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The feeding and management of Thoroughbred and Standardbred Racehorses displaying clinical signs of recurrent exertional rhabdomyolysis

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Abstract

Data on the feeding and management of racehorses and the prevalence of trainer-identified recurrent exertional rhabdomyolysis (RER) were collected via a cross-sectional face-to-face survey of 100 registered Thoroughbred and Standardbred trainers (n=1,771 horses). Data were collected on the number of horses in full work, number displaying signs of RER, gender, and age (≤ 3 or > 3 years), amount and type of forage available, and weights of all forages and concentrates. The estimated crude RER prevalence was 8.4% (95% CI 7.2-10.8%) with no significant difference in prevalence between breeds. Premixed feeds were fed to 98% (1,742/1,771) of the total population, and 99% (148/149) of the horses that displayed signs of RER. Feeds specially formulated for horses that “tie-up” were fed to 50% (75/149) of horses displaying RER signs. However, 64% (48/75) of these had additional grain, or a standard racing feed, included in the diet. Average starch levels (% of DE) provided to horses displaying signs of RER were $33.4 \pm 1.1\%$. Only 7% (11/149) of horses displaying signs of RER were provided with dietary starch levels at the recommended allowance ($< 20\%$ of DE).

Introduction

Within New Zealand, 55% of Thoroughbreds and 50% of Standardbreds that are registered with a trainer never start in a race (Tanner et al. 2010; 2011). The majority of horses lost from training exit due to trainer decisions resulting from poor performance or lack of talent. Musculoskeletal injury accounts for the majority of the involuntary losses and 78% of all involuntary interruptions to training (days unable to train) (Perkins et al. 2005a,b; Bolwell et al. 2016). Injuries contributing to lameness are the most common musculoskeletal reasons for involuntary losses, with data available on the prevalence and risk factors for conditions such as dorsal metacarpal disease, tendon and ligament injuries and catastrophic injuries (Perkins et al. 2005a,b; Bolwell et al. 2016). While these are reported by trainers to be the common problems, the contribution of conditions such as recurrent exertional rhabdomyolysis (RER) or “tying up” to the proportion of involuntary losses in both Thoroughbreds and Standardbreds is currently unknown.

Exertional rhabdomyolysis (ER) is the overarching term for the various disorders causing muscle pain and stiffness that are triggered by exercise (Harris & Rivero 2017). It is the most common equine myopathy (MacLeay et al. 1999b) that affects most athletic breeds (Harris & Rivero 2017). Chronic and recurrent exertional rhabdomyolysis (RER) represent a syndrome of repeated exercise-associated muscle damage (McKenzie & Firshman 2009). This is accompanied by increased activity of muscle enzymes, often with mild exertion at lower training intensity levels below the anaerobic threshold (Valberg 2005). While each type of exertional rhabdomyolysis has been known to occur in a variety of different breeds (Valberg 2010; Harris & Rivero 2017), there is potential economic loss to the racing industries with a high prevalence of RER (5-10%) reported

in Thoroughbreds (MacLeay et al. 1999a,b). Symptoms of RER are easily identifiable and most trainers are able to identify the condition immediately. A history of poor performance can be the main presenting sign (Martin et al. 2000), however, further outward signs include muscle cramping, stiffness, shifting lameness, sweating, tachypnoea (Aleman 2008; McKenzie et al. 2003), and lack of impulsion (Valberg 2005) which generally begin after 15 to 30 minutes of aerobic exercise (Valberg 2010). Continued exercise will often cause excessive sweating, increased respiratory rate and reluctance to move due to painful muscle contractures, commonly in the hindquarters (Valberg 2005; 2010). Modification of feeding and management have been shown to minimise the symptoms of RER: the current dietary recommendations for horses in intense work are to limit starch sources to less than 20% of daily energy and include at least 20% of energy requirements as fat (McKenzie & Firshman 2009; Valberg 2010; Harris & Rivero 2017).

