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Estimation of Genetic Parameters for Finished and Furlong Times in Thoroughbred Racehorses

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ABSTRACT : The objective of this study was to estimate genetic parameters for racing performance traits of thoroughbred racehorses, using a total of 58,124 racing records of 4,200 horses at Gwacheon Racing Park collected from January 2002 to December 2006. This study measured start one furlong time, last three and last one furlong times, and the resulting furlong time averages were 14.2 seconds, 39.9 seconds and 13.9 seconds, respectively. Furlong time means a split time measured based on a 1/8-mile (or approximately 201 m) distance and finished time means total racing time measured from start position to finish line. In the shortest distance races of 1,000 m, the average last three and last one furlong time was fastest at 38.7 seconds and 13.6 seconds, respectively. The correlation between finished time and start one furlong time decreased as the race distance increased, and the same trend was recognized from the correlation between finished time and last three furlong time. In short distance races of 1,400 m or less, the starting ability was found to be an important trait. The average speed was highest at 56 km/h for a 1,000 m race and lowest at 53.2 km/h for a 1,700 m race. Heritabilities of the start one furlong time, the last three and last one furlong time were estimated to be 0.337, 0.245 and 0.210, respectively; and repeatabilities for them were 0.452, 0.353 and 0.309, respectively. Phenotypic and genetic correlations between the start and the last one furlong time were negative at -0.141 and -0.155, respectively. (**Key Words :** Furlong Time, Finished Time, Genetic Parameter, Heritability, Repeatability, Thoroughbred)

INTRODUCTION

Today, the animal model is widely applied in livestock industries for the estimation of genetic parameters at national level based on the theory of the best linear unbiased prediction (BLUP). Many studies have reported the genetic progress of economically important traits achieved by selection based on BLUP. The following heritabilities have been estimated for best racing time in trotters: 0.36 by Minkema (1975), 0.25 by Hintz (1980) and 0.27 by Saastamionen and Nylander (1996). Árnason et al. (1982) reported that the heritability of best racing time varied in three different populations with values of 0.36 in Dutch, 0.12 in North Swedish and 0.18 in Russian trotters. Concerning the finished time, Ojala and Van Vleck (1981) found the heritability and repeatability (r) of 0.30 (r = 0.70), and Thuneberg-Selonen et al. (1999) estimated them as between 0.23-0.28 (r = 0.50-0.57). Racing times have also been used as a measure of performance in thoroughbred racehorses. The heritability of racing time was reported as 0.09-0.11, depending on race distance. Park and Lee (1999) estimated a higher heritability of 0.27 to 0.30 for racing time. The furlong time of Korean racehorses has been measured since January 2002. Furlong time is a split time measured based on a 1/8-mile (or approx. 201-meter) distance. In a race, furlong time is measured at the point of 200 m from the start and at 200 m and 600 m before the finish line. The start one furlong time has a critical effect on the entire race and is a very important trait for racing performance especially in short distance races of 1,400 m or less (Lee and Park, 2000). The U.S. equine industry places priority on speed for racehorse improvement, and thus there are a large number of brilliant and classic stallions. In Europe, on the other hand, racehorse improvement is based on staying power, therefore, solid and professional stallions

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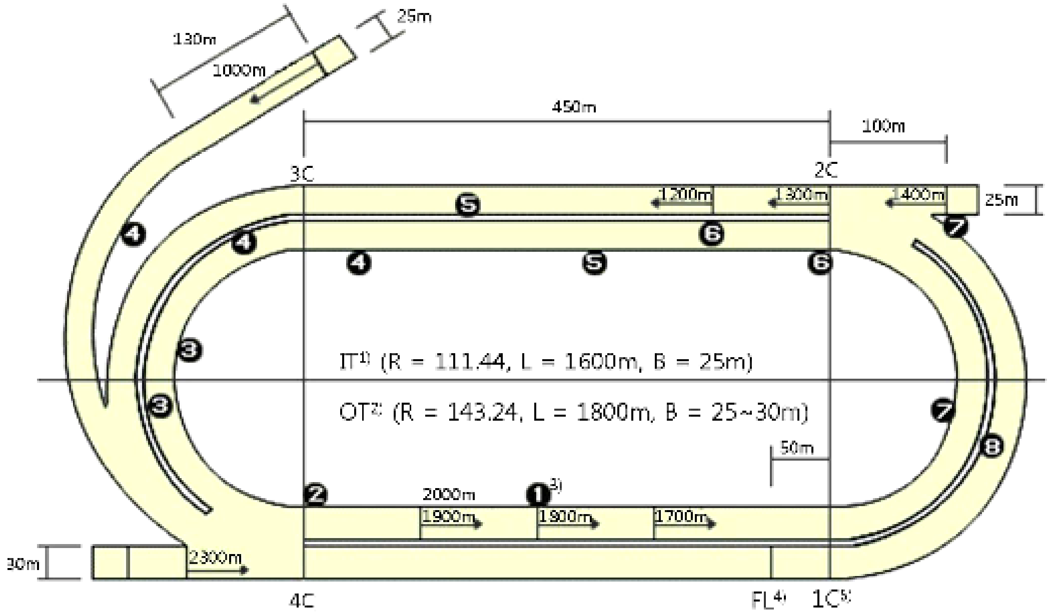

