Risk factors for metabolic elimination in endurance rides in New Zealand

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Introduction

Endurance sport today

The sport of endurance riding has been rapidly expanding in the last couple of years [1]. Between 1994 and 2011, the number of Fédération Equestre Internationale events increased from 16 to 276 [2]. Based on the number of events, endurance is the second most popular FEI discipline, after show jumping [2].
Endurance is described by the FEI as a 'test of the competitor's ability to safely manage the stamina and fitness of the horse over an endurance course in a competition against the track, the distance, the climate, the terrain and the clock.' [1]. The distance of an endurance ride varies between 16 and 160 km and is divided into loops. The distance of the loop must be between 16 and 40 km [1]. After every loop there is a compulsory rest period, the hold time. Depending on the level of the endurance ride, a minimum riding weight is set, which consists of the rider and all equipment, excluding the bridle. The minimum weight must be maintained during the ride [1].
Despite some differences between countries, the overall winning speed has been increasing in recent years. It has been proposed that due to the increasing speeds, the injuries that are seen in endurance horses are different compared to 20 years ago [2]. There is some discussion as to whether the welfare of endurance horses is keeping up with the changes in the sport [3]. Therefore, there has been an increase in research focused on endurance horses and the elimination rates [4]. Much of the published literature has focused on the international aspect of the endurance sport and mainly on FEI events. To date there is little documentation of the situation in New Zealand.

Veterinary examinations

The veterinary examinations during an endurance ride are needed to protect the welfare of the horses and to make sure that horses only proceed if they are 'fit to continue' [1]. The veterinary commission, which is responsible for the veterinary examinations, consists of a President, a Foreign Veterinary Delegate, members and treating veterinarians. The number of entries and the level of the event influence the required number of veterinarians that are needed for the veterinary examinations. The President and the Foreign Veterinary Delegate must be experienced endurance veterinarians and together they oversee the work of other members of the veterinary commission, advise if needed, form the panel for voting and provide second opinions. [1]
The veterinary examinations are performed before, during and after the ride [1]. The pre-ride vet-check consists of evaluating heart rate and heart sounds, respiratory rate,

muscle tone, gastrointestinal (GIT) sounds, skin recoil, mucous membranes, capillary refill time (CRT), back and girth and legs and hooves. Finally, the gait and impulsion are evaluated. In the vet-checks during and after the ride, the cardiac recovery index (CRI) is also evaluated [1]. The cardiac recovery index quantifies the horse's ability to recover after exercise.

Reasons for elimination

A horse can be eliminated from the ride if the veterinarians consider the horse not fit to continue, based on the metabolic or orthopaedic status of the horse. Horses can also be eliminated for other reasons that could compromise their well-being, such as sore back, sore in the mouth or wounds [4]. General impression, heart rate, cardiac recovery index, colour and moisture of mucous membranes, capillary refill time, skin recoil and the intensity and presence of GIT sounds are criteria that are used for evaluating the metabolic status of a horse [1].

What happens metabolically during an endurance ride?

The primary reasons for a compromised metabolic status of an exercising endurance horse are dehydration or exertional rhabdomyolysis (tying up) [5]. Dehydration is one of the main contributors to exhaustion observed in the endurance sport [6]. The hydration status of a horse is evaluated by measuring heart rate, evaluating the colour, moisture and capillary refill time of the mucous membranes, skin recoil and auscultation of the gastrointestinal (GIT) sounds [7].

In a resting state, total body water is about 65% of the body weight of a horse [7]. Most water is consumed by drinking (85%), 10% comes from metabolic water and 5% comes from food intake. Water is lost in urine, faeces, sweat and through evaporation across the respiratory tract.

During exercise, the metabolism of fuel creates a substantial heat load which causes an increase in core temperature. After prolonged exercise, an increase of 1-2 °C in core temperature has been found. The increase in core temperature triggers sweat production, which is used to prevent hyperthermia. The sweat evaporates from the skin surface, which is the main mechanism of heat loss during endurance exercise. The sweating rates during endurance exercise are directly related to the increase in core temperature. However, not all sweat evaporates, because some amounts drip from the body before they are evaporated to cool the horse down. In high humidity conditions, more sweat drips from the body in comparison with conditions with a lower humidity.

