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Research Article

Estimates of Genetic Parameters for Racing Times of Thoroughbred Horses

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Abstract: The aim of this study was to estimate the genetic parameters for racing times, which are needed for a selection program of Thoroughbred horses in Turkey. The racing records used in the study were obtained from the Turkish Jockey Club. The trait used in the study was racing time for racing distances of 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, and 2400 m. The data from each racing distance were analyzed separately. Genetic parameters were estimated by REML procedure using the DFREML program. Estimates of heritability ranged from 0.177 to 0.353, depending on the racing distance. While estimates of heritability were highest for the 2 shortest distances (1200 and 1300 m), it was lowest for 2400 m, the longest distance. Estimates of pe^2 were lower at shorter distances than at longer distances. Estimates of repeatability varied from 0.289 to 0.404, depending on the racing distance. These results indicated that a moderate level of genetic progress is possible for racing time if selection is based on the phenotypic value of the horses.

Key Words: Thoroughbred horse, racing time, heritability, repeatability

İngiliz Atlarının Yarış Süreleri için Genetik Parametre Tahminleri

Özet: Araştırmada, Türkiye'deki İngiliz atlarının yarış süreleri üzerine yapılacak bir seleksiyon programı için gerekli olan genetik parametrelerin tahmin edilmesi amaçlanmıştır. Araştırma için Türkiye Jokey Kulübünün yarış kayıtlarından yararlanılmıştır. Araştırmada özellik olarak 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200 ve 2400 m yarış mesafeleri için yarış süreleri ele alınmıştır. Her bir yarış mesafesi ayrı olarak analiz edilmiştir. Genetik parametreler REML prosedürü aracılığı ile DFREML programı kullanılarak tahmin edilmiştir. Yarış mesafesine bağlı olarak kalıtım derecesi 0,177 ile 0,353 arasında tahmin edilmiştir. Kalıtım derecesi, en kısa mesafeler olan 1200 m ve 1300 m'de en yüksek değer alırken, en uzun mesafe olan 2400 m için en düşük olarak tahmin edilmiştir. pe^2 kısa mesafeler için uzun mesafelere oranla daha küçük tahmin edilmiştir. Yarış mesafesine bağlı olarak tekrarlama derecesi ise 0,289 ile 0,404 arasında tahmin edilmiştir. Bu sonuçlar, fenotipik değerlere göre yapılacak seleksiyon ile atların yarış süreleri için orta düzeyde bir genetik ilerleme sağlanabileceğini göstermektedir.

Anahtar Sözcükler: İngiliz atı, yarış süresi, kalıtım derecesi, tekrarlama derecesi

Introduction

Horse racing is one of the most popular sports in Turkey. Official horseraces are organized by the Turkish Jockey Club (TJK) at the İstanbul, Adana, Bursa, Ankara, İzmir, and Şanlıurfa hippodromes. These hippodromes have both turf and dirt tracks, except the Şanlıurfa hippodrome, which has only a dirt track. The races are arranged separately for Thoroughbred and Arabian horses. The breeding of Thoroughbred horses is carried out only on private farms, while the breeding of Arabian horses is carried out on both state and private farms in Turkey. Thoroughbred horses begin to participate in official races at 2 years old, whereas Arabian horses begin at 3 years old.

Racing performance of horses is generally measured by racing time or finish rank for a given distance, total earnings over a certain period, and handicap weight (1,2). Ojala and van Vleck (3) reported that racing time was more heritable than traits based on placing or money won, and would be more useful in evaluating sires for

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racing ability. Ricard (1) also reported that racing time is often used as a selection criterion in Trotters and that genetic progress was observed in most countries. Furthermore, racing time in each race is the only direct measure of speed and is a suitable quantitative measure that can be used to evaluate the genetic racing performance of horses (1,2,4).

Accurate estimates of genetic parameters are essential to achieve optimum genetic progress in any selection program. Genetic parameter estimates for racehorses were generally based on the paternal half-sib or the offspring-dam regression method (2,5,6). Otherwise, the restricted maximum likelihood (REML) method of fitting an animal model has the most desirable statistical properties for estimating variance components (7,8).

