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Research Article

Estimates of Genetic Parameters for Racing Performances of Arabian Horses

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Abstract: The aims of the study were to investigate the effects of the type of track, age, sex and origin of horse on racing time for Arabian horses, and to estimate the genetic parameters for racing time. The racing records used in this study were obtained from the Turkish Jockey Club. The trait used in the study was racing time for racing distances of 1200 m, 1300 m, 1400 m, 1500 m, 1600 m, 1800 m, 1900 m, 2000 m, 2100 m and 2200 m. The data from each racing distance were analysed separately. Genetic parameters were estimated by REML procedure using the DFREML program. The effects of type of track, sex and origin of horse on racing time were significant for all racing distances. The effect of horse age on racing time was not significant for distances of 1300 m, 1500 m, 2000 m and 2200 m, whereas it was significant for other distances. Estimates of heritability ranged from 0.175 to 0.304, and repeatability ranged from 0.295 to 0.460, depending on the racing distance. These estimates indicated that the genetic progress for racing performance could be achieved if breeders use accurate selection programmes.

Key Words: Arabian horse, racing time, heritability, repeatability, fixed effects

Arap Atlarının Yarış Performansları için Genetik Parametre Tahminleri

Özet: Araştırmada, Arap atlarının yarış süresi üzerine atın yaşı, cinsiyeti ve orijini ile zemin tipinin etkilerinin incelenmesi ve yarış süreleri için genetik parametrelerin tahmin edilmesi amaçlanmıştır. Araştırma için Türkiye Jokey Kulübünün yarış kayıtlarından yararlanılmıştır. Araştırmada özellik olarak 1200 m, 1300 m, 1400 m, 1500 m, 1600 m, 1800 m, 1900 m, 2000 m, 2100 m ve 2200 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 süresi üzerine zemin tipi ile atın cinsiyeti ve orijininin etkileri tüm yarış mesafeleri için önemli bulunmuştur. Yarış süresi üzerine atın yaşının etkisi 1300 m, 1500 m, 2000 m ve 2200 m yarış mesafeleri için önemsiz, diğer mesafeler için ise önemli bulunmuştur. Yarış mesafesine bağlı olarak kalıtım derecesi 0,175 ile 0,304 arasında, tekrarlama derecesi ise 0,295 ile 0,460 arasında tahmin edilmiştir. Bu araştırmada elde edilen genetik parametre tahminleri, yetiştiriciler tarafından uygun seleksiyon programlarının uygulanması durumunda yarış performansı için genetik ilerleme sağlamanın mümkün olabileceğini göstermektedir.

Anahtar Sözcükler: Arap atı, yarış süresi, kalıtım derecesi, tekrarlama derecesi, sabit etkiler

Introduction

In Turkey, official horse-racing is organised by the Turkish Jockey Club (TJK) in İstanbul, Adana, Bursa, Ankara, İzmir and Şanlıurfa hippodromes. These hippodromes have both turf and dirt tracks except for the Şanlıurfa hippodrome, which has only a dirt track. The races are arranged separately for Arabian and Thoroughbred horses. The breeding of Arabian horses is carried out in both the state studs of horses (Anadolu, Karacabey, Sultansuyu) and private farms, while the breeding of Thoroughbred horses is carried out only in private farms in Turkey. Arabian horses begin to participate in the official races at 3 years old, whereas Thoroughbred horses begin at 2 years old.

The performance of the racehorses can be measured by the racing time for a given distance, amount of earning over a certain period and handicap weight and similar performance traits. 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 (1-3).

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There have been many studies carried out to investigate the major factors affecting the race performance of horses. Age, sex, origin of the horse and type of track were reported to be environmental factors influencing the racing time of various horse breeds (1,2,4-6). In these studies, it is generally reported that male horses were much faster than females (4,5,7-9), and racing time improved with age of horse (1,2,8,9).

Accurate estimates of genetic parameters for racehorses are essential to achieve optimum genetic progress in a selection programme. Genetic parameter estimates for racehorses were generally based on the paternal half sib or the offspring-dam regression method (1,10,11). Otherwise, the restricted maximum likelihood (REML) method has the most desirable statistical properties for estimating variance components (12-14).

