Equine Veterinary Journal

Equine Veterinary Journal ISSN 0425-1644
DOI: 10.1111/j.2042-3306.2011.00534.x

The association of 2-year-old training milestones with career length and racing success in a sample of Thoroughbred horses in New Zealand

J. C. TANNER*, C. W. ROGERS and E. C. FIRTH†

Massey Equine, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand
†National Research Centre for Growth and Development, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand.

*Correspondence email: J.C.Tanner@massey.ac.nz; Received: 27.07.11; Accepted: 19.11.11

Summary

Reasons for performing study: There is increasing evidence that exercise early in life has a positive effect on musculoskeletal health. At present, there is little whole population research investigating the effect of racing as 2-year-olds on future racing career.
Objectives: To investigate the association between attaining training milestones as 2-year-olds with length of career and racing success in Thoroughbred horses in New Zealand.
Methods: Retrospective data were obtained of the 2001/02-born Thoroughbred foal crop. The 3 training milestones were: registered with a trainer, trialled and raced. The association of the training milestones with career length was measured using the outcomes: number of race starts and number of years raced, in a Cox regression model. Logistic regression models analysed the association of the training milestones with the outcomes: won or placed in a race. Linear regression was performed to assess the association of training milestones with total career earnings.
Results: Of 4683 horses in the population; 3152 horses were registered with a trainer, 2661 horses trialled and 2109 horses raced. Horses that raced as 2-year-olds had significantly ($P<0.001$) more race starts than those first raced as 3-year-olds or older, this was also true when the 2-year-old year data were omitted. Horses that raced as 2-year-olds had significantly ($P<0.001$) more years racing. Horses registered with a trainer, trialled or raced as 2-year-olds were more likely to have won or been placed in a race than those that achieved the milestones as 3-year-olds or older. Horses that first trialled and raced as 2-year-olds had greater total earnings than those that first trialled or raced at a later age.
Conclusions and potential relevance: Two-year-old training milestones had a strong association with positive racing career outcomes. Horses in training or racing as 2-year-olds may have better musculoskeletal health throughout life than horses that are first in training or racing at a later age.

Keywords: horse; Thoroughbred; racehorse; racing performance; 2-year-old

Introduction

Recent scientific evidence suggests that exercise early in life has a protective effect [1–3]. The positive influence of early exercise may not be restricted to the young foal but also the early onset of race training because some studies point to a positive association of an early start of a racing career and career length [4–6].

Internationally, there has been a steady decline in the annual Thoroughbred foal crop. In the United States, the Jockey Club has shown a decline in foal numbers since 1990 [7]. Similarly, the number of mares served within the Thoroughbred industry in New Zealand decreased from 10,176 in 1989 [8] to 6488 in the 2010 season [9]. Fewer foals in any given year cohort has a flow-on effect for many later years, in which fewer horses are available for training and thus fewer available to race. Furthermore, wastage studies have reported as many as 50% of Thoroughbred foals born fail to race [10,11] and wastage is a cause for concern within the racing industry as it has both welfare and financial implications. Musculoskeletal injuries (MSI) are one of the main causes of wastage and days lost from training [12–14]. Therefore, minimising the risk of MSI is of great importance. If early exercise were indeed to have a positive effect on musculoskeletal health then it may be possible to manipulate the initiation and structure of race training to reduce the risk of MSI or to reduce the number of involuntary interruptions to training [15].

Horses pass through the various stages from training through to racing by meeting various training milestones that are easily quantifiable and recognised by the industry. Three training milestones were used in this study. The first is 'Registered with a trainer' (REG), which is the official notification to New Zealand Thoroughbred Racing (NZTR) from a trainer that a horse is in training in his/her stable. The second training milestone is that a horse is 'Entered in a Trial' (TRIAL). Trials are competitive events managed by the New Zealand racing authorities, used to assess race potential and readiness, and to reveal potential to the betting public. The third training milestone is 'Competing in a race' (RACE) for the first time. For clarity and brevity in this paper, the 3 milestones are referred to by the abbreviations as shown above.

The aim of this article was to examine the association between achievement of these training milestones and racing success in a year cohort population of Thoroughbreds in New Zealand. It was hypothesised that Thoroughbred horses that attained a training milestone for the first time as 2-year-olds would have significantly longer and more successful racing careers than those that achieved the same milestone as 3-year-olds or older.

