Genetic correlations between racing performance at different racing distances in Thoroughbreds and Arab horses

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ABSTRACT: The purpose of this study was to find out whether abilities to win races of different distances are different traits. Data included information on 14 665 starts of 1 646 Thoroughbreds, aged 2 to 9 years and on 10 862 starts of 1 145 Arab horses, aged 3 to 10 years. The data comprised seven racing distances for Thoroughbred horses, i.e. 1 000, 1 200, 1 300, 1 400, 1 600, 1 800, >1 800 m, and five for Arab horses, i.e. 1 400, 1 600, 1 800, 2 000 + 2 200, >2 200 m. Placings at the finish (square root) of different racing distances were treated as different traits and analysed by a two-trait animal model. The highest heritability (0.16) was obtained for the shortest distance in Thoroughbreds. Heritability for longer distances was much lower (0.04–0.09). The heritability estimates for Arab horses are very low for all distances (0.02–0.08). Genetic correlations between racing distances ranged from 0.54 to 0.98 in Thoroughbreds and from 0.95 to 0.99 in Arab horses. Genetic correlations in Thoroughbreds decreased as the differences of each racing distance increased whereas they remained high and constant in Arab horses. It means that we discuss very much the same trait measured only at different race distances for Arab horses but a little bit different in the case of Thoroughbreds.

Keywords: Thoroughbreds; Arab horses; racing performance; genetic correlations; animal model

Racehorses are raced at several distances and placed in different rankings at the finish, winning several earnings at each racing distance. However, the horse's racing performance is not always best at one racing distance. Since performance is unlikely to be constant over a distance (some horses are sprinters, some stayers, and the ability to win a 1 000m race does not imply the ability to win a 2 000m race), some authors (Oki et al., 1995; Williamson and Beilharz, 1996; Oki et al., 1997) analysed the racing performance separately in each distance range. The effect of environmental factors connected with specific race such as number and level of competitors, track and weather conditions may be higher for long distance races than for short distance races. Oki et al. (1995) suggested that the racing performance at the different distances might be regarded as different traits. Also, a trait measured in two different environments is to be regarded as two traits (Falconer, 1989). In this case the breeding value of horses should be evaluated for each racing distance separately. However, a difficulty will arise when the breeding value of each racing distance is used in selection, particularly if the selection is not conducted to breed sprinters and stayers. In other words, there arises a problem whether the ability to win a short distance race is the same trait as the ability to win a long distance race. From the practical aspect the question is whether we can combine the results from all the distances in a single run when estimating breeding values of racing horses by an animal model.

If genetic correlations between racing performances evaluated at different racing distances are high, the traits can be regarded as the same character. The aim of this study was to find out whether the abilities to win races of different distances are different traits for Thoroughbreds as well as for the Arab horses.

MATERIAL AND METHODS

Individual animal placings at the finish (ranking) in flat races at Warsaw, Sopot and Wroclaw racecourses from 1998 to 2002 were obtained from the

Polish Jockey Club Bulletin. The data comprised seven racing distances for Thoroughbred horses, i.e. 1 000, 1 200, 1 300, 1 400, 1 600, 1 800, > 1 800 m, and five for Arab horses, i.e. 1 400, 1 600, 1 800, 2 000 + 2 200, > 2 200 m. Since the genetic and phenotypic correlations between placings at the finish and earnings are high (Chico 1994; Sobczyńska and Kownacki, 1997; Sobczyńska and Łukaszewicz, 2002) and the money prizes are awarded just to the first five or four horses, it was decided to measure the ability to win with the placings at the finish. The data included information on 14 665 starts of 1 646 Thoroughbreds (828 stallions and 797 mares), aged 2 to 9 years and on 10 862 starts of 1 145 Arab horses (663 stallions and 481 mares), aged 3 to 10 years. As there were only 21 and 1 gelding for Thoroughbreds and Arab horses, respectively, they were classified together with mares. The placings were square-root transformed to normalize its distribution.