While the prevalence of trainer identified RER has been investigated in various countries such as America, England, Sweden and Australia (MacLeay et al. 1999a; McGowan et al. 2002; Isgren et al. 2010; Cole et al 2004), the majority of the research is specific to Thoroughbreds and there is currently no published literature describing the prevalence of trainer-identified RER in New Zealand. In addition, there are no reports within the international literature, or within New Zealand, on the feeding or management decisions made by Standardbred or Thoroughbred racehorse trainers regarding horses with symptoms of RER. The aim of this study is to estimate the prevalence of trainer-identified RER and describe the associated feeding practices of Thoroughbred and Standardbred racehorses with and without clinical signs of RER in New Zealand.

Materials and methods

The population of interest was horses in race training with trainers with a public licence, or permit to train (~700 each for Thoroughbred and Standardbred). The aim was to sample 100 registered Thoroughbred and Standardbred racehorse trainers with at least one horse currently in full race work. At each of the following training centres (Pukekohe, Cambridge, Palmerston North, Christchurch, Invercargill) throughout the North and the South Islands large-scale trainers known to one of the authors (LW) were selected. After an introductory phone call, a visit to their stables and training facilities was conducted. Further trainers were then recruited at the same training venue, or area, using a snowball-sampling technique beginning with a referral from the initial trainer contacted. This process was repeated until 100 trainers were recruited.

The survey was developed using a number of iterations and testing using racing-industry personnel (none of which were included in the subsequent survey). The survey was then pilot tested on one trainer with < 10 horses and one trainer with > 20 horses in work. After two iterations of the survey, data capture was started.

Prior to recruitment, the trainers were provided with a one-page summary and overview of the study. The symptoms of the condition (RER) were described in detail, by the interviewer (LW), to each trainer, and if they were not aware of “tying up” and how to identify the symptoms, they were excluded from the study. The survey consisted of four sections of open and closed questions by one interviewer (LW). Initially trainers were asked for demographic data on the number of horses in work, their age and sex, and the proportion of horses trained that were showing symptoms of RER, before asking for specific details of diets for horses that were displaying symptoms of RER and horses that were not. Further questions were also asked relating to management, including size of the turn-out area each horse had access to. The survey concluded with two qualitative questions relating to why the trainer adopted the current feeding practices for the horses with RER, what they believed were the risk factors of the condition, and what nutritional measures they thought they should be taking to manage the condition.

All surveys were carried out in person at the trainers' stables. The trainers provided a description of the supplementary feed offered to the horses, including the quantity, brand and/or type of feed offered. All hay, fibre products and concentrate feeds offered in a daily diet for all horses were weighed and expressed as weight of dry matter offered (Verhaar et al. 2014). Feeds were classified as added roughages, standard racing premixed (compound) feeds, specialty “tie up” premixed feeds, grains (such as oats, barley or maize), feeds formulated and marketed as high-fat supplements, or miscellaneous (three feeds that were formulated for growing horses).

The digestible energy (DE), crude protein (CP), fat, fibre and starch levels for New Zealand hay and chaff types were obtained from reference data (five-year average) of

samples submitted for wet chemistry and near infrared (NIR) testing at a commercial nutrition laboratory (R J Hill Laboratories Limited, 28 Duke Street, Hamilton 3240, New Zealand). Total N concentration was determined using the Dumas method (AOAC protein 968.06, DM930.15, 925.10) and organic matter (OM) determined by ashing samples for 16 hours at 550°C (Randall et al. 2014). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined by the detergent procedures of Van Soest et al. (1991). *In vitro* OM digestibility (OMD) was determined by the enzymatic method of Roughan and Holland (1977). Hot water-soluble carbohydrate (HWSC) was determined using Nelson's determination of reducing sugars and pectin was determined using the Blumenkrantz method for uronic acid determination (McWilliam et al. 2004). Nutrient contents for branded ensiled roughages were obtained from literature provided by the manufacturer. National Research Council (NRC 2007) values for digestible energy, crude protein, fat, fibre and starch were used for all grains and other basic feed ingredients (e.g., sunflower seeds, linseed).