Materials and methods

Data

The study utilised retrospective data from the online official databases of the New Zealand Thoroughbred industry. An extract from the database of NZTR provided data for the 2001/02-born foal crop. Information available included horse identity, brand, sex, sire, dam, exports, imports, last registered trainer, the achievement (or not) of the 3 industry-recognised training milestones (REG, TRIAL and RACE), stratified by age group, number of career and annual trial and race starts for the years from 2003 and career and annual earnings. Trainer was the trainer of the horse at the time of data extraction and may not have been the trainer for that horse's entire career and was thus left out of statistical analysis. Data were current to the end of the horses' 7-year-old season. For statistical analysis, at each milestone the horses were categorised as follows; first registered with a trainer as a 2-year-old (REG_{2yo}), first registered with a trainer as a 3-year-old or older ($REG_{\geq 3yo}$), first trialled as a 2-year-old ($TRIAL_{2yo}$), first trialled as a 3-year-old or older ($TRIAL_{\geq 3yo}$), first raced as a 2-year-old ($RACE_{2yo}$), first raced as a 3-year-old or older ($RACE_{\geq 3yo}$).

Data analysis

Descriptive analysis: Horses were categorised as male or female as no castration records were available. Horses were excluded from the datasets if they were unregistered, exported at ≤1 year of age or imported at ≥2 years of age; those horses that had raced over jumps were excluded to remove potential bias. Data were structured for analysis in Excel and imported into STATA 11[a] for analysis. Frequencies were used to describe the number of REG, TRIAL and RACE horses within each year age group. Chi-square (χ^2) tests were used to compare the effect of sex on the 3 training milestones and within each age group.

Survival analysis: Time to end of racing were measured in both number of years raced and as number of race starts. Survival time commenced in the year in which the horse first raced for the number of years raced outcome or the horse's first race when time was measured as number of race starts. Exploratory analyses were conducted to assess the median survival time of each training milestone and Log Rank tests for equality of survivor functions were performed. Kaplan-Meier survival curves were produced to measure career length in both years raced and number of races. Cox regression analysis was performed using the Breslow method of handling ties to assess the association between binary descriptors of the 2-year-old training milestones as exposure variables with the outcomes number of years raced and number of race starts. Variables showing some univariable association (P<0.2) with the outcomes were evaluated in a multivariable model with each variable removed sequentially from the model in a backward stepwise fashion. Variables that were significant (P≤0.05) or that improved model fit (likelihood ratio test statistic (LRTS) P≤0.05) were retained in the model. The goodness-of-fit of the models were assessed using the Nelson-Aalen cumulative hazard function plotted with Cox-Snell residuals [16].

Logistic regression: Simple logistic regression was performed on the 3 training milestones as exposure variables influencing the outcomes: 1) won a race and 2) placed (first, second or third) in a race. Variables showing some univariable association (P<0.2) with each outcome were evaluated in a multivariable logistic regression model with each variable removed sequentially from the full model in a backward stepwise fashion. Exposure variables with a Wald-test P≤0.05 or that improved model fit (LRTS P≤0.05) were retained in the model. An assessment of goodness-of-fit of the models were performed using the Hosmer-Lemeshow test statistic [17].

Linear regression: Linear regression was used to test the association between the training milestones as exposure variables and the continuous outcome natural logarithm of total earnings + $100 (subsequently referred to as Total Earnings). The natural logarithm (ln) transformation of earnings was used to improve the normal distribution of the data. The raw earnings of all horses that raced had $100 added to further improve normality. The training milestone variables were analysed with total earnings at a univariable level and those variables showing some association (P<0.2) with the outcome were evaluated in a multivariable linear regression model. The model was built with each variable being removed sequentially from the full model in a stepwise fashion. The variables showing a 2-tailed P≤0.05 or that improved model fit (LRTS P≤0.05) were retained in the final model. The continuous variable total race starts was centred prior to squaring and fitted as a quadratic term to improve overall model fit. Studentised residuals were plotted to test normality and multicollinearity was tested.

Results

Descriptive results

The 2001/02 Thoroughbred foal crop contained 5634 horses, of which 87 (1.5%) were not branded (and therefore not fully registered), 428 (7.6%) horses exported as foals or yearlings and 266 (4.7%) non-New Zealand born horses imported as 2-year-olds or older were removed from the dataset, as were 170 (3.0%) horses that raced as jumpers (hurdles and steeplechase). Therefore, 4683 (83.1%) horses (2230 [47.6%] males and 2453 [52.4%] females) were the study population.

