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A description of veterinary eliminations within British National Endurance rides in the competitive season of 2019

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Abstract:
Veterinary eliminations within the equestrian sport of endurance have predominantly been evaluated based on data from international competitions. However, in order to take part in international competition, each horse and rider must qualify by completing rides under their national federation. The aim of this study was to analyse the competitive data and veterinary eliminations, specifically lameness, from competitions run by the British governing body of endurance: Endurance GB, during the 2019 competitive season. Competitive results for 765 ride starts from seven different ride venues were evaluated; 81.6% (n = 624) horses successfully completed the rides, with the remaining 18.4% (n = 141) failing to complete the ride. The majority of horses that were unsuccessful were eliminated for lameness at veterinary inspections (n = 83; 58.9%). Horses competing in single loop rides (up to 55km rides) had a success rate of 88.6% (n = 624), in contrast, horses competing in rides of three loops or more (>80km rides) reported a decreased success rate of 61.8% (n=81). Hind limb lameness was identified more frequently (n = 50; 60.2%) compared with forelimb lameness (n=33; 39.8%). Further consideration should be given to the differences between single loop rides, where a higher percentage are presented to the veterinary panel as lame prior to the start, and multi loop rides, where a higher percentage of horses are eliminated lame during the ride and potential risk factors for the increased prevalence of hind limb lameness observed.

Key words: endurance racing, equine welfare, lameness, horse,

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Introduction:

The governing body of endurance riding within the UK, Endurance GB (EGB) schedules over 100 competitions between March-October each year. Single day competitions range from 20-160km rides and are categorised as graded endurance rides (GER) or competitive endurance rides (CER). Horses and riders compete through a series of GER before being eligible to compete in CER. Riders or horses do not necessarily have to qualify as a consistent combination but can qualify as an individual (Endurance GB, 2020). Graded endurance rides must be completed within a set range of speeds, the minimum and maximum speeds are dependent on the qualification level of the horse and rider (8-15kmph for novices and 9-18kmph for open and advanced level). A summary of qualification levels and progression requirements are shown in Appendix A.

If horses do not complete the ride within the required time frame, they fail to qualify (FTQ) and are eliminated for being out of time (OOT). Advanced level horses are eligible to compete in competitive endurance rides (CER). These are race rides, with a minimum speed of 10kmph, where the first horse past the finish line, who successfully passes the vetting, is declared the winner. Each competition regardless of distance has a veterinary inspection at the start and finish, with distances over 55km also requiring veterinary inspections at intervals of 30-40 km during the ride. The horse must successfully pass all the veterinary inspections in order to complete the ride (Endurance GB, 2020).

The veterinary inspection consists of a metabolic inspection, where the heart rate must be below 64 bpm, within 20 minutes during the ride and within 30 minutes at the end of the ride. The veterinarian also listens to gut sound, checks the hydration levels of the horse and ensures its muscle tone and general demeanour indicate that it can continue the next phase of the competition. If they are not satisfied that the horse is able to continue on metabolic grounds it is eliminated and fails to qualify for metabolic reasons (FTQME). The horse must also be trotted, without tack 30m in a straight line, away from and towards the examining veterinarian. If they assess the horse to be lame, or have an un-even gait pattern, the horse is asked to re-trot. During the re-trot, additional members of the veterinary team will observe the horse trotting. During a GER, this may only be one additional member. During a CER, there will be a panel of three veterinarians. Each veterinarian marks on a voting slip if they consider the horse to 'pass' or 'fail'. The voting takes place without discussion and individual outcomes are passed to the ground jury who gives the majority decision as to whether the horse has passed or failed to qualify due to lameness (FTQLA). If a horse passes a veterinary inspection, but the rider feels it is not in the best interest of the horse to continue, then they can 'retire on course' (ROC) (Endurance GB, 2020).

Previous studies in Endurance and international statistics have identified that the most common reason for elimination is lameness (Bennet and Parkin, 2018; Fédération Equestre Internationale, 2019; Fédération Equestre Internationale, 2020; Fielding *et al.,* 2011; Nagy *et al.,* 2010; Nagy *et al.,* 2012; Nagy *et al.,* 2014; Younes *et al.,* 2016). Most studies have focussed on international competitions where competitors, (horses and riders) are experienced. These studies have identified that horses are at increased odds of lameness in rides over longer distances or when they have been ridden at faster speeds (Bennet and Parkin, 2018b). However, this by no means implies that the risk of lameness at shorter distances and slower speeds is negligible.

At national level, Nagy *et al.,* 2017, surveyed the membership of EGB to identify the most common issues their horses faced and 80% confirmed that their horse(s) had had an episode of lameness within their competitive career. Additionally, anecdotally, the most common reason EGB for elimination is considered to be lameness. There is a need to identify if this perception is accurate, to facilitate proactive risk management to improve the welfare and increase the competitive longevity of the horses competing within the sport at a national level.

Within EGB endurance competitions while records are kept for horses that have been eliminated for lameness, details surrounding the lameness are not specified/recorded. Ordinarily, outside of competition, when a veterinarian is examining a horse for lameness, a series of diagnostic tests, such as nerve blocks and/or appropriate imagery may be performed to identify the source of the lameness (American Association of Equine Practitioners, 2019). Whilst it is recognised that the veterinary examinations during competition are not diagnostic, and lameness is often multifactorial, further information could be gathered. Additionally, the current options for veterinary eliminations are usually for 'lameness' or 'metabolic' despite the case that some metabolically compromised horses also present lame and vice versa. A greater depth of information surrounding lameness at the point of elimination is required, such as which limb(s) are most commonly affected, the severity of lameness' and whether this changes dependent on the competition level and distance. This would facilitate a more accurate evaluation of risk factors which would potentially allow more in-depth awareness and enable preventative strategies to be considered and implemented.