Digestible energy, crude protein, fat and fibre content of the premixed feeds were obtained from literature provided by the feed manufacturer (from either the published feed label details or the official company web page). Starch levels of premixed feeds were often not declared and were subsequently obtained from samples submitted to a commercial nutritional laboratory (R J Hill Laboratories Limited, 28 Duke Street, Hamilton 3240, New Zealand) through removal of the free sugars and enzymatic hydrolysis of starch using wet chemistry and NIR testing. All nutrient levels were initially reported in grams per kilogram. Fat was then converted to megajoules (MJ) to be expressed as a percentage of total dietary energy (MJ) by assuming a gross energy value of 9.5 mcal/kg (NRC 2007). Starch was converted to megajoules using an energy-partitioning calculator (Pagan 1998). All nutrient levels were reported on a dry matter basis and any nutrient values for commercial concentrates that were published “As Fed” were converted using a standard 90% dry matter value (Verhaar 2014).

Data were tested for normality using the Shapiro-Wilks test and are presented using simple descriptive statistics (mean ± standard error of the mean or deviation). Prevalence and respective confidence intervals were calculated using EpiInfo (CDC 2018). Odds ratios were calculated for the odds of a horse displaying signs of RER in a large or small stable (> 13 horses in full work and ≤ 13 horses in full work), and the odds of a horse displaying RER based on gender and age group (≤ 3 years and > 3 years) using EpiInfo (CDC 2018). An analysis of variance was used to calculate differences in feed values with horse breed and RER status as fixed effects using STATA IC12 (College Station, TX, USA)

Results

Data were collected on 995 Thoroughbreds and 776 Standardbreds (n=1,771 horses) trained by 53 and 46

trainers respectively (1 trainer trained both breeds). The majority of Thoroughbred trainers were based in the North Island (41/53, 77%) whereas the majority of Standardbred trainers were based in the South Island (34/46, 74%). The trainers of Thoroughbreds and Standardbreds had a mean of 15 (range 1-80) and 12 (2-45) horses “in work” respectively at the time of the survey. Based on estimates from the literature, this sample represented 18% (995/5,500) of the Thoroughbreds and 39% (776/2,000) of the Standardbreds in race training. The distribution of horses across the training centres reflected the underlying distribution of most Thoroughbreds based in the North Island and most Standardbreds based and trained in the South Island. The estimated prevalence of horses identified by trainers as presenting with RER symptoms was 8.41% (95% CI 7.1-9.8) with a prevalence of 8.8% (95% CI 7.2-10.8) in Thoroughbreds and 7.9% (95% CI 6.2-10) in Standardbreds. There was no significant difference in prevalence between breeds. In both the Thoroughbred and Standardbred population, the prevalence was greater in fillies (≤ 3 years old), (14%, 95% CI 10.7-18% and 13.9%, 95% CI 10.4-18.3% respectively) than it was in mares (> 3 years old) or the male population of any age.

The lack of available bodyweight data prevents the comparison among horses, or breeds, on a per kg bodyweight basis. Thoroughbreds (non-RER and RER)

were offered more concentrate (kg) per day than were Standardbreds and, hence, had greater values for digestible energy, crude protein and fat. Within breed, RER horses were fed less total concentrate, less DE, less starch and more fat ($P<0.05$) than were non-RER horses (Table 1).

The majority of Thoroughbred trainers (94%, 49/52) fed premixed feeds to 99% (897/907) of the non-RER horses. Of the Thoroughbred trainers that fed premixed feeds, 27% (13/49) fed only the premix and 73% (36/49) added other ingredients to the premixed feeds. Of these trainers, most added either grains such as oats, barley or maize (72%; 26/36) or a vegetable fat source (39%; 14/36) and a few (11%; 4/36) added both a grain and a fat to the premix or premixes (Table 2).

Most Standardbred trainers (96%, 45/47) fed premixed feeds to 97% (697/715) of the non-RER horses. Of these trainers, few (4%; 2/45) fed premixes on their own. The majority of those adding to the premix added grain (76%; 34/45) half added a fat source (53%; 24/45), and 33% (15/45) added both a grain and a fat to the premix or premixes. Grain provided as the main concentrate was fed by only 6% (3/52) of Thoroughbred and 4% (2/47) Standardbred trainers.

Almost all trainers with RER horses fed premixed feeds. The exception was one Thoroughbred trainer that fed only grain combined with oil or a high-fat supplement,

Table 1 Daily feed offered and estimated nutrients (mean and standard error) from concentrates and roughage in a population of 1,771 Thoroughbred and Standardbred racehorses trained by 100 different trainers in New Zealand.