High humidity reduces the opportunity for cooling due to evaporation and thus the efficiency of sweat to reduce core temperature, as the high atmospheric water vapour pressure restricts the evaporation of sweat from the skin surface. This leads to a difference in sweat rates in different humidity conditions. While trotting and cantering at a steady pace under mild weather conditions, horses lose about 5-7 L of sweat per hour. However, if the temperature and the humidity increase, the sweat rates can reach about 10-12L per hour [7].
The electrolytes sodium, potassium and chloride are essential for balancing the body fluids. Electrolytes are consumed in feed, and they are lost by three routes, namely urine, faeces and sweat. In endurance rides, sweat is the primary mechanism for the loss of electrolytes [7]. A lot of endurance riders give their horses an oral electrolyte paste with the intention to supplement the electrolyte concentrations. These electrolyte oral pastes have been found to increase the thirst reflex of the horse during endurance rides, which minimises the fluid imbalance and thus the chance of dehydration. [7, 8]

Because of the metabolic demands of muscles and the demand for increased blood flow to the skin for cooling, the cardiac output increases. The blood is redistributed away from primarily the abdominal organs, which are less active during exercise. Eventually, if more fluid is lost due to sweating and the horse gets more dehydrated, a competition for blood between active muscle and skin can develop, leading to a decrease in either performance or cooling [7].

Exertional rhabdomyolysis or exercise-induced myopathy is a muscle disorder that is common in different sport horses. The aetiopathogenesis is complex and poorly understood, but possible risk factors include gender, age, aspects of food and stress. [9] In an endurance vet-check, the horses that are suspected to develop exertional rhabdomyolysis can show a pale colour of mucous membranes, decreased or absent auscultable GIT sounds, a capillary refill time ≥2 seconds [5], lameness [10], muscles that are firm and painful at palpation, sweating, a high respiratory rate, a high heart rate and muscle tremors. Sometimes, when a horse urinates in the vet inspection area, discoloured urine may be seen in severe cases. The diagnosis of exertional rhabdomyolysis can be confirmed by showing an increase in the activity of serum creatine kinase (CK) and aspartate transaminase (AST). [11]

International prevalence and risk factors of metabolic elimination

After lameness, metabolic disorders are the most common reason for elimination from an endurance ride [1] . The prevalence of elimination due to metabolic reasons reported

in the literature varies according to the country of origin. In the USA a prevalence of 4.2% was reported [1], which was approximately half of the mean elimination rate of 10.8% that was reported based on the examination of records from 9 countries [12]. In a more detailed examination of FEI endurance rides held between 2008-2012 Nagy et al. reported metabolic elimination rates of 8.7% [2] and 8.9% [4]. Reflecting the large variation between countries, a higher prevalence of metabolic eliminations (53.7%) was reported in a study of endurance rides in Malaysia [13]. Differences in elimination rates between countries [2, 12] may be due to differences in terrain, climate, training methods and riding style [2]. This is supported by the identification of venue and surface of the track as risk factors for metabolic elimination, with riding more than 100 meters in deep sand or soil in all loops or in all but one of the loops increasing the risk of elimination due to metabolic reason [4]. A longer ride length has also been found to be associated with metabolic reasons for eliminations [14].

Horses that were of the Appaloosa, Missouri Fox Trotters, Tennessee Walking Horse, Quarter Horse or Thoroughbred breed were also reported to be more likely to become metabolically compromised compared with Arabian horses. It isn't clear why Arabian horses seem to be better at endurance than other breeds, but is suggested that it is because of their smaller body mass [14], or because of the better fat metabolism that Arabs have in comparison with other breeds [15]. Another theory about risk factors for metabolic elimination is that horses younger than six years old seem to be less at risk compared with older horses. This could be because of a more conservative racing strategy with younger horses [14].

Metabolic eliminations seem to occur at later stages of the ride compared with eliminations caused by lameness, which makes the stage of the ride when the elimination occurs another risk factor [4]. Another factor contributing to a higher risk for metabolic elimination is a high number of horses starting in a ride, as it is thought that the rides with a high number of entries are more competitive [2, 4, 12].