Risk factors for FTQ and FTQLA have been documented at international level and include multiple competitive starts, insufficient rest periods between competitions, high speeds (> 20kmph) and previous FTQ and FTQLA in a horse's competitive history (Bennet and Parkin 2018a, 2018b; Fielding *et al*., 2011; Nagy *et al.,* 2010; Nagy *et al.,* 2014, Younes *et al.,* 2016; Zuffa *et al*., 2021). However, no studies to date have examined the risk factors associated with FTQ and FTQLA at British national level. This information is important in order to establish whether risk factors differ between national and international competition, to ensure that appropriate education and proactive risk mitigation strategies can be implemented across all levels of the sport to improve equine welfare and public perception of the sport.

Therefore, this study aimed to consider lameness eliminations in more detail than previously studied, by identifying the most commonly affected limb(s), understanding the severity of lameness presented, and if changes found were dependent on the stage or level of competition. Subsequent relationships between risk factors and lameness across national level British endurance are reported elsewhere (Bloom *et al.,* unpublished data).

Methods:

Participants

Following agreement from EGB, seven national rides were attended between June-October 2019, totalling thirteen days of competition. Prior to each ride, an information sheet was sent via email to the ride organisers, technical stewards, ground jury and attending veterinarians detailing the study and the data that would be requested. Horses competing across all distances in rides run under EGB rules, with full veterinary examinations were included in the study. Horses competing in FEI rides were excluded, as were horses competing in pleasure ride classes as these are run under different rules. Ethical approval was granted by the Hartpury University ethics board prior to data collection.

Measures

At the rides attended, information collected by EGB as standard was obtained by taking copies of the official results, including, the start and finish time for each loop and the duration of the ride, time taken to present to the veterinarian (multi-loop rides only) and the official heart rate of the horse at the veterinary inspections during the ride and at the finish. In addition, the subjective steepness of the ride, based on the route description documented on the ride entry (e.g. serious hills or flat forest tracks) and trot up surface were documented. The air temperature and relative humidity were recorded using a calibrated digital temperature and humidity meter (Peak-Meter PM6508). These measurements were taken hourly at the venue from the time the first horse(s) started the competition, until the final horse completed the ride.

During the veterinary inspection, at each of the rides attended, if a horse was asked to re-trot within any of the veterinary inspections throughout the ride, each member of the veterinary panel (VP) watching the horse trot was asked to note whether they believed the horse to be lame/not lame. If they considered the horse to be lame, they were then asked to identify which limb(s) they considered the horse to be lame on, and to assess the severity of lameness using the American Association of Equine Practitioners (AAEP) 6-point scale, shown in Table 1.

Table 1: American Association of Equine Practitioners Lameness Scale*

Grade	Description
0	Lameness not perceptible under any circumstances
1	Lameness is difficult to observe and is not consistently apparent, regardless of circumstances (e.g. under saddle, circling, inclines, hard surfaces etc)
2	Lameness is difficult to observe at walk or wen trotting in a straight line but consistent under certain circumstances (e.g. weight-carrying, circling, inclines, hard surface etc)
3	Lameness is consistently observable at trot under all circumstances
4	Lameness is obvious at a walk
5	Lameness produces minimal weightbearing in motion and/or rest or a complete inability to move

*Table from American Association Equine Practitioners, 2019

Voting slips were handed to the ground-jury member to give the decision to the rider as to whether the horse had passed or failed the veterinary inspection. The ground jury then handed the slips to the researcher to analyse. No external intervention was required or placed upon participants and all data were anonymised. The only addition to the standard vetting procedure was the notation of limb(s) and grade, there were no changes to the physical veterinary examination.

Horse demographics such as age, sex and breed were collected and historical information for each horse taking part was downloaded from the Endurance GB website. This information included: the number of years the horse had been competing, the number of successful and unsuccessful rides, the cumulative distance attempted over the horse's career, the number of previous FTQ and FTQLA occurrences for the horse and how long prior to the ride currently being attended these negative outcomes occurred. The length of time between the ride attended and the previous competition, the previous FTQ and the previous FTQLA was also calculated.

Data Analysis

Frequency analysis of factors was completed. Historical data met non-parametric assumptions and are reported as median± interquartile range unless otherwise stated. A series of Spearman's Rank Correlations ($p<0.05$) examined the relationship between the number of times a horse

FTQ in their career, or FTQLA in their career and the age of the horse, the length of their competitive career (years) the number of rides the horse had attempted in their career and successfully completed in their career, the distance (km) the horse had attempted in their career and the distance (km) the horse had successfully completed in their career. The correlation coefficient was identified as either positive or negative, with the strength of the association being determined by its proximity to either +1 or -1. The closer to 1 (positive or negative), the stronger the association between the ranks (Schober *et al.*, 2018). Correlation coefficients of 0.0-0.30 were considered negligible, values of 0.31-0.50 were considered low, 0.51-0.70 moderate, 0.71-0.90 high and 0.91-1 very high (Mukaka, 2012). All analyses were completed using Statistical Product and Service Solutions software (Version 26.0 IBM, Portsmouth). Multivariable modelling evaluated risk factors associated with FTQ and FTQLA; these results are presented separately (Bloom *et al.*, unpublished data).