	Thoroughbred		Standardbred	
	Non RER Mean \pm sem	RER Mean \pm sem	Non RER Mean \pm sem	RER Mean \pm sem
Concentrates offered				
Conc (kg DM)	6.55 \pm 0.17 ^A	5.63 \pm 0.15*	4.96 \pm 0.15 ^B	4.12 \pm 0.16*
DE (MJ)	95.35 \pm 2.45 ^A	84.34 \pm 2.33*	73.60 \pm 2.17 ^B	62.93 \pm 2.40*
CP (g)	908.02 \pm 26.99 ^A	828.22 \pm 24.23	674.29 \pm 20.25 ^B	584.45 \pm 22.44*
CP (g)/kg DM	138.35 \pm 1.62 ^A	147.57 \pm 1.72*	131.33 \pm 2.68 ^B	132.75 \pm 3.69
Fat (g)	446.01 \pm 16.36 ^A	458.17 \pm 19.17	333.78 \pm 13.03 ^B	342.42 \pm 14.71
Fat (g)/kg DM	68.02 \pm 1.95	81.97 \pm 2.78*	66.45 \pm 2.64	82.65 \pm 4.47*
Fibre (g)	633.41 \pm 24.23	481.27 \pm 18.47*	456.33 \pm 20.11	361.81 \pm 23.53
Fibre (g)/kg DM	96.42 \pm 2.28	85.10 \pm 2.05*	86.85 \pm 2.62	83.35 \pm 5.36
Starch (g)	2,664.68 \pm 81.74	2,089.19 \pm 83.97*	2,612.87 \pm 94.84	1,626.90 \pm 83.80*
Starch (g)/kg DM	408.79 \pm 6.8 ^A	365.39 \pm 8.60*	510.81 \pm 22.68 ^B	364.22 \pm 13.47*
Added forages				
Kg DM	4.82 \pm 0.20	4.82 \pm 0.20	3.46 \pm 0.20	3.46 \pm 0.20
DE (MJ)	45.65 \pm 2.41	45.65 \pm 2.41	33.14 \pm 2.30	33.14 \pm 2.30
CP (g)	644.56 \pm 32.37	644.56 \pm 32.37	445.99 \pm 26	445.99 \pm 26
Fat (g)	119.92 \pm 5.46	119.92 \pm 5.46	81.48 \pm 4.61	81.48 \pm 4.61
Fibre (g)	1,368.20 \pm 56.36	1,368.20 \pm 56.36	976.07 \pm 55.96	976.07 \pm 55.96
Starch (g)	103.82 \pm 5.55	103.82 \pm 5.55	77.12 \pm 4.55	77.12 \pm 4.55
Total				
DE (MJ)	140.92 \pm 3.13	130.13 \pm 3.30	106.37 \pm 3.65	97.36 \pm 4.28
CP (g)	1,546.79 \pm 41.99	1,490.45 \pm 42.30	1,116.43 \pm 37.92	1,011.96 \pm 38.92
Fat (g)	565.29 \pm 17.57	586.87 \pm 21.44	414.33 \pm 14.32	426.10 \pm 16.45
Fibre (g)	2,000.93 \pm 55.09	1,879.50 \pm 59.46	1,426.89 \pm 61.14	1,346.61.03 \pm 70.45
Starch (g)	2,767.89 \pm 82.13	2,220.88 \pm 83.57	2,637.64 \pm 102.22	1,709.20 \pm 85.66
C:R DM Basis	6.6 \pm 0.17:4.8 \pm 0.20	5.6 \pm 0.15:4.8 \pm 0.20	5.0 \pm 0.15:3.5 \pm 0.20	4.1 \pm 0.16:3.5 \pm 0.20

*Footnote: Capital letter superscripts indicate significant difference between breed for non-RER feed values. A * superscript indicates that differences between RER and non-RER horses within breed are significantly different ($P<0.05$).

Table 2 Main feed composition of the diet offered to a population of Thoroughbred (n = 995) and Standardbred (n = 776) racehorses trained by 100 different trainers in New Zealand.