New Zealand

Although a large international study examining reasons and risk factors for elimination included New Zealand [2], there is still a need for more detail and specific examination of potential risk factors, of reasons for metabolic elimination and of the speed of endurance rides in New Zealand to accurately describe the endurance sport in New Zealand and to spot possible trends over the last decade.

Material & methods

Data collection

Ride results were extracted from the Equestrian Sports New Zealand (ESNZ) website for the seasons 2010-2011, 2011-2012 and 2012-2013 until April 2013 and entered into a customised Access database.

Rides with a distance <40 km were excluded from the data set, because they are introductory or "fun rides" and not officially part of the endurance schedule. Horse age and horse gender were added if this information was available. This information was retrieved from the ESNZ website.

Ride date, ride club, ride location, ride category, ride distance, rider name and horse name information were recorded for the entire data set, while part of the results contained records of ride venue, rider gender, horse gender, horse age, heart rates, total ride times, ride results and reason for elimination information if applicable.

The entire data set included 540 rides and data of 4,168 unique starts. From these 4,168 starts there were 65 eliminations due to metabolic reasons. The 4,103 starts that weren't metabolically eliminated included starts that had qualified, but also contained retirements, disqualifiers, eliminations due reasons other than metabolic and starts which didn't have records of their results. These are categorised as 'not eliminated for metabolic reason' or 'non-metabolics'.

Distance, age and ride club are other variables that have been categorised. Distance was categorised as 40 km, 50 km, 60 km, 80 km, 90 km, 100 km, 120 km and 160 km. Age was categorised as <6 years old, 6-10 years old, 11-15 years old, 16-20 years old and >20 years old. The ride clubs were divided into regular club rides, North Island championships, South Island championships and the national championships.

Statistical analysis

Initially data was examined with histograms, and data described as means and standard deviations for continuous variables which included number of rides per month, number of starts per horse, number of starts per month and total ride time.

The baseline or reference value for each risk factor was the variable with the highest number of total starts. The association of variables were tested using a Chi-square test

with the statistics programme Epi Info 7. Variables were included in the multivariable model if the p-values of the results from the Chi-Square test were <0.21. The limit of p<0.21 was chosen because of the univariable preselection. These variables were then entered in a multivariable logistic regression model within Stata IC 12 (StataCorp LP, Texas, USA). Variables were removed from the multivariable model in a stepwise procedure i.e. risk factors that were not significant were excluded from the model until only risk factors that were significant were left in the model.

Results

Descriptive analysis: ride level

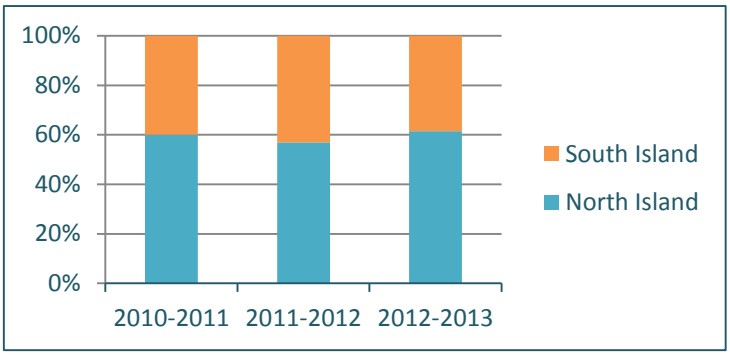

Fig.1: percentage of rides per season per island

The number of rides held differed across seasons. 2011-2012 was the season with the most rides (202, 37%), followed by 2012-2013 with 173 (32%) rides and 2010-2011 with 165 (31%) rides. Each month, 17 rides (S.D. 9.9) were held. The majority of the rides (320/540, 59%) were held in the North Island, while the other 220 (41%) were competitions on the South Island, there was no variation in this pattern across the seasons *(fig.1).*

The novice and open category dominate the endurance sport with 88% of all the rides used in this study being either novice or open. The 1* rides accounted for 6%, while the 2* and 3* rides made up for 3% and 2% respectively.