Results:

Competitive results from 765 entries were collected and evaluated. Results were obtained from rides ranging from a single loop ride (22-48km), to six loop rides over two or three days, with a maximum distance of 174km. The longest single day ride consisted of four loops and a total of 101km. Only one ride had the veterinary inspection on hard ground (concrete), whilst the other six were on grass. The majority of the grass trot up lanes were not mown or specialised areas, but the flattest area of the venue fields. One ride was considered ‘steep’, with the ride information detailing ‘serious hills’, the other rides were considered to have ‘minimal climbs’. Temperature ranged from 8.4-29.8°Celcius. Relative humidity ranged from 39.1% to 100%, with bright sunshine to heavy rain. Table 2, shows the conditions for each ride.

Table 2: Environmental, climatic and topographical conditions at each ride

Ride	1	2	3	4	5	6	7
Month	June	July	July	Sept	Sept	Oct	Oct
Temperature ºCelcius	14.3-20.1	21.6-29.8	16.3-24.6	12.4-26.2	15.7-18.2	13.2-16.6	8.4-10.0
Relative Humidity %	49.3-83.2	40.8-52.8	44.4-78.5	39.1-68.8	62.4-100	61.3-74.6	77.0-87.6
Weather	Sunshine, light breeze	Bright sunshine, minimal breeze	Cloudy with sunny spells	Bright sunshine, minimal breeze	Heavy Rain	Cloudy with sunny spells some rain showers	Rain most of the day
Route Description	Grassy downland tracks, undulating	Forest, heath and farmland, fast sandy tracks, gently undulating	Bridleways, private tracks in park. Very little roadwork	Good going on field margins, across grassland and bridleways, minimal roadwork	Private tracks and field headlands.	Grass and heather on rolling plateaux with some serious hills	Grass tracks, bridleways, flat, clay soil.

The greatest number of entries were in single loop rides n=526 (68.7%). Single loop rides were all categorised as GER with a completion speed of 11.7± 1.9kmph. Two-loop rides (GER’s), 64-80km accounted for 14.1% of entries (n=108) with a completion speed of 12.5± 1.6kmph. Rides of three loops and above, which ranged from 80-174km accounted for 17.1% of entries (n=131), within these rides 64.1% (n=84) were categorised as CER with a completion speed of 12.5± 2.9kmph and the remaining 35.9% were GER with a completion speed of 12.0± 1.1kmph.

Table 4 shows the number of horse starts dependent on how many loops the ride consisted of and the outcomes of the competitions. The highest number of entries were in single loop rides (n = 526, 68.8%) with a success rate of 88.6% (n = 466) this decreased to 71.3% (n = 77) in rides of 2 loops and 61.8% (n = 81) for rides of 3 loops or more as shown in Figure 1. Lameness accounted for 83.3% of FTQ's in rides of six loops, but only 55% of FTQ's in single loop rides. The overall prevalence of lameness was 10.8%, however in rides of three loops or more, 26.0 % of horses that started the competitions were eliminated for lameness.

Table 3: Ride entries and results per number of loops

Number of loops	1	2	3	4	5	6	All rides
Entries (n)	526	108	105	7	2	17	765
Entries %	68.76	14.12	13.72	0.92	0.26	2.22	100
Completions (n)	466	77	65	4	1	11	624
Completions %	88.59	71.30	61.90	57.14	50.00	64.71	81.57
FTQ (n)	60	31	40	3	1	6	141
FTQ %	11.41	28.70	38.10	42.86	50.00	35.29	18.43
Lame (n)	33	16	27	2	0	5	83
Lame % of FTQ	55.00	51.61	67.50	66.67	0	83.33	58.87
FL Lame (n)	15	4	12	1	0	1	33
FL Lame % of Lame	45.45	25.00	44.44	50.00	0	20.00	39.76
HL Lame (n)	18	12	15	1	0	4	50
HL Lame % of Lame	54.55	75.00	55.56	50.00	0	80.00	60.24
Met (n)	5	3	2	0	0	0	10
Met % of FTQ	8.33	9.68	5.00	0	0	0	7.09
Ret (n)	11	12	8	0	1	1	33
Ret % of FTQ	18.33	38.48	20.00	0	100.00	16.67	23.40
FTQ other (n)	11	0	3	1	0	0	15
FTQ other % of FTQ	18.33	0	5.00	33.33	0	0	10.64
FTQ Start (n)	5	4	1	0	0	0	10
FTQ Start % of FTQ	8.33	12.90	2.50	0	0	0	7.10
FTQ During ride (n)	4	20	30	2	1	6	63
FTQ During Ride % of FTQ	6.67	64.52	75.00	66.67	100.00	100.00	44.68
FTQ End (n)	51	7	9	1	0	0	68
FTQ End % of FTQ	85.00	22.58	22.50	33.33	0	0	48.23

*Percentages not exact due to rounding. Forelimb (FL), Hindlimb (HL), Fail to Qualify (FTQ)