The heritability estimates reported in the literature for racing time generally ranged from low to moderate (2,5,6,8-11). Moritsu et al. (2) estimated heritability for Thoroughbred horses to be 0.11 and 0.09 for distances of 1200 m and 1800 m, respectively. Mota et al. (9) reported estimates of 0.12 for best racing time of Thoroughbred horses. The estimates of heritability for Thoroughbred horses reported by Oki et al. (8) varied from 0.081 to 0.254, depending on the track type and race distance. Hintz (5) also reported low estimates of heritability (0.15) for racing time of Thoroughbred horses. Estimates of heritability for racing time of Quarter horses were reported to be 0.24 by using half-sibs (6) and 0.17 by using the REML procedure (10). Grosu et al. (11) reported heritability estimates of 0.22 for best career time of Romanian Trotters, and Hintz (5) reported estimates of 0.32 for racing time of Trotters. Estimates of repeatability for racing time were reported to be 0.32 by Willham and Wilson (6) for Quarter horses, 0.29 by Grosu et al. (11) for Romanian Trotters, and 0.55 by Villela et al. (10) for Quarter horses.

Although horse racing in Turkey is highly organized, and nutrition, training methods, veterinary procedures, and track conditions have been improved, no research has been carried out to improve the racing performance of racehorses by a selection program. The aim of the current study was to estimate the genetic parameters for racing time over various distances, which might be used in a selection program for Thoroughbred horses in Turkey.

Materials and Methods

The racing records of Thoroughbred horses used in this study were obtained from the Turkish Jockey Club and included official races from January 1998 to December 2003. During this period, the racing distances were 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, and 2400 m. However, in the study, only the racing distances of 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, and 2400 m were used for analyses, as the number of races at 900 (42 races), 1000 (118 races), and 1100 m (136 races) were inadequate to estimate the genetic parameters. Information available on each race included hippodrome, track type, date of the race, age, sex, official finish time, rank of the horses, and weight of the jockey. The pedigree information of horses was also included. Finish times were measured in seconds by electrical timing and photo-finish cameras. The trait used in the study was racing time and the data from each distance were analyzed separately. The records of horses that could not complete races were deleted from the data set. The records of horse finish times, which were greater than the phenotypic average of + 3 x standard deviation for that racing distance, were also removed the dataset. The resulting data set used for the analysis consisted of 74,470 performance records from 7425 races. The characteristics of the data used in the analyses are presented in Table 1.

Variance components and genetic parameters were estimated by the REML method for a single-trait animal model, which combines information from paternal half-sib, maternal half-sib, and dam-offspring effects. The single-trait animal models included animals' additive genetic effects, fitted random effect, and permanent environmental effects fitted as an additional random effect, uncorrelated with all other effects in the model. The animal model used to estimate the variance components was

$$Y = X\beta + Z_a a + Z_{pe} pe + e$$

where Y is the vector of observations, β, a, pe, and e are vectors of fixed effects, direct additive genetic effects (animal), permanent environmental effects, and the residual effects, respectively, and X, Z_a, and Z_{pe} are incidence matrices relating observations to β, a, and pe, respectively.

To identify fixed effects to be included in the animal models, the preliminary least squares analysis of variance was carried out by the GLM procedure in SPSS 10.0. The effects of type of track, sex, age of horse, weight of jockey, and the interaction between month of year and hippodrome were fitted to the mathematical model used in preliminary least squares analysis. According to the results of preliminary least squares analysis, non-significant factors were not fitted to animal models used to estimate the genetic parameters. Finally, components of single-trait animal models used to estimate the genetic parameters for racing time of Thoroughbred horses by racing distance are given in Table 2.

Genetic parameters were estimated using the DFREML 3.0 program of Meyer (12), employing the simplex procedure to locate the maximum of the log likelihood as described by Meyer (13). The search for the maximum of the likelihood was stopped if the variance of the simplex function values were less than 10^{-8}. Restarts were performed to confirm global convergence.

Heritability was estimated by dividing direct additive genetic variance (σ_a^2) by phenotypic variance (σ_P^2). The repeatability, which is a measure of the repeatability of the racing performance of a horse, was calculated from the ratio between the sum of direct additive genetic and permanent environmental variances ($\sigma_a^2 + \sigma_{pe}^2$), and phenotypic variance (8,10).

Table 1. Description of data used for analysis by racing distance.