Most rides (78%) were either 40 km or 80 rides. The 160 km ride and 90 km ride were offered rarely, 9 times in the three seasons (both 2% of all rides). Other distances with data included 50 km rides (3%), 60 km rides (7%), 100 km rides (5%) and 120 km rides (5%).

A total of 540 riders competed of which 427 had gender records, the majority being females (77%).

These 540 riders competed with 649 different horses. Of these 649 horses 544 had records of their age at the start of a ride *(Table 1).*

Age category	**<6**	**6-10**	**11-15**	**16-20**	**>20**
Percentage of all horses	5.30%	58.81%	29.17%	6.40%	0.31%

Table 1: Percentage of horses per age category in years

Just over half of the horses (58%) were males, the majority being geldings. The mean number of starts per horse was 6.422 (S.D. 5.99) over the three seasons.

Descriptive analysis: start level

From the 4,168 starts, 3,460 starts qualified. There was a small difference in the number of starts per season. The season 2010-2011 had 1370 starts, 1471 starts in the season 2011-2012 and 1327 in the part of 2012-2013 we have results of. The number of starts per month varied throughout the season with the highest number of starts (661) in October (*fig.2)*. Across the three seasons there were 130 (S.D: 78.72) starts per month.

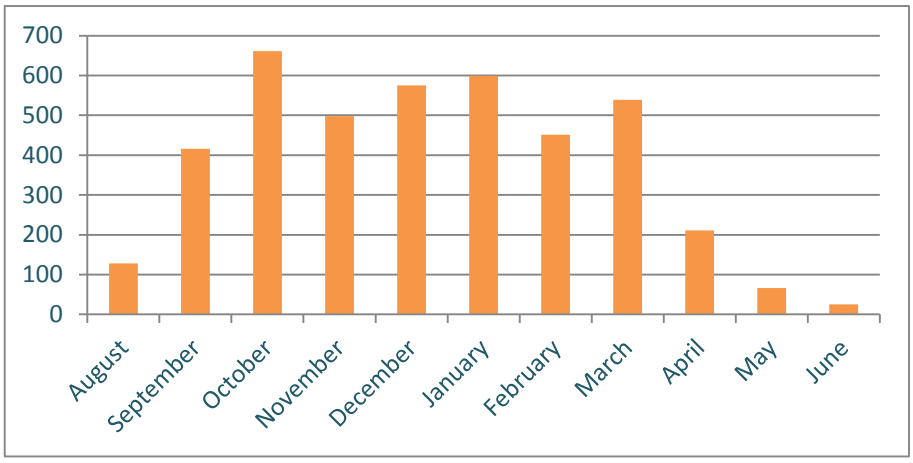

Fig. 2: Number of starts per month. July did not have any starts.

Most of the starts were in the North Island, (2924 / 4168). Across the three seasons, the distribution of starts between the islands differed, which was in part due to the national championships being held in the south island in the 2011-2012 season *(Table 2)*. Even though there was a difference in the number of starts between both islands, the distribution of the starts in categories was similar with the novice and open category having most starters.

Season	North Island	South Island	Grand Total
2010-2011	70.29%	29.71%	100.00%
2011-2012	62.95%	37.05%	100.00%
2012-2013	78.00%	22.00%	100.00%
Grand Total	70.15%	29.85%	100.00%

Table 2: Percentage of starts per island and season

The 4,168 starts were all in competitions organised by one of 18 clubs or in the North Island, South Island or national championships. Twelve clubs organised the rides on the north island, while six clubs were located in the south island. There were 50 ride venues identified, however, of 20% of the starts the venue was unknown. The 50 ride venues were almost evenly distributed over the north and south island (26 on the north island, 24 on the south island).

Possible levels per ride included the categories novice, open, 1*, 2* or 3*. The open category had the highest number of starts, followed by the novice category and the 1*, 2* and 3* categories respectively. Most of the starts were in 40 km and 80 km rides. The 50 km and 90 km rides had the least competitors. *(Table 3)*.