Genetic correlations between placings recorded at different racing distances were estimated by the following animal model:

$$y_{ijklmnop} = \alpha + A_i + G_j + R_k + T_l + r_m + pe_n + a_o + b \times x_{ijklmnop} + e_{ijklmnop}$$

where:

$y_{ijklmnop}$ = placings at the finish
α = the intercept ($\alpha = \mu - bx$)
A_i = fixed effects of i^{th} age
G_j = fixed effects of j^{th} sex
R_k = fixed effects of k^{th} race
T_l = fixed effect of l^{th} trainer
r_m = random effects of m^{th} rider
pe_n = random effects of n^{th} permanent environment
a_o = the random genetic additive effect of o^{th} horse
b = partial regression
$x_{ijklmnop}$ = the weight carried
$e_{ijklmnop}$ = the random error effect

The above model was employed for both: pairwise (two-trait) analyses of different distances and (single-trait) analyses of each distance separately.

Thoroughbred horses older than 3 years were grouped into one age class. Similarly, Arab horses older than 4 years were put into one age group. The Thoroughbreds were ridden by 149, and the Arab horses by 106 riders. There were 37 trainers for Thoroughbreds, while Arab horses were trained by 31 trainers. Trainer was fitted in the model to avoid a possible bias coming from training methods aimed at winning at a particular distance. It was decided not to fit the breeder/owner effect in the model as it was found that it explained too much of the additive genetic variance (Sobczyńska, 2003; Sobczyńska and Łukaszewicz, 2004).

Pedigree information strengthens the connectedness between animal and fixed effect, hence it is an important element in the estimation of genetic variance and covariance. When known, pedigree information from at least three generations (animal, parents, grandparents) was used for the construction of the additive relationship matrix. The pedigree files consisted of 3 365 Thoroughbreds and 2 275 Arab horses. Thoroughbreds were the progeny of 228 sires and 925 dams. Arab horses

Table 1. The number of records (above diagonal) and Thoroughbred horses (below diagonal) that had records in either one racing distance and in both racing distances

Racing distance (m)	1 000	1 200	1 300	1 400	1 600	1 800	> 1 800
1 000	2 172 1 065	3 253	2 244	2 328	3 126	1 496	1 243
1 200	742	2 495 1 072	3 165	3 204	4 019	1 850	1 449
1 300	554	670	1 716 850	1 713	1 866	1 461	1 152
1 400	525	631	597	2 036 861	4 539	1 886	1 462
1 600	585	698	639	730	3 549 1 014	3 471	2 874
1 800	360	409	361	412	543	1 341 608	1 843
1 800	271	293	260	297	428	333	1 353 476

Table 2. The number of records (above diagonal) and Arab horses (below diagonal) that had records in either one racing distance and in both racing distances

Racing distance (m)	1 400	1 600	1 800	2 000 + 2 200	> 2 200
1 400	1 078 485	4 086	1 878	602	247
1 600	463	5 620 1 086	6 956	2 783	1 155
1 800	306	745	2 770 788	2 525	1 157
2 000 + 2 200	139	338	350	933 367	939
> 2 200	61	136	146	142	472 163

were descended from 222 sires and 654 dams. The computations of variance components were run separately for each breed. (Co)variance components were estimated by the restricted maximum likelihood (REML) method using the software of Misztal (1998).

RESULTS AND DISCUSSION

The material is described in Tables 1 and 2. Table 1 shows the number of records and individual Thoroughbred horses that have records at one racing distance and at two distances. The highest proportions of Thoroughbred horses (more than 1 000) and starts are observed at distances of 1 000, 1 200 and 1 600 m, the smallest (476) at a distance of >1 800 m. The shorter distances are predominantly occupied by two year olds, whose number of races is limited by racing regulations, thus, despite a similar number of horses, the number of records at short distances is one third smaller compared to a distance of 1 600 m. Long distance races (1 800 and > 1 800 m) are prestigious races in which competition limits the number of horses. The number of horses running both racing distances decreases as the differences of each racing distance increase.