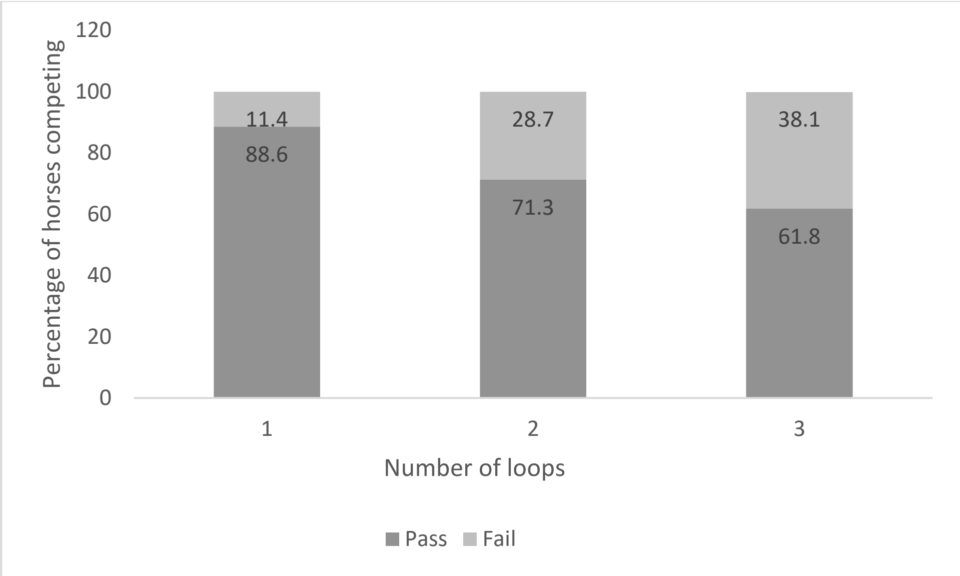

Figure 1. The percentage of horses that passed or failed the competition for single loop rides, two loop rides and rides of 3 or more loops.

Metabolic eliminations (n=10) accounted for 7.1% of eliminations, 23.4% of eliminations (n=33) were due to the rider retiring the horse from the competition and 10.6% of eliminations (n=15) were due to other reasons; one of these was due to a sore back, one was due to a wound and the others were due to course errors or failure to meet the minimum speed requirements (Fig. 2).

Figure 2. For horses that failed to qualify, the percentage of the failures in one loop, two loop and three+ loop rides and the reasons for their elimination from competition.

Of horses that FTQ, the highest percentage, 58.9% (n=83) were eliminated for lameness. In single loop rides 55% (n=33) of all FTQ were FTQLA. Lameness eliminations accounted for 51.6% (n=16) in two-loop rides and 68% (n=34) in rides of three loops and above. Hind limb lameness accounted for 60.2% (n=50) of all lameness eliminations. Fig.3 demonstrates the split between single loop and multi-loop rides.

Figure 3. Percentage of lame horses eliminated for forelimb or hind limb lameness for single loop rides and multi-loop rides

Excluding single loop rides, where there is only a veterinary examination at the start and the finish, the majority of horses that FTQ did so during the ride 72.8% (n = 59). Of those that FTQ, 21% (n = 17) did so at the end of the ride. The remaining 6.2% (n = 5) of FTQ's were declared lame at the pre-ride veterinary inspection. No horses were declared lame at the start in rides consisting of four loops and above.

Examining veterinarians agreed on which limb was lame in 100% of cases where two veterinarians observed the re-trot. Agreement was only slightly less (83%) when three veterinarians observed the re-trot. The highest grade of lameness was a grade four. This occurred in three cases. One was a forelimb lameness at the penultimate ride of the competitive season, and the other two cases were hind limb lameness's at the final ride of the season. The median lameness grade was 2±1.

Historical Horse Data:

The competitive history and demographics for the horses competing varied considerably with some horses having competed in lower distances the previous day, and others having not competed for several years. Table 4 shows the background information on the horses competing. The median age of the horses was similar across all distances, with the upper range of horses competing going into their twenties. The cumulative competitive distances had a vast range, particularly in the single loop categories where some horses had not competed before and others having attempted over ten thousand kilometres.

Historical Correlations:
Across all distances, significant positive correlations were found between all historical parameters investigated, and the number of competitive rides horses had previously been eliminated from for all FTQ reasons (Table 5) and for FTQLA only (Table 6).

Table 4: Historical data for horses competing

Variable	Single Loop Median± IRQ (Range)	2 loops Median± IRQ (Range)	3+ loops Median± IRQ (Range)
Age	11± 5 (5-29)	12 ±6 (6-24)	11± 4 (6-24)
Number of Years Competing	2± 5 (0-19)	3 ± 4 (0-17)	4 ± 5 (1-14)
Days since previous ride	34±50 (1-1980)	27± 22 (6-3314)	34± 35 (5-757)
Distance previous ride	40± 10 (16-160)	44±28 (16-144)	80± 38 (31-143)
Days since previous FTQ	223± 441 (6-3716)	265.5± 286.75 (7-2618)	294± 405 (2-2944)
Days since previous FTQLA	371.5± 711.25 (14-3710)	307± 558.75 (21-2652)	395± 612.75 (20-3591)
FTQ 2019	0 ± 1 (0-4)	0 ± 1 (0-3)	0± 1 (0-5)
FTQ Career	1±3 (0-21)	2± 5 (0-21)	3± 5 (0-18)
FTQLA 2019	0 ± 0 (0-3)	0 ± 1 (0-3)	0± 1 (0-3)
FTQLA Career	0±1 (0-15)	1± 3 (0-10)	1± 3 (0-10)
Rides attempted 2019	3 ± 5 (0-15)	4± 2 (0-12)	4± 3 (0-11)
Rides completed 2019	3± 4 (0-14)	3± 4 (0-11)	3± 3 (0-9)
Rides attempted in career	10.5± 23 (0-200)	29± 31.75 (3-90)	23± 30 (2-98)
Rides completed in career	9 ± 20 (0-180)	26± 25 (3-83)	18± 28 (1-87)
km attempted 2019	114 ± 195 (0-694)	178.5 ± 156.5 (0-822)	216± 238 (0-898)
km completed 2019	105±171 (0-694)	155 ± 147.25 (0-622)	189± 178 (0-698)