Reports on estimates of genetic parameters calculated using animal model methodology for racing time of Arabian horses were limited. The objectives of the current study were, firstly, to evaluate the fixed effects, which are considered to influence the racing time, and, secondly, to estimate the genetic parameters for racing time over various distances, which are needed to design a breeding programme for Arabian horses.

Materials and Methods

The racing records of Arabian horses used in this study were obtained from the Turkish Jockey Club, and included official races from January 1998 to October 2003. During this period, the racing distances were 900 m, 1000 m, 1100 m, 1200 m, 1300 m, 1400 m, 1500 m, 1600 m, 1700 m, 1800 m, 1900 m, 2000 m, 2100 m, 2200 m and 2400 m. However, as the number of races for 900 m, 1000 m, 1100 m, 1700 m and 2400 m were inadequate to estimate the genetic parameters, only the racing distances of 1200 m, 1300 m, 1400 m, 1500 m, 1600 m, 1800 m, 1900 m, 2000 m, 2100 m and 2200 m were used for analyses. Information available on each race included the track type and date of the race, and age, sex, origin, official finish time and rank of the horses. The pedigree information of horses was also included. Finish times were measured as seconds by using electrical timing and photo-finish cameras. The trait used in the study was racing time, and the data from each distance were analysed separately. The records of horses that could not complete the race were deleted from the data set. The resulting data set used for the analysis consisted of 65027 performance records from 6353 races. The characteristics of the data used in the analyses are presented in Table 1.

Variance components and genetic parameters were estimated by the Restricted Maximum Likelihood (REML) method for a single trait animal model using derivative-free process. To identify fixed effects to be included in the animal models, the least-squares analysis of variance was carried out by the GLM procedure in SPSS 10.0 program. The fixed effects considered were type of track (dirt or turf), sex (male or female), age of horse (3-8 years and older for 1200-1600 m; 4-8 years and older for 1800-2200 m), and origin of horse (Anadolu, Karacabey, Sultansuyu State Studs or private farms). Type of track, sex and origin were significant for all distances and were included in the animal models. Age

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

	Distance									
Item	1200 m	1300 m	1400 m	1500 m	1600 m	1800 m	1900 m	2000 m	2100 m	2200 m
No. of Records	10226	3088	15351	5337	8671	3238	8565	5139	3192	2220
No. of Animals with Records	2072	1355	2190	1401	1657	1111	1550	1210	942	813
No. of Sires	172	141	176	142	160	124	144	122	105	108
No. of Dams	858	584	900	601	724	500	675	538	399	343
Mean, Second	85.22	93.69	100.12	109.20	115.81	133.05	139.28	147.68	153.79	161.86
Standard Error, Second	0.051	0.098	0.042	0.091	0.065	0.123	0.079	0.117	0.117	0.150
No. of Races	1007	292	1483	525	835	281	839	526	336	229
No. of Records / No. of Races	10.15	10.58	10.35	10.17	10.38	11.52	10.21	9.71	9.50	9.69

of horse was not significant for distances of 1300 m, 1500 m, 2000 m and 2200 m; therefore the animal model for these distances excluded age of horse as a fixed effect.

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 (type of track, age, sex and origin), 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.

The DFREML 3.0 program of Meyer (15) was used to estimate genetic parameters. 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_a^2) and repeatability was estimated from the ratio between the sum of direct additive genetic and permanent environmental variances ($\sigma_a^2 + \sigma_a^2$) and phenotypic variance (5).

Results

The least squares means (LSM) and standard errors of the fixed effects for racing time are presented in Tables 2 and 3.

The effects of the type of track, sex and origin of horse on racing time were significant for all distances ($P < 0.001$). The racing time was shorter on turf tracks than on dirt tracks. Male horses were much faster than female ones. Among the origin groups, the horses that originated from Anadolu State Stud had better performance than others for all distances. The horses from private farms were the slowest. The effect of age of horse on racing time was not significant for distances of 1300 m, 1500 m, 2000 m and 2200 m, whereas it was significant for other distances. There was a tendency for racing time to improve with age.