A distance of 1 600 m was the most representative distance for Thoroughbreds and Arab horses. The smallest number of Arab horses (163) were raced at the distance of >2 200 m (Table 2). The total average number of races at a specific distance as well as both racing distances was higher for Arab horses.

The highest genetic variance, relative to the phenotypic one (0.16), was found for the shortest distance, at which almost all the Thoroughbred horses begin their racing career (Table 3). It was of the same magnitude as in the whole population regardless of the race distance (Sobczyńska and Łukaszewicz,

Table 3. Heritability (h^2) and repeatability (r) coefficients of placings recorded at different racing distances for Thoroughbreds and Arab horses

Racing distance (m)	Thoroughbreds		Arab horses	
	h^2	r	h^2	r
1 000	0.16	0.39		
1 200	0.04	0.27		
1 300	0.09	0.19		
1 400	0.07	0.16	0.02	0.20
1 600	0.07	0.20	0.07	0.34
1 800	0.04	0.17	0.08	0.22
> 1 800	0.06	0.28		
2 000 + 2 200			0.06	0.20
> 2 200			0.07	0.38

2004). The heritability estimate is similar to that reported by Villela et al. (2002) for Quarter horses, who are racing at short distances, and by Lee et al. (1995) for Thoroughbreds. Heritability at longer distances is much smaller (0.04–0.09). When selection for the ability to win begins at the shortest distances, one expects that the genetic variance will drop as a reaction to the successive steps of selection. This phenomenon is indeed found in Thoroughbred horses. Lower genetic variance is expected in the longest distance races also due to the fact that two years old Thoroughbreds are not likely to race in those races (almost all young Thoroughbreds race at short distances, and do not race at distances longer than 1 600 m). The heritability estimates for racing time in Thoroughbreds reported by Oki et al. (1995) and Buttram et al. (1988) in the American Quarter horses showed the same tendency. On the other hand, in the study of Williamson and Beilharz (1996) longer distance categories tended to show higher heritabilities than the shorter categories although this trend was by no means clear.

The heritability estimates for Arab horses are very low for all distances (h^2 ranged from 0.02 at 1 400 m to 0.08 at 1 800 m) and they are much smaller than in the whole population regardless of the race distance (Sobczyńska and Łukaszewicz, 2004). A different trend in heritability estimates across racing distances for two breeds may result from the fact that at the beginning of their career Arab horses race both at short (1 400 m) and long distances (2 000 m) when young Thoroughbreds race only at a short distance (practically, they do not race over 1 400 m).

Breed similarity can be observed when the repeatabilities of the performances are compared (Table 3). They are similar across medium-distance races in the Thoroughbreds and Arab horses indicating that, at low heritabilities, the specific environment gains importance in moulding the performance. In particular, the covariance between repeated performances is of environmental nature in the longest races, which is true of both breeds. The main difference regards, however, the repeatability of ranking at the shortest distance at which the young horses race. Young horses differ between themselves because of both genetic abilities and permanent environment specific to each horse. Comparing heritability and repeatability coefficients of placings recorded at different racing distances for two breeds one may suppose that in the Arab horses the environment of rearing animals influences their early performance much more than their additive genetic background does.

The differences between the horses regarding their ability to win at the longest distance races tend to be rather due to specific environment than due to the differences between their breeding values.

To sum up, it is risky to compare directly the assessment of heritability for short races and long races for Thoroughbreds. Short races contain not only true sprinters but also stayers primarily racing to gain fitness for their future races. Furthermore, young horses start their racing in sprint events and compete at short distances before the decision to race them at long-distance categories or to retire them from the track. Poor performers never progress to longer events. Thus, the longer distances contain a selected population and the genetic variation among horses and hence the heritability estimates should be lower than existing in the sprint races where sprinters and stayers compete against each other.