km attempted career	364± 1057 (0-10924)	1090± 2029.5 (110-5628)	1357± 1835 (104-6904)
km completed career	327.5± 877 (0-9364)	931± 1382 (110-5161)	1106± 1500 (80-5746)

Table 5 Correlations between horse factors and total number of Failed to Qualify results within horse career

Correlation Variables	Spearman's Rank
All Rides	
km attempted in career	R=0.797 N=765 p<0.001
Rides attempted in career	R=0.777 N=765 p<0.001
Years competing	R=0.744 N=765 p<0.001
km completed in career	R=0.736 N=765p<0.001
Rides completed in career	R= 0.717 N=765 p<0.001
Age	R=0.474 N=765 p<0.001
Single Loop Rides	
km attempted in career	R=0.765 N=526 p<0.001
Rides attempted in career	R=0.753 N=526 p<0.001
Years competing	R=0.721 N=526 p<0.001
km completed in career	R=0.709 N=526 p<0.001
Rides completed in career	R=0.697 N=526 p<0.001
Age	R=0.456 N=526 p<0.001
2 Loop Rides	
km attempted in career	R=0.756 N=108 p<0.001
Rides attempted in career	R=0.753 N=108 p<0.001
km completed in career	R=0.673 N=108 p<0.001

Rides completed in career	R=0.671 N=108 p<0.001
Years competing	R=0.670 N=108 p<0.001
Age	R=0.452 N=108 p<0.001
3+ Loop Rides	
km attempted in career	R=0.798 N=131 p<0.001
Rides attempted in career	R=0.781 N=131 p<0.001
Years competing	R=0.754 N=131 p<0.001
km completed in career	R=0.707 N=131 p<0.001
Rides completed in career	R=0.684 N=131 p<0.001
Age	R=0.601 N=131 p<0.001

Table 6 Correlations between horse factors and total number of Failed to Qualify due to Lameness within horse career

Correlation Variables	Spearman's Rank
All Rides	
km attempted in career	R=0.739 N=765 p<0.001
Rides attempted in career	R=0.712 N=765 p<0.001
km completed in career	R=0.686 N=765 p<0.001
Years competing	R=0.676 N=765 p<0.001
Rides completed in career	R=0.662 N=765 p<0.001
Age	R=0.457 N=765 p<0.001
Single Loop Rides	
km attempted in career	R=0.691 N=526 p<0.001
Rides attempted in career	R=0.677 N=526 p<0.001
km completed in career	R=0.643 N=526 p<0.001
Rides completed in career	R=0.631 N=526 p<0.001
Years competing	R=0.631 N=526 p<0.001
Age	R=0.420 N=526 p<0.001

2 Loop Rides	
km attempted in career	R=0.683 N=108 p<0.001
Rides attempted in career	R=0.652 N=108 p<0.001
Years competing	R=0.613 N=108 p<0.001
km completed in career	R=0.611 N=108 p<0.001
Rides completed in career	R=0.575 N=108 p<0.001
Age	R=0.397 N=108 p<0.001
3+ Loop Rides	
km attempted in career	R=0.787 N=131 p<0.001
Years competing	R=0.764 N=131 p<0.001
Rides attempted in career	R=0.755 N=131 p<0.001
km completed in career	R=0.709 N=131 p<0.001
Rides completed in career	R=0.688 N=131 p<0.001
Age	R=0.652 N=131 p<0.001

Discussion:

This study confirms that lameness is the most frequent cause of elimination in British national endurance competitions. This result is in agreement with previous studies (Bennet and Parkin, 2018; Fielding *et al.*, 2011; Nagy *et al.*, 2010; Nagy *et al.*, 2012; Nagy *et al.*, 2014; Nagy *et al.*,2017; Younes *et al.*, 2016) and statistics from international endurance rides (Fédération Equestre Internationale, 2019; Fédération Equestre Internationale, 2020).

The results have also identified that lameness is the leading cause of elimination throughout all distances, from single loop to multi-loop rides in EGB competitions. The majority of studies to date have focussed on rides of above 80km and not at entry level competition (Bennet and Parkin, 2018; Fielding *et al.*, 2011; Nagy *et al.*, 2010; Nagy *et al.*, 2012; Nagy *et al.*, 2014; Younes *et al.*, 2016). Further work to increase understanding of risk factors for lameness across all levels of the sport, that can inform management and competition strategies, to reduce the incidence and reoccurrence of lameness, are required to safeguard equine welfare and the future sustainability of the sport.