Diet	Thoroughbred				Standardbred			
	Trainers	Horses	As Fed (kg) ^a	Energy DE MJ ^a	Trainers	Horses	Amount of concentrate fed (kg) ^a	Concentrate DE MJ ^a
Grain only (non-RER)	4% (2/52)	0.8% (7/907)	3.9±0.98	58.5±14.69	2% (1/47)	1% (10/715)	4.6	69
RER	0	0	0	0	0	0	0	0
Premix only (non-RER)	25% (13/52)	30% (272/907)	6.6±0.08	96.7±1.22	4% (2/47)	4% (26/715)	5.5±0.14	79.5±1.27
RER	51% (19/37)	61% (54/88)	5.3±0.21	80.1±3.36	24% (6/25)	13% (8/61)	4±0.36	59.2±5.45
Premix plus grain (non-RER)	42% (22/52)	43% (394/907)	7.1±0.1	100±1.26	40% (19/47)	42% (302/715)	5±0.07	71±0.98
RER	16% (6/37)	14% (12/88)	6.7±0.43	95.4±6.24	32% (8/25)	38% (23/61)	5±0.43	73±5.91
Premix plus fat or oil (non-RER)	19% (10/52)	19% (169/907)	6.1±0.1	92±1.5	19% (9/47)	16% (111/715)	4.3±0.12	65±1.69
RER	27% (10/37)	23% (20/88)	5.7±0.27	86.6±4.11	16% (4/25)	16% (10/61)	4±0.28	61.6±3.64
Grain plus fat or oil (non-RER)	2% (1/52)	0.3 (3/907)	4.5	66.3	2% (1/47)	1% (8/715)	6	95
RER	3% (1/37)	1% (1/88)	5.95	95.1	0	0	0	0
Premix plus grain plus fat or oil (non-RER)	8% (4/52)	7% (62/907)	6.5±0.3	99.5±4.7	32% (15/47)	36% (258/715)	5.3±0.06	77.9±0.81
RER	3% (1/37)	1% (1/88)	7	104	28% (7/25)	33% (20/61)	4±0.28	60±3.33

^aData presented as mean and standard error of the mean

which was the same ration fed to the horses that didn't show RER signs (Table 2). Half the Thoroughbred trainers feeding premixed feeds (53%; 19/36) fed only premixed feeds to 61% (54/88) of the total population of horses displaying symptoms of RER (Table 2). Most trainers added fat (31%; 11/36), some added grain (19%; 7/36), and few (3%; 1/36) added both grains and an oil or a high-fat supplement. Premixed feeds specifically formulated for horses that "tie up" were fed by 46% (17/37) of Thoroughbred trainers to 51% (45/88) of horses. Few of the trainers that fed specialty "tying up feeds" combined grain with the premix (18%; 3/17) and five trainers (29%) combined the "tie up" feed with a standard racing feed.

All 25 Standardbred trainers fed premixed feeds to their horses displaying signs of RER. In comparison to Thoroughbred trainers, fewer Standardbred trainers fed only premixed feeds (24%; 6/25 to 13%; 8/61 horses). Most trainers added additional ingredients to premixed feeds in the diets (76%; 19/25), with 79% (15/19) of trainers that added ingredients adding grains, 58% (11/19) adding fat and 37% (7/19) adding both a grain and a fat source to the premix or premixes in the diet.

Premixed feeds specifically designed for horses that "tie up" were fed by 32% (8/25) of Standardbred trainers to 49% (30/61) of horses, and 75% of these trainers (6/8) combined them with a grain. No Standardbred trainers combined specialty "tying up" feeds with other premixed feeds designed for racehorses.

A number of Thoroughbred or Standardbred trainers specifically removed the grain from the horse's diet if they showed signs of RER (22%; 8/37 and 28%; 7/25 respectively) and few Thoroughbred or Standardbred trainers specifically added oil or a high-fat supplement to the horse's diet if it showed signs of RER (5%; 2/37 and 8%; 2/25) respectively.

Most RER horses, irrespective of breed, were fed higher levels (percentage) of starch within the diet than recommend in other reports (McKenzie & Firshman 2009; Valberg 2010; Harris & Rivero 2017), with only three trainers feeding below 20% starch as a proportion of energy. Dietary starch levels fed by both Thoroughbred and Standardbred trainers to RER horses varied from 11.7% to 55.6% of total energy with a mean of 33.4±1.1%. Two of the trainers feeding starch at the recommended levels to their RER horses were feeding feeds designed for "tying up" and the other trainer was feeding a standard racing feed at low levels (2.4 kg/d).