Percentage of Starts	Ride distance (km)								
Ride category	40	50	60	80	90	100	120	160	Grand Total
Novice	22.84%	0.67%	1.08%	11.30%	0.10%	0.00%	0.00%	0.00%	35.99%
Open	16.77%	0.86%	3.26%	19.19%	0.53%	1.73%	0.31%	0.00%	42.66%
1*	0.00%	0.00%	0.00%	5.01%	1.75%	4.01%	0.00%	0.00%	10.77%
2*	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.01%	0.00%	7.01%
3*	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.57%	3.57%
Grand Total	39.61%	1.54%	4.34%	35.51%	2.38%	5.73%	7.32%	3.57%	100.00%

Table 3: Percentage of starts per ride distance and ride category

The novice, open and 1* category can contain more than one different distance. This is different from the 2* and 3* category, which can only be a 120 km and 160 km ride respectively *(fig.3)*.

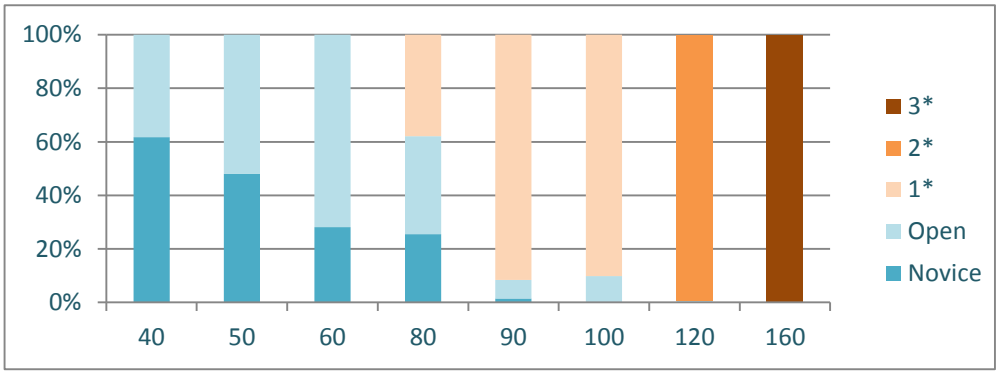

Fig. 3: Percentage of starts per ride distance and ride category.

The season starts off with only novice and open starts, but as the season progresses higher levels starts are included. This continues until April, when the highest percentage of 3* starts take place. After April, there are only novice and open starts for the rest of the season.

From the 4,168 starts, 3,671 had records of the total ride time. From these records, we excluded the starts that did not qualify because sometimes the elimination happened between loops, which could lead to a total ride time that wasn't representative for the whole distance. This generated 2400 results of qualified starters that had total time records. *(fig.4)*.