A higher frequency of hindlimb lameness was identified in comparison to forelimb lameness across all race distances, but this was amplified in multi-loop rides. An increased incidence of hindlimb (tarsal injuries) has previously been reported in endurance horses presenting at a veterinary clinic (Murray *et al.*, 2006). Additionally, a small study of 22 horses competing in endurance had their gait pattern objectively analysed at the time of competition with portable inertial sensor-based systems. The highest percentage of irregular gait pattern (41.7%) was attributed to the hind-limb(s) (Lopes *et al.*, 2018). Further research as to why hindlimb lameness is more apparent than forelimb lameness needs to be conducted in order to develop and implement preventative and risk management strategies to increase the competitive longevity of the horses without compromising on their welfare.

Despite the finding of this study that the number of FTQ's and number of FTQLA's increase with the number of rides attempted, there is no information available, nor any current requirement as to whether riders seek veterinary advice post elimination prior to returning to competition. Nagy *et al.* (2017) found that only 52% of riders had their horses' lameness eliminations followed up with veterinary examination and advice, with many riders, anecdotally calling lameness eliminations 'bad luck', or suggesting 'the horse was not lame in the first place'. This is an issue described by veterinarians when asked about challenges faced when examining horses in endurance competitions (Mira *et al*., 2019). Although riders may consider eliminations to be 'bad luck' objective analysis identified 21 out of 22 horses to have an irregular gait pattern at the time of competition (Lopes *et al.,* 2018). These combined findings suggest that more horses would benefit from veterinary follow up post lameness elimination to identify the cause and to enable specific diagnosis. Riders, trainers and owners must take responsibility for seeking appropriate professional advice post elimination, for diagnosis and appropriate phased return to work and competition. Repeated images or reports of lame horses within the sport will negatively impact on the public perception of endurance, therefore it must be emphasised that strategies are in place to prevent lameness', but when they do occur, aftercare and return to sport must be appropriately and professionally managed. Consideration should perhaps be given to implementing the rule of the FEI that three lameness eliminations within a rolling year require a lameness investigation prior to returning to competition (Fédération Equestre Internationale, 2020).

The competitive history of the horse, particularly the cumulative distance attempted was strongly correlated with the number of FTQ and FTQLA outcomes, particularly as race distances increased (>80 km) in rides of three loops and above. Across human and equine endurance sports, the cumulative impact of repeated competition, which may be indicative of microtrauma, is associated with an increased risk of injury (Bennet and Parkin, 2018; Burns *et al.,* 2003; Fielding *et al.,* 2011; Henley *et al.,* 2006; Martig *et al.,* 2014; Parkin *et al.,* 2005.) This may well occur during training but is then exacerbated by competition when physiological demands are increased. As the horses begin to fatigue, the low grades of lameness which may be too subtle for the average rider to identify, are evident to the expert veterinarians, who are in place to safeguard the welfare of the horse and remove them from competition prior to a more severe injury occurring. Additional rest periods have been found to reduce the likelihood of a negative outcome and may allow for micro trauma to heal (Bennet and Parkin, 2020). Extended mandatory out of competition periods have been implemented at FEI level, particularly in the case of consecutive FTQ and FTQLA where three consecutive FTQLA results in a 180 day mandatory out of competition period and requires a veterinary inspection prior to being allowed to compete again (Bennet and Parkin, 2020; Fédération Equestre Internationale, 2020). Current EGB rules state an additional eight days mandatory rest are added for FTQLA or FTQME outcomes which is clearly much less than the FEI specified rest periods (Endurance GB, 2020). However, the descriptive profiling of EGB horses shows a median of >300 days across each distance since the horses were last FTQLA which would indicate the majority of British endurance horse owners are resting post lameness. Perhaps the return to competition is the more important aspect in risk reduction and greater consideration should be given to the training and rehabilitation post injury of endurance horses. There is currently no specific evidence to suggest the optimal way to train endurance horses, but evidence in human sports suggest that the majority of non-contact sporting injuries are due to incorrect training-loads and a sudden increase in demand (Gabbett, 2016). This would be similar to an endurance horse who may train on flat ground, being asked to attend and compete in the ride described as having ‘serious hills’, with the rider unaware that training on the flat ground may not prepare the horse sufficiently for hills and vice versa. However, the evidence also suggests the majority of these injuries which are predominantly soft tissue in nature, are preventable with appropriate training, rehabilitation and preparation for competition (Gabbett, 2016). Therefore, further focus should be placed on the training of endurance horses and ensuring that riders utilise appropriate professionals to advise them accordingly based on their individual horses and aspirations.

Differences between distances

Across the differing number of loops of rides, age only had a correlation coefficient >0.5 for both FTQ and FTQLA, when the rides were of three loops or more. Previous epidemiological studies, focussing on rides of 80km and above, have identified an increase in age of the horse as a significant risk factor in deleterious outcomes (Adamu *et al.,* 2014; Bennet and Parkin, 2018). This is unsurprising, given the physiological changes and joint degeneration that occur during aging. Additionally, older horses, who have been competing for longer, are also likely to have a greater risk of increased cumulative micro trauma which may be exacerbated by an increased length of time exposed to risk and an increased demand on the musculoskeletal system over the longer distances.