There were a total of 3152 (67.3%) REG horses, 2661 (56.8%) TRIAL horses and 2109 (45.0%) RACE horses that had raced in 29,577 races by the end of their 7-year-old season. There were 1531 (32.7%) horses that failed to be registered with a trainer, 2022 (43.2%) that never trialled and 2574 (55.0%) horses that never raced. A total of 580 (12.4%) horses were exported as 2-year-olds or older prior to having a race in New Zealand. Of the horses that raced, 1038 (49.2%) (529 females and 509 males) won at least one race and 1346 (63.8%) (676 females and 670 males) were placed in at least one race by the end of their 7-year-old season. Overall, more (but not significantly more [P = 0.44]) female horses raced than males. However, within each age group, there was a significant sex effect on racing as 2-year-olds (P<0.001), 3-year-olds (P = 0.013), 5-year-olds (P = 0.05) and 6-year-olds and older (P = 0.003); there was no sex effect on racing in the 4-year-old year. Table 1 describes the number of horses to achieve each of the training milestones and the age at which they did so.

Survival analysis

Univariate analysis: REG_{2yo} horses had more median race starts (11 (interquartile range [IQR] 5–21) than $REG_{\geq 3yo}$ horses (8 race starts [IQR 3–18]). When the 2-year-old year was omitted from the race starts outcome, REG_{2yo} horses had 10 (IQR 4–20) race starts compared with 8 (IQR 3–18) for $REG_{\geq 3yo}$ horses. $TRIAL_{2yo}$ horses had 12 (IQR 5–22) race starts compared with 8 (IQR 3–19) races for $TRIAL_{\geq 3yo}$. When the 2-year-old year was omitted from the outcome, $TRIAL_{2yo}$ horses had 10 (IQR 4–20) race starts compared with 8 (IQR 3–18) race starts for $TRIAL_{\geq 3yo}$ horses. $RACE_{2yo}$ horses had 16 (IQR 8–25) race starts compared with 8 (IQR 3–18) race starts in $RACE_{\geq 3yo}$ horses. When the 2-year-old year was omitted from the outcome $RACE_{2yo}$ horses had 12 (IQR 5–23) race starts compared with 8 (IQR 3–18) race starts for $RACE_{\geq 3yo}$ horses. For the number of years raced outcome, $RACE_{2yo}$ horses had a median 3 years of racing (IQR 2–4) compared with 2 years racing (IQR 1–3) for $RACE_{\geq 3yo}$ horses.

Multivariable analysis: In the final multivariable models (Table 2) $RACE_{2yo}$ horses remained significant in all models as they had significantly less risk (P<0.001) of ceasing racing and thus were more likely to continue racing. Male horses were more likely to cease racing than female horses in the model outcome number of race starts and outcome number of race starts with the 2-year-old year omitted, but sex became nonsignificant with the

TABLE 1: The number and percentage of horses to achieve and age at attainment of training milestones within the 2001/02 born Thoroughbred foal crop

	Registered with trainer		Trialled		Raced	
Age (years)	Number	Percentage	Number	Percentage	Number	Percentage
2	1984	62.9	1318	49.5	443	21
3	871	27.6	919	34.5	1084	51.4
4	220	7	286	10.8	450	21.3
5	64	2	106	4	110	5.2
6–7	13	0.4	32	1.2	22	1
Total	3152	99.9	2661	100	2109	99.9

TABLE 2: Results of multivariable Cox regression models of the association between 2-year-old training milestones and 3 outcomes measuring career length; number of race starts, number of race starts (2-year-old year omitted) and number of years raced, for a population of Thoroughbred horses in New Zealand born in 2001/2002

	Coefficient	s.e.	P value	Hazard ratio	95% CI
Outcome: Number of race starts					
$Race_2$	-0.444	0.054	<0.001	0.641	0.577–0.713
Sex (male)	-0.169	0.044	<0.001	0.845	0.775–0.921
Outcome: Number of race starts (2-year-olds year omitted)					
$Race_2$	-0.288	0.054	<0.001	0.750	0.675–0.833
Sex (male)	-0.168	0.044	<0.001	0.845	0.775–0.921
Outcome: Number of years raced					
$Race_2$	-0.543	0.057	<0.001	0.581	0.520–0.651
Sex (male)	-0.080	0.044	0.07	0.923	0.847–1.006

number of years raced outcome. The Nelson-Aalen goodness-of-fit test indicated no evidence of lack of fit for the final model for the outcomes number of race starts and number of race starts with 2-year-old year omitted but there was some evidence of poor fit for the number of years raced outcome.