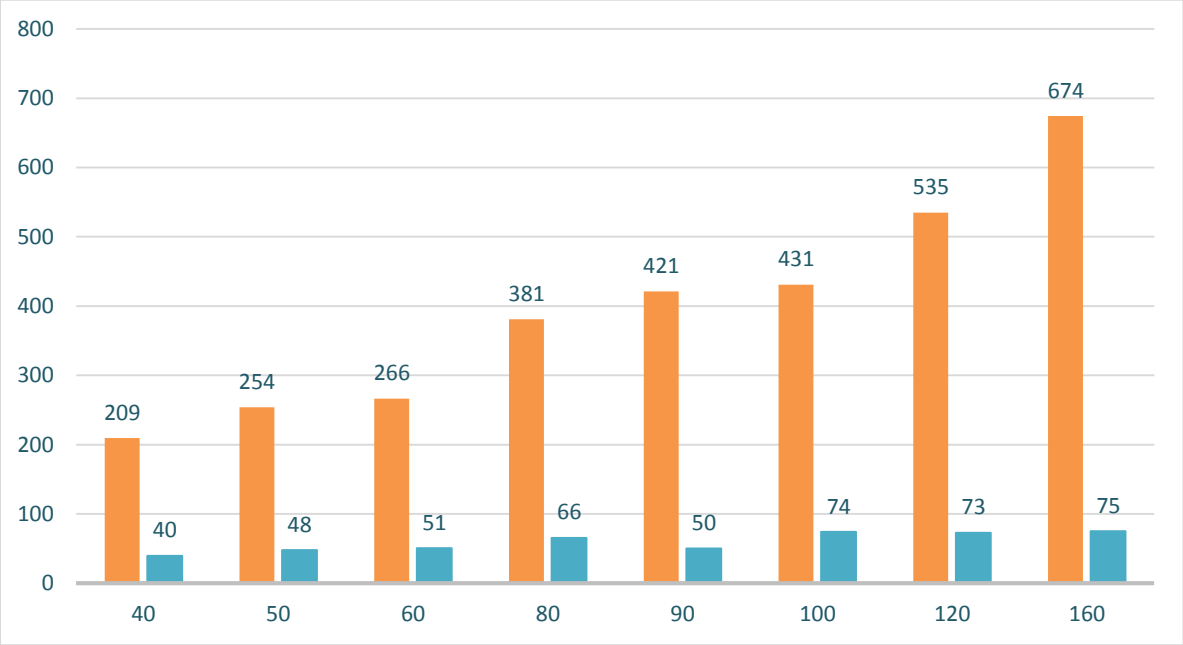

Fig.4: Mean total time in minutes per ride distance in yellow. In blue the standard deviation per ride distance.

Metabolic eliminations

Thirteen starts did not have records of the result of the ride. From the 4,155 starts that were left, only 65 were eliminated because of metabolic reasons. The overall metabolic elimination rate in this study was 1.6%. *(Table 4)*.

Season	Not eliminated for metabolic reasons	Eliminated for metabolic reasons	Grand Total
2010-2011	98%	2%	100.00%
2011-2012	99%	1%	100.00%
2012-2013	98%	2%	100.00%
Grand Total	98%	2%	100.00%

Table 4: Elimination rate for metabolic eliminations per season

There was quite a difference between the metabolic elimination rate of the national championships, North Island championships, South Island championships and 'regular' club rides. At the nationals, 5% of the horses were eliminated for metabolic reasons. The lowest metabolic elimination rate (1%) occurred in rides that were regular club rides.

As seen in figure 5, the highest percentage of metabolic eliminations were in 160 km rides. After that, 120 km rides had the highest percentage of metabolic eliminations followed by the 60 km rides. Therefore, it is only logical that the 2* and 3* categories also had the highest elimination percentages. When looking only at rides ≥100 km, the metabolic elimination rate was 4%.

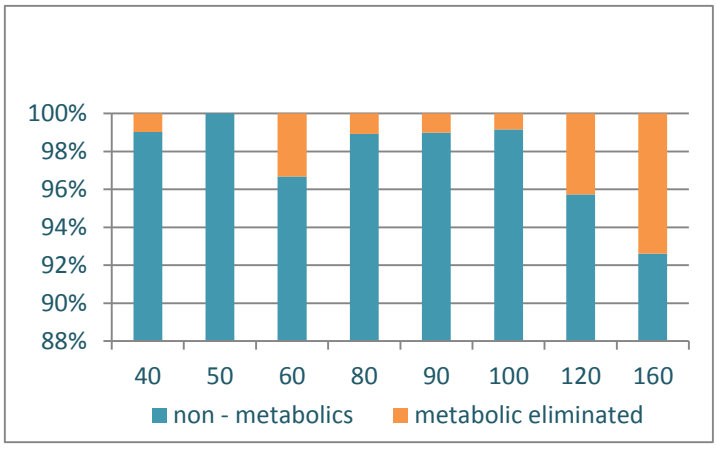

Fig. 5: Elimination rate for metabolic reasons per ride distance

Figure 6 shows the metabolic elimination rate per month, with in March and April the highest elimination rates (4%) of all starts.

The difference between elimination rates between islands was small (2% for the north island and 1% for the south island).