Most of the genetic correlations between placings at two different racing distances in Thoroughbreds are high and range from 0.54 to 0.98 (Table 4). They seem to decrease as the differences between racing

Table 4. Genetic (above diagonal) and environmental (below diagonal) correlations between placings recorded at two different racing distances in Thoroughbreds

Racing distance (m)	1 000	1 200	1 300	1 400	1 600	1 800	> 1 800
1 000		0.97	0.85	0.90	0.87	0.68	0.54
1 200	0.71		0.82	0.87	0.83	0.63	0.75
1 300	0.53	0.93		0.98	0.95	0.81	0.95
1 400	0.39	0.95	0.98		0.97	0.84	0.92
1 600	0.47	0.63	0.95	0.95		0.85	0.95
1 800	0.61	0.73	0.81	0.94	0.96		0.89
> 1 800	0.35	0.43	–0.26	0.12	0.49	1.05	

Table 5. Genetic (above diagonal) and environmental (below diagonal) correlations between placings recorded at two different racing distances in Arab horses

Racing distance (m)	1 400	1 600	1 800	2 000 + 2 200	> 2 200
1 400		0.98	0.98	0.95	0.98
1 600	0.99		0.99	0.97	0.99
1 800	0.98	0.97		0.98	0.98
2 000 + 2 200	0.98	0.99	0.99		0.97
> 2 200	0.98	0.51	0.98	0.99	

distances increase – the lowest correlation (0.54) was observed between the ability to win at 1 000 m and ability to win at > 1 800 m. However, the average of 21 estimations was high (0.85). The present results match closely the genetic correlations between racing times published by Oki et al. (1997). The genetic correlations between the nearest distance classes remain high as the racing distances increase.

The genetic correlations between placings recorded at two different racing distances in Arab horses are presented in Table 5. The values were very high and almost the same for all pairs of distances (0.95–0.99). Generally, genetic correlations between placings found for the Arab horses are higher than those estimated in the Thoroughbreds population. Despite longer distances at which the Arab horses race and probably more factors affecting the result of the race genetic correlations were higher in relation to Thoroughbreds. It means that we discuss very much the same trait measured only in different distances races.

The environmental correlations between rankings at the finish at different distance races for Thoroughbreds decreased as the differences between racing distances increased (Table 4). They were all positive and only rankings at a distance 1 300 m and over 1 800 m are negative and equal – 0.26. Such a low estimate of the environmental correlation may result from a low number of records and horses competing at both distance races. In Arab horses the correlation of 0.51 (Table 5) between ranking at a distance 1 600 and ranking at a distance over 2 200, which does not follow the pattern, may result again from a low number of horses participating at both distances. However, the environmental correlation between ranking at 1 400 m and ranking at >2 200 m that was estimated on the basis of small numbers of horses is very high.

Ranking at the finish describes a horse's ability to compete in a group of other rivals. The competition at all the distances is similar but not the same – the level of competitors increases at long distance races, as prestigious races performed at long distances. Furthermore, there is a better opportunity to utilize tactics by jockeys or trainers at longer distance races. Fedorski (1977) dealt with a similar problem. He found a high genetic correlation between placings in the first race in the season and placings in the remaining races in the season for two, three and four years old Thoroughbred horses. He suggested that the results of the first race in the season were a good prognosis of the horse's career in the season. Likewise, the results achieved by horses at the shortest distance race predict their quality as competitors in other distance races, particularly for Arab horses.

It can be concluded that rankings at different distance races are the same traits for Arab horses, but not exactly the same for Thoroughbreds. In Europe it is expected that horses will be specialized in different distance categories, whereas in Poland it is more common to see horses starting over a variety of distances, with the expectation that they will perform well independently of the distance. For example in Poland selection starts at short distances but sires for breeding are chosen on the basis of long distance race results. Sprint races give some information about speed but hardly any information about stamina, so if breeders want to produce horses that could compete on an international level, they must acknowledge that their selection practices need revision.

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