Estimates of variance components and genetic parameters for racing time of Arabian horses by racing distance are presented in Table 4.

Estimates of direct additive genetic variance varied from 3.119 to 12.487, depending on the race distances. Estimates of heritability ranged from 0.175 for a distance of 2200 m to 0.304 for a distance of 1600 m. Heritabilities were estimated with small standard errors (0.026-0.071) 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 0.295 (2200 m) to 0.460 (1500 m).

Discussion

To determine the fixed effects included in the animal models, preliminary analyses were carried out by the GLM procedure. According to the preliminary analyses, racing time was shorter on turf than on dirt tracks for all distances. Moritsu et al. (1), Oki et al. (2) and Mota et al. (4) also reported the same finding for racing time of Thoroughbred horses. Least squares means of racing time for males in the current study were shorter than those for females. The significant superiority of males for racing time were also reported by Villela et al. (5) for Quarter horses, by Mota et al. (4) for Thoroughbred horses, by Saastamoinen and Ojala (7) for Trotters, by Rönningen (8) for North-Swedish Trotters and by Ojala (9) for Finnish horses. Otherwise in the study of Moritsu et al. (1) effect of the sex was reported to be non-significant for a distance of 1200 m, and to be significant for a distance of 1800 m. The tendency for racing time to become shorter as the horses aged found in the current study was in agreement with reports of Rönningen (8) for North-Swedish Trotters, Oki et al. (2) for Thoroughbred horses, Moritsu et al. (1) for Thoroughbred horses and Ojala (9) for Finnish horses. However, Mota et al. (4) and Villela et al. (5) found the effect of age on racing time to be non-significant for Thoroughbred and Quarter horses, respectively. The results of the current study showed that origin of horse has a significant effect on racing time for all distances. Villela et al. (5) and Lungu et al. (6) also reported the influence of origin on racing time to be significant.

The estimates of heritability for racing time of horses have been reported for several breeds. Moritsu et al. (1) reported estimates, which were based on the intraclass correlation of paternal half-sibs, of 0.11 and 0.09 for distances of 1200 m and 1800 m, respectively, for Thoroughbred horses. Mota et al. (4) estimated heritability

Table 2. Least squares means (LSM) and standard errors (SE) of the fixed effects for racing times by racing distances of 1200 m, 1300 m, 1400 m, 1500 m and 1600 m.