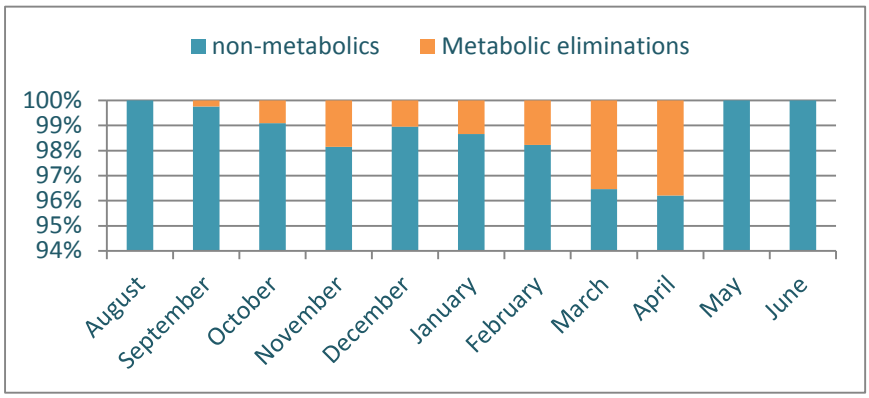

Fig. 6: Metabolic elimination rate per month

There was no effect of horse gender on metabolic elimination. The horse age category 6-10 years old has the highest percentage of metabolic eliminations (1.75%) *(Table 5)*.

Age category	Not eliminated for metabolic reasons	Eliminated for metabolic reasons	Metabolic elimination rate	Grand Total
<6	138	1	0.72%	139
6-10	2756	49	1.75%	2805
11-15	876	11	1.24%	887
16-20	170	2	1.16%	172
>20	6	0	0.00%	6
Grand Total	3946	63	1.57%	4009

Table 5: Number of starts and metabolic elimination rate per age category.

Statistical Analysis

A chi-square test showed that the odds for metabolic elimination were higher when entering a 60 km ($p<0.01$, OR 3.4779, 95% CI 1.3435 – 9.0031), a 120 km ($p<0.01$, OR 4.5161, 95% CI 2.1495 – 9.4879) or a 160 km ($p<0.01$, OR 8.0856, 95% CI 3.6802 – 17.7644) ride compared with entering a 40 km ride.

Also, entering a 2* ($p<0.01$, OR 3.8896, 95% CI 1.9255 – 7.8572) and 3* ($p<0.01$, OR 6.6539, 95% CI 3.1437 – 14.0835) ride increased the odds of metabolic elimination compared to entering an open ride.

With respect to month effect the month October was marked as baseline because it had the highest number of starts. Compared with October, March ($p<0.01$, OR 4.0042, 95% CI 1.5877 – 10.0986) and April ($p<0.01$, OR 4.3021, 95% CI 1.4754 – 12.5444) both had a significantly higher risk for metabolic elimination.

There was also a significant difference between the types of starts. There was a significantly higher risk for metabolic elimination when entering the national championships ($p<0.01$, OR 4.3545, 95% CI 2.3960 – 7.9139) compared with entering club rides or rides in the north or south island championships. Ride location, rider gender, horse gender, horse age and season all did not have a significant effect.

Variables with p-values <0.21 were entered in a multivariable analysis. Aside from the risk factors with a $p<0.05$ value as mentioned above, ride season was also included because of the p-value for 2010-2011 compared with 2011-2012 ($p=0.1518$). Table 6 shows the results of the multivariable analysis.

Risk factor	Variable	p-value	Odds ratio	95% confidence interval
Ride Month	August	-	-	-
	September	0.217	0.2629	0.0315 - 2.1925
	October	baseline	baseline	baseline
	November	0.242	1.8876	0.6518 - 5.4665
	December	0.842	1.1229	0.3589 - 3.5135
	January	0.816	1.1402	0.3772 - 3.4471
	February	0.385	1.6211	0.5445 - 4.8263
	March	0.016	3.2687	1.2479 - 8.5618
	April	0.215	2.1467	0.6418 - 7.1810
	May	-	-	-
	June	-	-	-
Ride level	Novice	0.981	1.008	0.5276 - 1.9256
	Open	baseline	baseline	baseline
	1*	0.122	0.378	0.1102 - 1.2970
	2*	0.008	2.7018	1.2937 - 5.6424
	3*	0.001	4.3112	1.8499 - 10.0473

Table 6: The results of the multivariable analysis. There are no results for the months August, May and June since there were no metabolic eliminations in those months.

Discussion

Descriptive results

This is the first study performed on endurance rides and their metabolic elimination rate in New Zealand. The study provides an overview of the national endurance sport and data for comparison with international endurance rides. A number of risk factors were evaluated, but only a few proved to be significantly associated with metabolic elimination.