Logistic regression

The final multivariable logistic regression models for the outcomes; having won a race and being placed in a race are summarised in Table 3. The attainment of training milestones as a 2-year-old was significant across both outcomes modelled (P<0.001). Sex was significant for the outcome placed in a race (P<0.001) but not for the outcome won a race. The Hosmer-Lemeshow statistic for the won a race model was 0.01 (P = 0.99) and for the placed in a race model 3.41 (P = 0.49), indicating there was no evidence of lack of fit.

Linear regression

The variables REG_{2yo}, $TRIAL_{2yo}$ and $RACE_{2yo}$, sex and total race starts showed univariable association with the outcome Total Earnings. The final multivariable model is shown in Table 4. $TRIAL_{2yo}$ and $RACE_{2yo}$ horses had greater Total Earnings than horses that first trialled or raced at a later age. Male horses had greater Total Earnings than female horses. To improve model fit and r^2, total race starts was centred and fitted as a quadratic term resulting in an adjusted r^2 of 68.8%. Model diagnostics indicated that residuals were relatively randomly scattered around zero in a residual-vs.-fitted plot and the mean variance inflation factor (VIF) was 3.19.

Discussion

The aim was to investigate the association of 2-year-old training milestones with career length and racing success in a population of Thoroughbred horses in New Zealand. The data encapsulated the careers of an entire foal crop making it robust for population-based analysis. The failure of 32.7% (1531/4683) of horses to reach the first training milestone of being registered with a trainer implies a high percentage of wastage from the cohort studied, namely the 2001/02 born Thoroughbred cohort. This figure is similar to the approximately 32% previously reported by McCarthy [18] for Thoroughbreds across a number of foal crops in New Zealand and slightly lower than the 37.8% (2886/7640) of horses that fail to enter flat race training in the United Kingdom [11]. Regarding the TRIAL milestone, of the 2001/02 born Thoroughbred foals, 43.2% (2022/4683) did not trial, which represents a 10.5% attrition between the REG and the TRIAL milestones. The percentage of Thoroughbred horses that fail to trial is similar to the 40.3% of Standardbred horses failing to trial [19]. Of the study population, 55% (2574/4683) did not race in New Zealand, representing an 11.8% loss between the TRIAL and RACE milestones. As 12.4% (580/4683) of the population were exported as 2-year-olds or older prior to racing in New Zealand this would account for some of the losses between being registered with a trainer, trialling and racing. The demand for New Zealand Thoroughbreds in the Australian and Asian market is high [20] and horses that perform well at a trial are often sold directly to Australian buyers prior to racing. Other factors contributing to the loss of horses between these milestones may be lack of ability, MSI, death, or financial decisions of owners.

Most horses in the 2001/02 born population entered training and trialled as 2-year-olds, but of the horses that raced only 21% were $RACE_{2yo}$ horses. However, $RACE_{2yo}$ horses had significantly more race starts and more years racing than horses that started racing at a later age. Horses that were REG_{2yo} and $TRIAL_{2yo}$ had more median race starts than horses that achieved the milestones at a later age, but these milestones did not stay in the final Cox regression models. $RACE_{2yo}$ horses were at significantly less risk of ceasing racing, which indicates they are more likely to have more race starts and more years racing. The Cox regression models indicated that number of race starts was a better outcome for predicting career length than number of years raced. The number of race starts may be a more sensitive measure

TABLE 3: Results of multivariable logistic regression models of the variables significantly associated with the racing success outcomes: won a race and placed (first-to-third) in a race, for a population of Thoroughbred horses in New Zealand born in the 2001/2002 season

		Outcome: Won			Outcome: Placed		
		OR (95% CI)	Wald test	LRST P value	OR (95% CI)	Wald test	LRST P value
$RegTr_2$	No	Reference					
	Yes	2.39 (1.93–2.96)	<0.001		2.71 (2.23–3.29)	<0.001	
$Trial_2$	No	Reference					
	Yes	1.52 (1.23–1.87)	<0.001		1.48 (1.21–1.81)	<0.001	
$Race_2$	No	Reference		<0.001			<0.001
	Yes	3.91 (3.11–4.90)	<0.001		4.69 (3.67–5.99)	<0.001	
Sex	Female	Reference					
	Male	Not sig			1.17 (1.02–1.35)	<0.001	

OR = Odds ratio, CI = Confidence interval, LRST = Likelihood ratio test statistic.