Figure 1. The structure of Gwacheon racetrack. [1] Inner tract (R:radius, L:length, B:breadth). [2] Outer tract. [3] Furlong position (❶-❽). [4] Finish line. [5] Coner.

have been mainly kept for breeding (Steven Roman, 1986). Actually, many racehorses on their debut in a 1,000 m race are more likely to win if their starting speed is fast. Considering the Korean horseracing system as a higher graded horseracing, however, the staying power in the finished moment seems more important than the speed at the start in 1,900 m or longer races, offering higher earnings. From the aspect of horse improvement or the position of Korean horse owners, the ability of running faster at the start and spurting at the last moment would be the most desirable for racehorses. As already known, the winning horses at international race meetings mostly have both abilities to run fast for the start of the race and make an energetic spurt at the last moment (Steve Roman, 1986). However, there are few studies of furlong time in Korea and abroad. The purposes of this study were to estimate genetic parameters of furlong times and simultaneously to examine their applicability for the genetic improvement of Korea racehorses.

MATERIALS AND METHODS

The structure of Gwacheon racetrack

The racetrack of Gwacheon Horse Racing Park is composed of four layers of substratum, mixed-aggregates, granitic soil and sand. The lower substratum, 33 cm in depth, is formed of gravel of a grade not exceeding 10cm in diameter. The upper substratum, 10 cm in depth, is formed of crushed stone less than 4 cm in diameter. The course bed, 10 cm in depth, is formed of decomposed granite sand and the surface, 7 cm in depth, is covered with sand. The track is subdivided into two parts: 1,800 m outer track and 1,600 m inner track. The straight line distance is 450 m both for the outer and inner tracks, and they are 450 m and 350 m in curved line distances, respectively. The breadth of each track is 25-30 m for the outer and 25 m for the inner. The total track area is 77,257 square meters and the area of the inner track is 44,319 square meters. The racing direction is counterclockwise, and each track runs from the start line to the finish line. Figure 1 shows the starting position and the racetrack structure. The track has upward and downward slopes that are designed to make the races more exciting by getting runners to control their pace. The backstretch is higher by two meters than the homestretch so that spectators can view the race more conveniently (Figure 2). The track is well drained in case of rain and has a cross sectional gradient to prevent runners from deviating from the course due to the centrifugal force.

Data description

The data used in this study were 58,124 racing records collected from 4,200 thoroughbred racehorses that raced at Gwacheon racecourse from January 2002, when furlong time was first used to record domestic racehorses, to December, 2006, provided by the Korea Racing Association (KRA). The measured traits for racing performance were finished time (FT), start one furlong time (S1F), last three (L3F) and last one (L1F) furlong times. Records distributed outside 3.5 standard deviations from the mean of each distance were all eliminated from the data for reasons of possible injuries to the horse during the race, or unavoidable mistakes made by the jockey. Table 1 shows

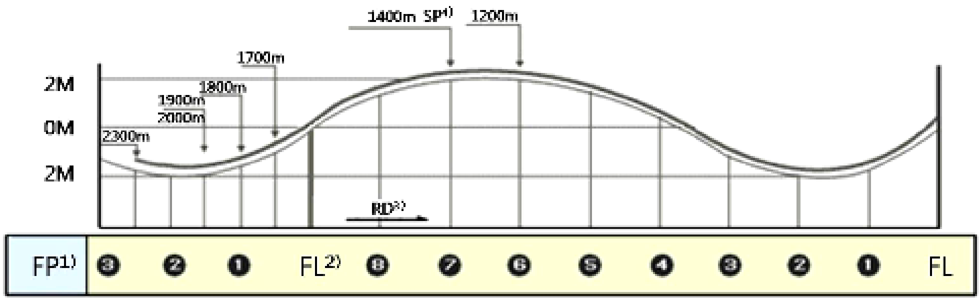

Figure 2. The Gradient of Gwacheon Racetrack. [1] Furlong position. [2] Finish line. [3] Racing direction. [4] Starting point.

the data structure and measured values. Except for the race distances of 1,900 m and 2,000 m, the finished time by race distances was distributed slightly rightward but most cases showed normal distribution. As the race distance increased, the standard deviation of finish time data increased. The overall average of S1F, L3F and L1F was 14.2 seconds, 39.9 seconds and 13.9 seconds, respectively. The S1F was fastest at 13.9 seconds for the 1,400 m race. The reason would be that horses ran on a long straight line at first with downward direction (Figure 2). In the 1,700 m race with the shortest straight line course from the start, S1F was slowest at 14.7 seconds on average, and for the shortest race distance of 1,000 m, L3F and L1F were fastest at 38.7 seconds and 13.6 seconds on average, respectively (Table 1).