Lower distances were found to have a reduced incidence of FTQ and FTQLA perhaps because they are thought to be less competitive and therefore riders may not demand as much of the horses physiologically in the lower distances. Moreover, there is a maximum and minimum speed, in the lower distances whereas in the higher distances which include CER there is not a maximum speed limit. Speed has been clearly linked to an increased risk of deleterious outcomes in endurance and a higher risk of injury in racehorses and whilst the speeds identified in this study are not high in comparison to the average >20km/h seen at international rides, perhaps a speed limit for horses competing in their first CER may be of benefit (Adamu *et al.,* 2014; Bennet and Parkin, 2018; Coombs and Fisher, 2012; Marlin and Williams, 2018; Nagy *et al.,* 2012; Parkin *et al.,* 2004; Younes *et al.,* 2016).

The highest percentage of ROC and FTQME occurred in two loop rides. Horses who are ROC must still be presented to the veterinarians at the ride and must pass the veterinary examination to ensure the outcome given is ROC. If they fail the veterinary examination the outcome will be given as either FTQLA or FTQME and the horse would be subjected to the MOOCP (Endurance GB, 2020). There is however no limit on the number of times a horse can be ROC and this should be monitored more closely. The first progression level from novice level to open level is a change from single loop to two-loop rides and the finding that two-loop rides have the highest percentage of ROC and FTQME could perhaps be explained by a lack of rider experience when ‘stepping up’ a level, or a lack of knowledge on how to manage a horse during a ride, such as utilising pacing strategies which have been found to be beneficial in successful ride outcomes (Marlin and Williams, 2018). Whilst riders have to complete five novice level rides and horses three novice level rides to qualify for open level, there are no clear support systems to support novice riders progressing, or to confirm that novice horses are ready to progress. Further research into the lower levels of competition would be of benefit to enable better education at grass roots level, and to secure a strong foundation prior to progressing on to higher levels of competition. In turn, this is likely to be of benefit to the sport of endurance as success at lower levels is more likely to encourage participants to continue and progress within the sport, rather than having a pessimistic perception, based on negative experiences and outcomes (Teixeira et al., 2012). Above all, the sport of endurance is complex and the rider, as the responsible athlete for the horse, must have the appropriate knowledge and understanding in multiple aspects of training, fitness and the principles of training in order to appropriately meet their duty of care to their horse and ultimately optimise their competitive performance.

Recommendations:

Future work to further elucidate why hindlimb lameness occurs more than forelimb lameness at all levels of the sport, but more so as the distance increases, is required to support the development and implementation of evidence-informed management strategies that can reduce injury risk, enable successful return to competition and fundamentally optimise horse welfare and performance.

Training endurance horses is currently either based on anecdotal or extrapolated evidence., More specific evidence-informed training, progression and management strategies tailored to the level of competition would be of benefit for riders and their horses. Whilst riders must take responsibility, Endurance GB as the governing body should work in partnership with professionals to develop and provide training and guidance to continue to promote horse welfare at all times.

The results of this study also support increasing the length of MOOCP at national level, which should allow any potential micro trauma to heal. This may be of benefit in reducing negative outcomes at all levels of British Endurance and has been successfully demonstrated at FEI level (Bennet and Parkin, 2020).

Multiple lameness eliminations of the same horse should be closely monitored and consideration be given to adopting the FEI requirement that three lameness eliminations within a rolling year necessitates a veterinary review, prior to returning to competition.

Conclusion:

This study demonstrates that lameness is the most common cause of eliminations from endurance competitions in the U.K. across all distances. In addition, this study identified a higher frequency of hindlimb lameness, compared to forelimb lameness, the reasons for this should be explored further to allow early intervention and appropriate management and rehabilitation to maximise welfare and performance. Notable differences in eliminations exist between the distances where single loop riders have the highest success, but the step-up to two loop rides increases the incidence of FTQME and ROC eliminations and the highest percentage of lameness eliminations occurring in rides of three-loops or more. The incidence of hind limb lameness also increases from single to multi-loop rides, which may be associated with the increased distance between single loop and mulit-loop rides. The reasons for these differences warrant further exploration to develop specific education, training and risk mitigation strategies, appropriate to the level of competition which can improve the welfare and competitive success of the endurance horse.

References:

Adamu, L, Adzahan, N.M, Rasedee, A and Ahmad, B (2014) Physical parameters and risk factors associated with the elimination of arabian and crossed arabian endurance horses during a 120km endurance race. Journal of Equine Veterinary Science 34: 494-499. https://doi.org/10.1016/j.jevs.2013.10.175

American Association of Equine Practitioners (2019) Lameness exams: evaluating the lame horse. Available at: https://aaep.org/horsehealth/lameness-exams-evaluating-lame-horse Accessed: 10 February 2019.

Bennet, E.D, and Parkin, T.D.H. (2018) Fédération Equestre Internationale endurance events: risk factors for failure to qualify outcomes at the level of the horse, ride, and rider (2010-2015) The Veterinary Journal 236:44-48. https://doi.org/10.1016/j.tvjl.2018.04.011

Bennet, E.D, and Parkin, T.D.H. (2018) Fédération Equestre Internationale endurance events: riding speeds as a risk factor for elimination (2012-2015). The Veterinary Journal. 236: 37-43. https://doi.org/ 10.1016/j.tvjl.2018.04.012

Bennet, E.D. and Parkin, T.D.H. (2020) The impact of the mandatory rest period in Fédération Equestre Internationle endurance events. Equine Veterinary Journal 52: 268-272. https://doi.org/10.1111/evj.13148

Burns, J, Keenan, A, and Redmond A.C (2003) Factors associated with triathlon-related overuse injuries. Journal of Orthopaedic & Sports Physical therapy 33 (4): 177-184. https://www.jospt.org/doi/10.2519/jospt.2003.33.4.177

Endurance GB (2020) The rules and recommendations of Endurance GB. Available at: https://egb.myclubhouse.co.uk/Client/Cms/Attachments/2/2020%20Endurance%20GB%20Rule%20Book%20v4.pdf Accessed: 08 November 2020.