TABLE 4: Multivariable linear regression model analysis with the variables significantly associated with total earnings for the 2001/2002 born New Zealand Thoroughbred foal crop

	Coefficient	95% CI	P value
Total race starts*	0.269	0.258–0.280	<0.001
Total race starts^2*	-0.003	-0.003–0.002	<0.001
Raced at 2 years	0.339	0.183–0.496	<0.001
Trialled at 2 years	0.270	0.144–0.396	<0.001
Sex (male)	0.315	0.198–0.431	<0.001
(Adjusted $r^2 = 0.688$, RMS Error = 1.359, P<0.001, n = 2109)			

CI = Confidence interval, RMS = Root mean square error, *centred by subtracting the mean value from total race starts prior to squaring.

of a horse's career length than number of years raced. As there was evidence of lack of fit in the Cox regression model for the number of years raced outcome this indicates that other variables were required in the model. The inclusion of exercise data and trainer in the model would probably improve model fit but were not available to be included in this dataset. Overall, $RACE_{2yo}$ horses showed the strongest association with career length and racing success across all models tested. $TRIAL_{2yo}$ horses had strong association with all measures of racing success, and even REG_{2yo} horses were more likely to win or be placed in a race than horses that achieved this milestone at a later age.

A recent study investigating risk factors for interruptions to training prior to first trial start in 2-year-old Thoroughbred racehorses found that risk of MSI interruption decreased with the accumulation of high-speed events in training [15]. The accumulation of high-speed exercise has a protective effect on the risk of fracture [21,22] and has been shown to be positively associated with racing performance [23]. However, training exercise data was not available for the 2001/02 born Thoroughbred foal crop. Similarly, the occurrence of injury was not recorded and this may be a confounding factor for not racing or being successful. Perkins *et al*. [13] found 20.9% of Thoroughbred horses had an involuntary exit from training in a population of Thoroughbred horses in New Zealand. Trainer has been shown to be significantly associated with racing performance [24] but was not analysed in our dataset as the current listed trainer at the time of data extraction may not have trained the horse for the duration of its career. Trainer effects may have an association with training milestones as it is the trainer's decision to bring a horse into training, start a horse in a trial and enter it in a race. Thus trainer decisions may affect the age at which horses enter training, trial and race. Furthermore, trainer-level factors such as quality of horse, horse management, veterinary care and nutrition may play an important role in training and subsequent racing performance [23].

The significant associations of 2-year-old training milestones with career length and success in this study are similar to those in a companion study into Standardbred horses born in the same year in New Zealand [19]. Thus even across different breeds of racehorse it appears that the 2-year-old year is of importance to future racing performance outcomes. Within the Thoroughbred industry there has been a drive towards attaining 2-year-old racing performers [25], possibly due to the strong international export demand [20], but until recently this had been less important in the Standardbred industry. Even though some of the perceived better performing animals were removed from this population of Thoroughbred horses through overseas export, the 2-year-old training milestones remained strongly associated with career length and racing success.

In conclusion, while this study cannot show cause and effect, there is a strong association between attaining 2-year-old training milestones and achieving a longer and more successful career in Thoroughbred racehorses in New Zealand. Thus, provided proper training and management practices of 2-year-olds are adhered to, having horses in training and racing as 2-year-olds may be of benefit to musculoskeletal health.

Authors' declaration of interests

No conflicts of interest have been declared.

Source of funding

The New Zealand Racing Board through the Equine Partnership for Excellence.

Acknowledgements

The authors gratefully acknowledge funding from the New Zealand Racing Board through the Equine Partnership for Excellence and New Zealand Thoroughbred Racing for provision of data.

Manufacturer's address

[a]StataCorp, Texas, USA.

