the type of the race (Estberg et al., 1998a,b; Henley et al., 2006) and even the season the race took place in (Boden et al., 2007; Lyle et al., 2012).

These studies provided a starting point for the analysis of our study. We aim to identify the risk factors associated with equine fractures in the USA and Canada for 2009–2014. We also aim to make use of logistic regression models to quantify the probability of a Thoroughbred sustaining a fracture during flat racing and identify a population of horses at higher risk. This could inform the design and implementation of preventive measures aimed at minimising the number of Thoroughbreds sustaining fractures during racing in North America.

2. Materials and methods

The analysis reported in this paper is an observational retrospective cohort study based on racecourses reporting injuries to the Equine Injury Database (EID) from 1st January 2009 to 31st December 2014. The injury reports are recorded into the EID by veterinarians at the participating racetrack. The data were supplied by *The Jockey Club* and covered all tracks that voluntarily contributed to the EID in each year.

An equine fracture, sustained during the race, was specified as the outcome variable of this study. This definition included any possible fracture sustained by the horse during racing, including fatal and non-fatal fractures. Fractures were recorded by veterinarians at the track. A case start was defined as a start in a race in which the horse sustained a fracture. All official starts were used to calculate historical information for each horse but only the starts from the racecourses reporting injuries were used to assess the risk of equine fractures. Furthermore, approximately 3,990,000 workout starts made by the Thoroughbreds that raced during that period were also included in the analysis. Workout starts are timed exercise starts a horse makes during training observed on the track.

Risk factors specific to the North American jurisdiction have also been included such as a horse having previously entered the veterinarian's list, a list used by association and regulatory veterinarians to provide horses with illness, injury or soundness issues a brief respite from racing. More than 75% of horses exit the veterinary list within a month. Moreover, the number of times a horse has been previously scratched (withdrawn from the race on the day of the event) has been included as a risk factor. Furthermore, the betting odds of each horse, the ratio of payoff to stake, has been included as a risk factor. The odds rank of each horse was also included. Within a race we numerically ranked each horse according to their betting odds, the number 1 given to the horse favoured by the odds to win the race.

To find the association between the possible risk factors and fractures we created a univariable logistic regression model for each risk factor. The risk factors that were found to be associated with a p-value less than 0.20, were chosen to be included in a stepwise selection process. The p-value threshold of 0.20 was chosen to prevent the exclusion of a predictor that only becomes evident when possible confounders have been accounted for (Dohoo et al., 2003). For the stepwise selection we used a forward bidirectional elimination approach with Akaike's Information Criterion (AIC). AIC uses maximum likelihood to compare between models with different risk factors, with an added penalty for complexity which depends upon the number of parameters used to fit the data. The best model, following Occam's razor, is the one offering the highest information gain with least complexity (Bozdogan, 1987). We arrived at the final multivariable logistic regression models by including the risk factors selected through this process. We relied only on the AIC for including risk factors in the models and did not use any other exclusion criteria based on potential biological interaction or effect modification.

To assess the effect of clustering we created mixed-effect models that examined the potential effect of including horse as a random effect.

One model was created using all available starts and another multivariable logistic regression model was created on a subsample of the population consisting only of starts from horses that had been in racing for at least six months. This effectively includes every racing start of a horse, excluding the starts in the first six months of its career. This extra model was created to assess the risk factors that summarize historical racing information prior to each race.

To quantify the probability of a Thoroughbred sustaining a fracture and to obtain predictions, we created new multivariable models, including the risk factors already obtained, on data available only from the period 2009 - 2013. The data from 2014 were used to evaluate the predictive performance of each model. We used the Area Under the Receiver Operating Characteristic Curve (AUC), as suggested by Bradley (1997), to evaluate the models. This evaluation takes into account the extremely imbalanced outcome variable. Since the prevalence of a fracture is very low it is trivial for a model to achieve an accuracy of over 99.7% by simply predicting a 0% probability of an equine fracture at every start. A bootstrap with 10,000 iterations was used on the racing starts of 2014 to obtain the 95% confidence intervals on the AUC estimate.

All the statistical analyses and calculations in this study were conducted using RStudio, developed by RStudio Team (2015), and the R programming language by the R Development Core Team (2008).

3. Results

The analysis reported in this paper is based on data available for 230,034 Thoroughbreds racing at 89 racecourses in the United States and Canada. It includes 2,201,152 starts from the racecourses reporting injuries to the EID. The EID contains information for most races that took place in North America during that period and is a near census collection of the available data. These starts represent 91% of all official racing starts (2,429,443) in the USA and Canada for that period. The incidence of equine fractures during the period 2009–2014 was 2 per 1000 starts.

The results reported are from the fixed-effect only models as they were near identical to the models that included horse as a random effect. The absolute difference was less than 0.01 in the odds ratio for the fixed effects and no meaningful changes for the P-values.

The results from a final multivariable model for all horses are shown in Table 1. A total of 17 risk factors were included in the model.

Please cite this article in press as: Georgopoulos, S.P., Parkin, T.D.H., Risk factors for equine fractures in Thoroughbred flat racing in North America. PREVET (2016), http://dx.doi.org/10.1016/j.prevetmed.2016.12.006