Compared to the number of trainers that fed the recommended level of starch to RER horses, a higher proportion of trainers provided the recommended ≥ 20% of energy from fat (27%; 17/62) to 38% of horses (56/149) displaying RER signs. Dietary fat levels as percentage of energy fed by both Thoroughbred and Standardbred trainers ranged from 10.5% to 30.3% with a mean of 17.5±0.6%. Of the trainers feeding fat at the recommended levels to their RER horses, 65% (11/17) were adding oil or a high-

fat supplement. If they weren't adding fat, most trainers feeding adequate fat were feeding a specialty "tie up" feed (83%; 5/6).

One Thoroughbred trainer and two Standardbred trainers provided both < 20% starch and \geq 20% of fat as a total of energy requirements to their horses displaying RER signs.

Discussion

The prevalence of trainer-reported RER in New Zealand Thoroughbreds (8.8%) was within the range of 5-10% reported worldwide (MacLeay et al. 1999a, b; Cole et al. 2004), and similar to the prevalence reported for Swedish Standardbreds (6.4%) (Isgren et al. 2010). The higher prevalence identified in fillies (\leq 3 year old) reflected the increased risk reported for two-year-old fillies (MacLeay et al. 1999a, b; McGowan et al. 2002).

The quantity of concentrate offered to Thoroughbred racehorses (non-RER) was approximately 1 kg higher than that reported in an earlier New Zealand study (5.5 ± 0.16 kg, Williamson 2007). However, the current quantities were still lower than the reported levels offered to Thoroughbred racehorses in Australia (7.3 ± 0.24 - 7.8 ± 0.16 kg; Richards et al. 2006; Southwood et al. 1993). There is a lack of literature on the feeding of Standardbreds during racing, and the lower level of concentrates offered to Standardbreds in New Zealand (5 ± 0.15 kg) could be reflective of the higher level of pasture access received than Thoroughbreds, their smaller size (~30-50 kgs smaller than Thoroughbreds) and thriftier phenotype. Unfortunately bodyweight data was not able to be collected and, thus, prevented comparison on a per kg body weight basis. However, assumptions based on reported bodyweights (475kgs Thoroughbred, 436 kgs Standardbred (Coleman et al. 2002; Takahashi and Takahashi 2017)) indicate that on a per kg basis, Standardbreds were offered 20% less DE, indicating that body weight alone may not be the primary reason for the differences in feed quantities offered between breeds.

The proportion of New Zealand Thoroughbred trainers feeding pre-mixes has increased from 86% (Williamson 2007) to 99% of horses in this survey. This change may be due to premixed or compound feeds providing greater consistency of nutrition and increased convenience for the trainer. However, dietary manipulation and the proportion of New Zealand Thoroughbred trainers choosing to add grains to premixed feeds has increased from 54% (Williamson 2007) to 73%, and this practice was even higher in Standardbred trainers (91%).

Over half the trainers surveyed were feeding a standard pre-mix formulated for racehorses to RER horses (59%), and many of these trainers (59%) were adding additional grain. Only 24% of these trainers removed the grain from the horse's diets if they displayed RER signs. However, many of these (60%) continued to feed the RER horses a standard race feed.

The premix feeds in the study that are marketed as suitable for horses that "tie up" all contained lower starch

and higher fat and fibre levels than did the standard race feeds. While nearly half the horses were fed "tying up" feeds, most trainers were also providing grain (46%) or standard race feeds (29%), elevating the dietary starch levels above the recommended levels. This displays a lack of understanding regarding how feeds specifically formulated for tying up are formulated, the role of starch in the diet, and the need for a lower-starch diet in the management of RER.

This lack of knowledge around correct feeding practices for RER horses, especially the appropriate energy sources, implies that there has been poor dissemination of the recommended feeding practices for RER horses within the New Zealand racing community. Further investigation is required around current feeding practices, and the information sources used by trainers to obtain nutritional advice, especially specialist advice for conditions such as RER.

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