Endurance riding in New Zealand has a seasonal structure, as most horses are being spelled in winter for a couple of months. This results in an uneven distribution of starts per month and at the start of the season (August and September) only the shorter distances are being ridden. The horses that have been spelled in the winter aren't fully in shape yet, so the shorter rides are used for build-up. As the season progresses there are more longer-distance rides which are being entered with the aim to reach the goal set for the season, or as a build-up for even longer distances. Many riders design their season competition programme with the goal of competing at the North Island, South Island or national championships. The competitive season ends for most riders after these championships with the national championships being held at Easter.

The national championships are also an important factor in the distribution of the starts between islands per season. The island on which the national championships are being held changes every year. In 2011 and 2013 it was on the North Island, while in 2012 the national championships were located at the South Island. This explains the difference in the distribution of starts between islands per season.

Metabolic elimination

The prevalence of elimination for metabolic reasons (1.56%) in this study is much lower than that reported in other studies that report figures varying from 4.2% to 53.7%. A contributing factor to this low prevalence may be incompleteness of some data, or lack of (complete) information on the reasons for being vetted-out. Another possibility for the difference in metabolic elimination rate are the specific differences of the conditions in the countries where the studies are performed. Especially climate and terrain, but also horse management and riding style are possible risk factors that differ internationally. The differences in climate can be of influence because of differences in humidity and temperature. This interacts with the sweat production and cooling system of the horse,

and therefor with the hydration status. A study reporting a very high (53.7%) metabolic elimination rate was performed during one endurance event in Malaysia with 67 horses. [13] It is most likely, that because of Malaysia's tropical climate, the endurance horses there get more quickly dehydrated, causing them to be vetted out for metabolic reasons more often. A difference between terrains of different countries can also be a reason for the difference in metabolic elimination rates. New Zealand has a landscape with many hills that can get quite steep. Most riders ride more carefully on steep terrain, which makes them go slower or are lenient with their horse by riding at lower speed in steep terrain, provoking less exhaustion. Also the general riding style can be different internationally. The New Zealand people and lifestyle are thought of to be laid-back and easy going, which could also be reflected in their riding style. This would mean that the horses get pushed less hard compared with other countries. Other big influences in any competition are training, feeding and other management aspects. These risk factors haven't been investigated in this study, but it is assumed that these are major influences in the outcome of an endurance competition and have an influence on the metabolic elimination rate.

At the national level, the most important risk factors for metabolic elimination seem to be the ride level and the month March. This study showed that a big factor in the risk for metabolic elimination is riding in a 2* or 3* ride. The odds for getting metabolically eliminated is 2.7 times higher for riding in a 2* ride and 4.3 times higher for riding in a 3* ride compared with competing in rides of the open category. Even without distance in the multivariable model this stayed significant. Riding style could be a big influence in the elimination rate between ride categories. It is possible that the highest categories are ridden more competitively, which could lead to more exhaustion of the horse.

Competing in the month March has about 3x higher odds for metabolic elimination compared with competing in the month October. At first, it was assumed that this was caused by the Championship events that take place in March, but multivariable analysis showed that even without the type of ride in the model March still has significantly higher odds for metabolic elimination compared with October. Another possible explanation for this significance can be the weather conditions. Although March usually isn't the hottest month of the year, the average temperature is still 22 °C, only 2°C less than the hottest month, which is February. It is possible, that because of the lowering temperatures in March, riders underestimate the temperature and the impact the temperature has on the horse's electrolyte balance and hydration status.

Limitations of the study

A limitation of this study was that not every elimination had a reason for vetting out recorded. Also, some eliminations only mentioned 'treatment' as the reason for vet-out. Although there's a big chance that most of these horses were treated for metabolic problems, there was no proof of that.

Unfortunately it was not possible to compare the average speed of the endurance rides over the investigated seasons. This was because only 302 starts had speed records. The starts from season 2012-2013 did not have any speed records. Therefore, because of this low number of records it is not possible to determine whether the speed has been increasing over the last few years in New Zealand.

The fact that not the entire season 2012-2013 was used in this research made it sometimes more difficult to compare the three seasons. This is of course obvious when comparing the number of starts per season.

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