Fixed Effects	1200 m			1300 m			1400 m			1500 m			1600 m		
	n	LSM	SE	n	LSM	SE	n	LSM	SE	n	LSM	SE	n	LSM	SE
Type of Track		***			***			***			***			***	
Dirt	5840	87.62 ^{b}	0.06	1859	95.90 ^{b}	0.11	10138	102.83 ^{b}	0.05	4651	110.38 ^{b}	0.07	3273	119.41 ^{b}	0.09
Turf	4386	82.83 ^{a}	0.07	1229	91.49 ^{a}	0.13	5213	97.40 ^{a}	0.06	686	108.01 ^{a}	0.16	5398	112.21 ^{a}	0.08
Age		***			NS			***			NS			***	
3	4786	86.03 ^{d}	0.06	1182	93.63	0.12	4350	101.01 ^{d}	0.06	660	109.13	0.17	1037	116.21 ^{b}	0.16
4	2089	85.37 ^{c}	0.08	870	93.92	0.14	4173	100.48 ^{c}	0.06	1986	109.42	0.11	2865	115.74 ^{a}	0.10
5	1355	85.19 ^{bc}	0.10	440	93.81	0.19	2784	100.33 ^{c}	0.08	1135	109.36	0.14	1843	115.48 ^{a}	0.12
6	924	85.05 ^{ab}	0.12	277	93.78	0.23	1833	99.97 ^{b}	0.09	722	109.25	0.16	1300	115.83 ^{ab}	0.14
7	554	84.70 ^{a}	0.15	172	93.44	0.30	1174	99.77 ^{b}	0.12	447	109.06	0.20	841	115.45 ^{a}	0.17
8+	518	85.01 ^{ab}	0.16	147	93.55	0.32	1037	99.15 ^{a}	0.12	387	108.96	0.21	785	116.15 ^{b}	0.18
Sex		***			***			***			***			***	
Male	5609	84.83 ^{a}	0.06	1731	93.14 ^{a}	0.11	9222	99.57 ^{a}	0.05	3573	108.70 ^{a}	0.10	5368	115.30 ^{a}	0.07
Female	4617	85.62 ^{b}	0.07	1357	94.24 ^{b}	0.13	6129	100.67 ^{b}	0.06	1764	109.70 ^{b}	0.12	3303	116.32 ^{b}	0.10
Origin		***			***			***			***			***	
Anadolu Stud	2374	84.71 ^{a}	0.08	725	93.07 ^{a}	0.16	3850	99.47 ^{a}	0.07	1607	108.37 ^{a}	0.13	2308	114.93 ^{a}	0.11
Karacabey Stud	1517	84.87 ^{a}	0.10	489	93.46 ^{ab}	0.18	2650	99.97 ^{b}	0.08	843	109.11 ^{b}	0.15	1683	115.59 ^{b}	0.13
Sultansuyu Stud	1419	85.43 ^{b}	0.10	514	93.91 ^{b}	0.18	2347	100.16 ^{b}	0.09	1112	108.98 ^{b}	0.14	1358	115.75 ^{b}	0.14
Private Farms	4916	85.88 ^{c}	0.06	1360	94.32 ^{c}	0.13	6504	100.86 ^{c}	0.06	1775	110.32 ^{c}	0.12	3322	116.97 ^{c}	0.09

$^{a, b, c, d}$: The differences between the means of groups carrying various letters in the same column are significant (***$P < 0.001$).

NS : $P > 0.05$

Table 3. Least squares means (LSM) and standard errors (SE) of the fixed effects for racing times by racing distances of 1800 m, 1900 m, 2000 m, 2100 m and 2200 m.

Fixed Effects	1800 m			1900 m			2000 m			2100 m			2200 m		
	n	LSM	SE	n	LSM	SE	n	LSM	SE	n	LSM	SE	n	LSM	SE
Type of Track		***			***			***			***			***	
Dirt	1827	137.33 ^{b}	0.15	5022	142.77 ^{b}	0.10	3784	151.12 ^{b}	0.12	2010	157.30 ^{b}	0.14	1176	166.05 ^{b}	0.19
Turf	1411	128.77 ^{a}	0.17	3543	135.79 ^{a}	0.11	1355	144.24 ^{a}	0.18	1182	150.28 ^{a}	0.17	1044	157.68 ^{a}	0.20
Age		***			***			NS			**			NS	
4	947	133.83 ^{c}	0.21	3072	140.18 ^{c}	0.11	1709	147.59	0.07	901	154.34 ^{b}	0.19	609	161.93	0.25
5	769	133.25 ^{b}	0.22	2104	139.57 ^{b}	0.14	1189	147.76	0.19	853	153.93 ^{ab}	0.19	539	162.01	0.26
6	632	133.07 ^{ab}	0.24	1430	139.39 ^{b}	0.17	883	147.95	0.22	604	153.93 ^{ab}	0.23	444	161.76	0.29
7	442	132.67 ^{ab}	0.29	986	138.65 ^{a}	0.20	658	147.22	0.26	410	153.37 ^{a}	0.27	352	161.83	0.32
8+	448	132.42 ^{a}	0.29	973	138.61 ^{a}	0.20	700	147.90	0.26	424	153.38 ^{a}	0.27	276	161.79	0.36
Sex		***			***			***			***			***	
Male	2043	132.40 ^{a}	0.14	5695	138.55 ^{a}	0.09	3622	146.91 ^{a}	0.12	2323	153.14 ^{a}	0.12	1673	161.18 ^{a}	0.15
Female	1195	133.70 ^{b}	0.19	2870	140.01 ^{b}	0.12	1517	148.45 ^{b}	0.18	869	154.44 ^{b}	0.19	547	162.55 ^{b}	0.26
Origin		***			***			***			***			***	
Anadolu Stud	765	132.61 ^{a}	0.23	2506	138.45 ^{a}	0.13	1625	146.59 ^{a}	0.18	1079	152.71 ^{a}	0.18	688	161.35 ^{a}	0.24
Karacabey Stud	603	133.08 ^{a}	0.25	1625	138.98 ^{b}	0.16	861	147.33 ^{b}	0.23	600	153.78 ^{b}	0.23	442	161.68 ^{a}	0.29
Sultansuyu Stud	517	132.82 ^{a}	0.27	1656	138.99 ^{b}	0.16	1007	147.35 ^{b}	0.22	695	153.56 ^{b}	0.22	508	161.58 ^{a}	0.28
Private Farms	1353	133.68 ^{b}	0.17	2778	140.69 ^{c}	0.13	1646	149.45 ^{c}	0.17	818	155.11 ^{c}	0.20	582	162.85 ^{b}	0.25