References

1. Firth, E.C. (2006) The response of bone, articular cartilage and tendon to exercise in the horse. *J. Anat.* **208**, 513-526.
2. Rogers, C.W., Firth, E.C., McIlwraith, C.W., Barneveld, A., Goodship, A.E., Kawcak, C.E., Smith, R.K.W. and van Weeren, P.R. (2008) Evaluation of a new strategy to modulate skeletal development in Thoroughbred performance horses by imposing track-based exercise during growth. *Equine vet. J.* **40**, 111-118.
3. Barneveld, A. and van Weeren, P.R. (1999) Conclusions regarding the influence of exercise on the development of the equine musculoskeletal system with special reference to osteochondrosis. *Equine vet. J., Suppl.* **31**, 112-119.
4. More, S.J. (1999) A longitudinal study of racing Thoroughbreds: performance during first years of racing. *Aust. vet. J.* **77**, 105-112.
5. Sobczynska, M. (2007) The effect of selected factors on length of racing career in Thoroughbred racehorses in Poland. *Anim. Sci. Pap. Rep.* **25**, 131-141.
6. Bailey, C.J., Reid, S.W.J., Hodgson, D.R. and Rose, R.J. (1999) Factors associated with time until first race and career duration for Thoroughbred racehorses. *Am. J. vet. Res.* **60**, 1196-1200.
7. Anon. (2011) *The Jockey Club Online Fact Book*, The Jockey Club, New York.
8. Rogers, C.W., Gee, E.K. and Vermeij, E. (2009) Retrospective examination of the breeding efficiency of the New Zealand Thoroughbred and Standardbred. *Proc. NZ Soc. Anim. Prod.* **69**, 126-131.
9. Anon. (2010) *New Zealand Thoroughbred Racing Factbook*, New Zealand Thoroughbred Racing, Wellington.
10. Wilsher, S., Allen, W. and Wood, J. (2006) Factors associated with failure of Thoroughbred horses to train and race. *Equine vet. J.* **38**, 113-118.
11. Jeffcott, L.B., Rossdale, P.D., Freestone, J., Frank, C.J. and Towers-Clark, P.F. (1982) An assessment of wastage in Thoroughbred racing from conception to 4 years of age. *Equine vet. J.* **14**, 185-198.
12. Bailey, C.J., Reid, S.W.J., Hodgson, D.R. and Rose, R.J. (1999) Impact of injuries and disease on a cohort of two- and three-year-old Thoroughbreds in training. *Vet. Rec.* **145**, 487-493.
13. Perkins, N.R., Reid, S.W.J. and Morris, R.S. (2004) Profiling the New Zealand Thoroughbred racing industry. 2. Conditions interfering with training and racing. *N. Z. vet. J.* **53**, 69-76.
14. Dyson, P.K., Jackson, B.F., Pfeiffer, D.U. and Price, J.S. (2008) Days lost from training by two- and three-year-old Thoroughbred horses: a survey of seven UK training yards. *Equine vet. J.* **40**, 650-657.
15. Bolwell, C.F., Rogers, C.W., French, N.P. and Firth, E.C. (2011) Risk factors for interruptions occurring before the first trial start of 2-year-old Thoroughbred racehorses in training. *N. Z. vet. J.* in press.
16. Dohoo, I., Martin, W. and Stryhn, H. (2003) Modelling survival data. In: *Veterinary Epidemiologic Research*, Eds: I. Dohoo, W. Martin and H. Stryhn, AVC Inc, Charlottetown, Prince Edward Island. p 420.
17. Dohoo, I., Martin, W. and Stryhn, H. (2003) Logistic regression. In: *Veterinary Epidemiologic Research*, Eds: I. Dohoo, W. Martin and H. Stryhn, AVC Inc, Charlottetown, Prince Edward Island. pp 360-361.
18. McCarthy, G. (2009) Analysis of supply chain wastage in the thoroughbred and harness racing codes. In: *The Foundation Bulletin*, Ed: B. Goulden, New Zealand Equine Research Foundation, Palmerston North. pp 2-5.

19. Tanner, J.C., Rogers, C.W. and Firth, E.C. (2011) The relationship of 2-year-old training milestones with racing success in a population of Standardbred horses in New Zealand. *N. Z. vet. J.* **59**, 323-327.
20. Fennessy, P.F. (2010) An overview of the New Zealand Thoroughbred industry. *Proc. N. Z. Soc. Anim. Prod.* **70**, 137-139.
21. Verheyen, K., Price, J., Lanyon, L. and Wood, J. (2006) Exercise distance and speed affect the risk of fracture in racehorses. *Bone* **39**, 1322-1330.
22. Parkin, T.D.H. (2008) Epidemiology of racetrack injuries in racehorses. *Vet. Clin. N. Am.: Equine Pract.* **24**, 1-19.
23. Verheyen, K., Price, J. and Wood, J. (2009) Exercise during training is associated with racing performance in Thoroughbreds. *Vet. J.* **181**, 43-47.
24. Ely, E.R., Price, J.S., Smith, R.K., Wood, J.L.N. and Verheyen, K. (2010) The effect of exercise regimens on racing performance in National Hunt horses. *Equine vet. J.* **42**, 624-629.
25. Waldron, K., Rogers, C.W., Gee, E.K. and Bolwell, C.F. (2011) Production variables influencing the auction sales price of New Zealand Thoroughbred yearlings. *Proc. N. Z. Soc. Anim. Prod.* **71**, 92-95.