Fédération Equeste Internationale (2019) FEI endurance 2019 annual report. Available at: https://inside.fei.org/sites/default/files/FEI_Endurance_Report_2019.final.pdf Accessed 06 December 2020.

Fédération Equestre Internationale (2020). FEI endurance rules 2020. Available at: https://inside.fei.org/fei/disc/endurance/rules Accessed 06 December 2020.

Fielding, C.L, Meier, C.A., Balch, O.K., and Kass, P.H. (2011) Risk factors for the elimination of endurance horses from competition. Journal of the American Veterinary Medical Association 239 (4): 493-498. https://doi.org/10.2460/jama.239.4.493

Gabbett, T (2016) The training-injury prevention paradox: should athletes be training smarter and harder? British Journal of Sports Medicine 50: 273-280. http://doi.org/10.1136/bjsports-2015-095788.

Henley. W.E., Rogers, K., Harkins, L. and Wood, J.L.N. (2006). A comparison of survival models for assessing risk of racehorse fatality. Preventative Veterinary Medicine 74 (1): 3-20. https://doi.org/ 10.1016/j.prevetmed.2006.01.003

Lopes, M.A., Eleuterio, A., Mira, M., Health, E and Lopes, M. (2018). Objective detection and quantification of irregular gait with a portable inertial sensor-based system in horses during an endurance race- a preliminary assessment. Journal of Equine Veterinary Science 70: 123-129.
https://doi.org/ 10.1016/j.jevs.2018.08.008

Marlin, D. and Williams, J. (2018) Equine endurance pacing strategy differs between finishers and non-finishers in 120km single day races. Comparative Exercise Physiology 14 (1):11-18.
https://doi.org/10.3920/CEP170027

Martig, S., Chen, W., Lee, P.V.S., Whitton, R.C. (2014) Bone fatigue and its implications for injuries in racehorses. Equine Veterinary Journal 46: 408-415.
https://doi.org/10.111/evj.12241

Mira, M., Santos, C., Lopes, M.A. and Marlin, D. (2019) Challenges encountered by Fédération Equestre Internationale (FEI) veterinarians in gait evaluation during FEI endurance competitions: an international survey. Comparative Exercise Physiology 15 (5):1-8.
https://doi.org/10.3920/CEP180058

Mukaka, M.M (2012) A guide to appropriate use of correlation coefficient in medical research. Malawi Medical Journal 24 (3): 69-71.

Murray, R.C., Dyson, S.J., Tranquille, C. and Adams, V. (2006). Association of type of sport and performance level with anatomical site of orthopaedic injury diagnosis. Equine Exercise Physiology: Equine Veterinary journal Supplement 36: 411-416.
https://doi.org/10.1111/j.2042-3306.2006.tb05578.x

Nagy, A, Murray, J and Dyson, S (2010) Elimination from elite endurance rides in nine countries: a preliminary study. Equine Veterinary Journal 38: 637-643.
https://doi.org/10.1111/j.2042-3306.2010.00220x

Nagy, A, Murray, J.K. and Dyson, S.J. (2014) Descriptive epidemiology and risk factors for elimination from Fédération Equestre Internationale endurance rides due to lameness and metabolic reasons (2008-2011). Equine Veterinary Journal 46: 38-44.
https://doi.org/10.1111/evj.12069

Nagy, A., Dyson, S.J. and Murray, J.K. (2017) Veterinary problems of endurance horses in England and Wales. Preventative Veterinary Medicine 140: 45-52.
https://doi.org/10.1016/j.prevetmed.2017.02.018

Parkin, T.D.H., Clegg, P.D., French, N.P., Proudman, C.J., Riggs, C.M.,Singer, E.R., Webbon, P.M. and Morgan, K.L. (2005) Risk factors for fatal lateral condylar fracture of the third metacarpus/ metatarsus in UK racing. Equine Veterinary Journal 37: 192-199.
https://doi.org/10.2746/0425164054530641

Teixeira, P.J., Carraça, E.V., Markland, D and Ryan, R.M. (2012) Exercise, physical activity, and self-determination theory: A systematic review. International Journal of Behavioural Nutrition and Physical Activity [online]. 9 (78) [Accessed: 12th June 2020].
https://doi.org/10.1186/1479-5868-9-78

Younes, M., Barrey, E., Cottin, F. and Robert, C. (2016) Elimination in long-distance endurance rides: insights from the analysis of 7032 starts in 80-160km competitions. Comparative Exercise Physiology 12 (4): 157-167. https://doi.org/10.3920/CEP160022

Zuffa, T., Bennet, E.D. and Parkin, T.D.H. (2021) Factors associated with completion of Fédération Équestre Internationale endurance rides (2012-2019): Modelling success to promote welfare-oriented decisions in the equestrian sport of endurance. *Preventative Veterinary Medicine* [online]. 198 [Accessed: 18th December 2021]. https://doi.org/10.1016/j.prevetmed.2021.105534