$^{a, b, c}$: The differences between the means of groups carrying various letters in the same column are significant (** $P < 0.01$, ***$P < 0.001$).

NS : $P > 0.05$

Table 4. 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	1800 m	1900 m	2000 m	2100 m	2200 m
σ_a^2	3.890	3.119	4.535	3.821	6.385	8.512	7.348	12.487	5.968	6.171
σ_{pe}^2	1.661	2.299	2.932	4.737	3.183	5.850	5.737	4.310	6.730	4.204
σ_e^2	8.427	10.235	10.062	10.053	11.402	24.721	27.339	26.426	19.220	24.839
σ_p^2	13.977	15.652	17.529	18.611	20.971	39.082	40.424	43.224	31.917	35.214
h_d^2	0.278 (0.040)	0.199 (0.026)	0.259 (0.039)	0.205 (0.050)	0.304 (0.050)	0.218 (0.062)	0.182 (0.041)	0.289 (0.061)	0.187 (0.071)	0.175 (0.063)
pe^2	0.119 (0.034)	0.148 (0.026)	0.167 (0.034)	0.254 (0.047)	0.152 (0.045)	0.149 (0.056)	0.142 (0.036)	0.099 (0.053)	0.211 (0.067)	0.120 (0.060)
r	0.397	0.347	0.426	0.460	0.456	0.367	0.324	0.388	0.398	0.295

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, p_e^2: σ_{pe}^2/ σ_p^2, r: repeatability

using REML procedure to be 0.12 for best racing time of Thoroughbred horses. The estimates of heritability for Thoroughbred horses reported by Oki et al. (13) varied from 0.081 to 0.254, depending on the track type and race distance. Estimates of heritability for racing time of Quarter horses were reported 0.24 using half-sibs (11) and 0.17 using REML procedure (5). Hintz (10) estimated heritability for racing time in Thoroughbred horses to be 0.15 and in Trotters to be 0.32. Grosu et al. (14) reported estimates of 0.22 for the best career time of Romanian Trotters. Estimates of heritability for racing time obtained in the current study were in agree with those reported for Quarter horses (5,11), Trotters (10,14) and Thoroughbred horses (13); and were higher than those reported for Thoroughbred horses by Moritsu et al. (1), Mota et al. (4) and Hintz (10).

Estimates of heritability, which varied according to racing distances, obtained in the current study suggest that racing time at different racing distances might be considered as different traits when the horse is to be evaluated genetically. Oki et al. (13) reported a similar result for Thoroughbred horses.

Estimates of repeatability for racing time in the current study were in agreement with those of Willham and Wilson (11), who reported estimates of 0.32 for Quarter horses, and those of Grosu et al. (14), who reported estimates of 0.29 for Romanian Trotters; but were lower than the estimates of Villela et al. (5), who reported estimates of 0.55 for Quarter horses.

Estimates of heritability, which were moderate, and of repeatability, which were moderate to high, obtained in the current study indicated that genetic progress for racing performance of Arabian horses could be achieved if breeders use accurate selection programmes.

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