	Distance											
Item	1200 m	1300 m	1400 m	1500 m	1600 m	1700 m	1800 m	1900 m	2000 m	2100 m	2200 m	2400 m
No. of Records	9793	2258	15837	5061	10885	2255	3125	10355	5367	3946	2505	3083
No. of Animals with Records	2992	1360	3324	1981	2691	1238	1346	2513	1695	1477	1174	1156
No. of Sires	467	279	511	365	460	248	275	433	314	302	241	256
No. of Dams	1493	520	1679	929	1381	524	618	1254	799	664	507	554
Mean (seconds)	76.103	83.175	89.827	97.467	104.086	111.071	119.096	125.715	133.128	138.485	145.900	161.082
Standard Error (seconds)	0.069	0.89	0.060	0.085	0.061	0.138	0.127	0.094	0.106	0.101	0.132	0.161
No. of Races	1055	267	1554	528	1027	198	256	1010	548	412	247	323
No. of Records/No. of Races	9.282	8.457	10.191	9.585	10.599	11.389	12.207	10.252	9.794	9.578	10.142	9.545
No. of Records per Animal	3.273	1.660	4.764	2.555	4.045	1.821	2.322	4.121	3.166	2.672	2.134	2.667

Table 2. Components of single trait animal models used to estimate the genetic parameters for racing time by racing distance.

Effects	Distance											
	1200 m	1300 m	1400 m	1500 m	1600 m	1700 m	1800 m	1900 m	2000 m	2100 m	2200 m	2400 m
Fixed effects												
Type of Track	X	X	X	X	X	X	X	X	X	X	X	X
Age	X	X	X	X	X	X	X	X	X	X	X	X
Sex	X	X	X	X	X	X	X	X	X	X	X	X
Hippodrome x Month		X	X	X	X	X	X	X	X	X	X	X
Weight of Jockey		X	X	X	X	X		X	X	X	X	X
Random effects												
Direct genetic	X	X	X	X	X	X	X	X	X	X	X	X
Permanent environment	X	X	X	X	X	X	X	X	X	X	X	X

Results

Estimates of variance components and genetic parameters for racing time of Thoroughbred horses by racing distance are presented in Table 3.

Estimates of direct additive genetic variance varied from 1.255 to 3.984, depending on the racing distance. Estimates of heritability ranged from 0.177 for the distance of 2400 m to 0.353 at 1200 m. Heritabilities were estimated with small standard errors (0.030-0.069) and were different from zero ($P < 0.05$) for all race distances. Estimates of repeatability for racing time were moderate to high and ranged from 0.289 (1800 m) to 0.404 (2000 m).

Discussion

Estimates of heritability obtained in the current study, which varied from 0.177 to 0.353, are in agreement with the following estimates: Oki et al. (8), who reported estimates of 0.081 to 0.254 for Thoroughbred horses, Willham and Wilson (6), who reported an estimate of 0.24 for Quarter horses, Hintz (5), who reported an estimate of 0.32 for Trotters, and Grosu et al. (11), who reported an estimate of 0.22 for best career time of Romanian Trotters. On the other hand, estimates of the current study were higher than those reported for Thoroughbred horses by Moritsu et al. (2), Hintz (5), and Mota et al. (9).

In this study, while estimates of heritability were the highest for the 2 shortest distances (1200 and 1300 m), it was the lowest at 2400 m, the longest distance. Oki et al. (8) and Buttram et al. (7) reported a similar tendency of heritability estimates, which decreased as the racing distance increased, for Thoroughbred and Quarter horses, respectively. Oki et al. (8) reported that the decrease in heritability might be because as racing distance increases more factors, probably environmental, influence the racing speed.

Permanent environmental effects on racing performance may include such factors as early nutrition, injury, owner, and trainer (7). In the current study, estimates of pe^2 were lower at shorter distances (1200 to 1900 m) than at longer distances (2000 to 2400 m). Buttram et al. (7) also reported similar findings for Quarter horses and suggested that permanent environmental effects are not as important for short races as for longer races.

Estimates of repeatability obtained in the current study, which varied from 0.289 to 0.404, were higher

Table 3. Estimates of genetic parameters for racing times by racing distance (standard errors in parentheses).

	Distance											
Item	1200 m	1300 m	1400 m	1500 m	1600 m	1700 m	1800 m	1900 m	2000 m	2100 m	2200 m	2400 m
σ_a^2	2.588	1.255	2.045	1.792	2.429	2.484	2.805	3.984	3.211	2.806	2.583	3.695
σ_{pe}^2	0.077	0.287	0.758	1.064	1.227	1.465	0.956	1.188	2.501	1.915	2.805	3.654
σ_e^2	4.699	2.515	4.930	5.006	6.124	6.934	9.025	10.484	8.453	8.523	8.926	13.549
σ_p^2	7.334	4.056	7.733	7.862	9.780	10.883	12.786	15.656	14.165	13.244	14.313	20.898
h_d^2	0.353 (0.035)	0.309 (0.055)	0.265 (0.030)	0.228 (0.046)	0.248 (0.034)	0.228 (0.069)	0.214 (0.065)	0.255 (0.039)	0.227 (0.054)	0.212 (0.048)	0.180 (0.052)	0.177 (0.056)
pe^2	0.011 (0.031)	0.071 (0.062)	0.098 (0.027)	0.135 (0.045)	0.125 0.031)	0.135 (0.068)	0.075 (0.063)	0.076 (0.035)	0.177 (0.052)	0.145 (0.050)	0.196 (0.057)	0.175 (0.058)
r	0.364	0.380	0.363	0.363	0.373	0.363	0.289	0.331	0.404	0.357	0.376	0.352

σ_a^2: direct additive genetic variance; σ_{pe}^2: permanent environmental variance; σ_e^2: error variance; σ_p^2: phenotypic variance; h_d^2: direct heritability; pe^2: σ_{pe}^2/σ_p^2; r: repeatability

than those reported by Willham and Wilson (6) for Quarter horses and by Grosu et al. (11) for Romanian Trotters. In contrast to the current study, Villela et al. (10) reported a relatively high estimate of repeatability for racing time of Quarter horses.

The moderate estimates of heritability and moderate to high estimates of repeatability for racing time obtained in the current study suggest that a moderate level of genetic progress is possible for this trait, if selection is based on the phenotypic value of the horses.

References

1. Ricard, A.: Developments in the genetic evaluation of performance traits in horses. 6th World Congress on Genetics Applied to Livestock Production, Armidale, Australia. 1998; 388-395.
2. Moritsu, Y., Funakoshi, H., Ichikawa, S.: Genetic evaluation of sires and environmental factors influencing best racing times of Thoroughbred horses in Japan. J. Equine Sci. 1994; 5: 53-58.
3. Ojala, M.J., van Vleck, L.D.: Measures of racetrack performance with regard to breeding evaluation of trotters. J. Anim. Sci., 1981; 53: 611- 619.
4. Oki, H., Sasaki, Y., Willham, R.L.: Genetics of racing performance in the Japanese Thoroughbred horse: II. Environmental variation of racing time on turf and dirt tracks and the influence of sex, age, and weight carried on racing time. J. Anim. Breed. Genet., 1994; 111: 128-137.
5. Hintz, R.L.: Genetics of performance in the horse. J. Anim. Sci., 1980; 51: 582-594.
6. Willham, R.L., Wilson, D.E.: Genetic predictions of racing performance in Quarter horses. J. Anim. Sci., 1991; 69: 3891-3894.
7. Buttram, S.T., Wilson, D.E., Willham, R.L.: Genetics of racing performance in the American Quarter horse: III. Estimation of variance components. J. Anim. Sci., 1989; 66: 2808-2816.
8. Oki, H., Sasaki, Y., Willham, R.L.: Genetic parameter estimates for racing time by restricted maximum likelihood in the Thoroughbred horse of Japan. J. Anim. Breed. Genet., 1995; 112: 146-150.
9. Mota, M.D.S., Oliveria, H.N., Silva, R.G.: Genetic and environmental factors that affect the best time of Thoroughbred horses in Brazil. J. Anim. Breed. Genet., 1998; 115: 123-129.
10. Villela, L.C.V., Mota, M.D.S., Oliveira, H.N.: Genetic parameters of racing performance traits of Quarter horses in Brazil. J. Anim. Breed. Genet., 2002; 119: 229-234.
11. Grosu, H., Stanescu, M., Kremer, V., Lungu, S., Pana, C., Radoi, C.: Genetic parameters for repeated performances of the Romanian Trotters. 51st Annual Meeting of the European Association for Animal Production, The Hague, The Netherlands. 2000; 356.
12. Meyer, K.: DFREML Programs to Estimate Variance Components by Restricted Maximum Likelihood Using a Derivative - Free Algorithm, User Notes, 1998.
13. Meyer, K.: Restricted maximum likelihood to estimate variance components for animal models with several random effects using a derivative-free algorithm. Genet. Select. Evol., 1989; 21: 317-340.