Statistical method

Estimates of genetic parameters for the racing time traits were calculated using a Multiple Traits Restricted Maximum Likelihood (MT-REML) method (Misztal et al., 1992). The analytical animal model used was as follows;

$$y_{tijklmn} = \mu+d_{ti}+s_{tj}+m_{tk}+c_{tl}+a_{tm}+p_{tm}+e_{tijklmn}$$

where, $y_{tijklmn}$ = t^{th} racing time trait (FT, S1F, L3F and L1F), μ = overall mean, d_{ti} = fixed effect of the i^{th} racing distance (i = 1,000 m, 1,200 m, …, 2,000 m), s_{tj} = fixed

Table 1. Number of records, number of horses, means and standard deviations (SD) for finished (FT), start one furlong (S1F), last three furlong (L3F) and last one furlong (L1F) time by racing distance

Distance (m)	No. of records	No. of horses	FT Mean±SD	S1F Mean±SD	L3F Mean±SD	L1F Mean±SD
1,000	11,317	3,154	64.4±1.4	14.3±0.5	38.7±1.1	13.6±0.9
1,200	14,160	3,142	78.1±1.6	14.2±0.5	39.7±1.3	13.9±0.7
1,400	13,472	2,816	91.0±1.8	13.9±0.5	40.3±1.4	14.1±0.8
1,700	6,676	1,978	115.1±2.1	14.7±0.5	40.8±1.6	13.8±0.8
1,800	6,070	1,581	121.5±2.3	14.4±0.5	40.6±1.6	13.8±0.9
1,900	3,482	998	128.4±2.4	14.5±0.5	40.5±1.7	13.8±0.9
2,000	2,944	691	134.4±2.3	14.5±0.5	39.8±1.6	13.9±0.8
Overall	58,124	4,200[1]	-	14.2±0.5	39.9±1.6	13.9±0.8

[1] Total number of racehorses, not the column sum.

Table 2. Simple correlation among furlong times, finished time and placing order

Distance (m)	Finished time vs.			Placing order vs.		
	S1F[1]	L3F[2]	L1F[3]	S1F	L3F	L1F
1,000	0.55	0.84	0.39	0.50	0.54	0.24
1,200	0.49	0.74	0.55	0.36	0.52	0.42
1,400	0.38	0.69	0.55	0.24	0.52	0.48
1,700	0.27	0.59	0.46	0.19	0.50	0.50
1,800	0.25	0.59	0.44	0.16	0.49	0.50
1,900	0.21	0.57	0.46	0.15	0.49	0.49
2,000	0.24	0.55	0.48	0.15	0.57	0.55

[1] Start one furlong. [2] Last three furlong. [3] Last one furlong. All figures were significantly different from zero ($p<0.01$).

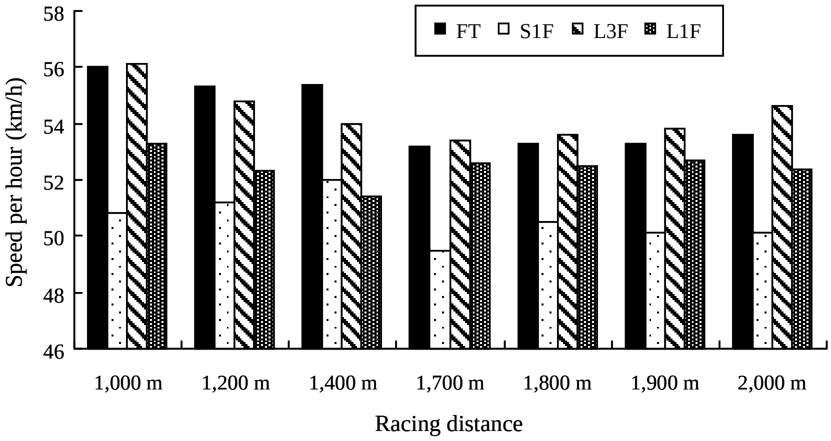

Figure 3. Speed per hour (km/h)[1] for finished (FT), start one furlong (S1F), last three furlong (L3F) and last one furlong (L1F) time by racing distance, [1] ((distance/time (second))×3,600 s)/1,000 m.

effect of j^{th} sex (j = gelding, stallion, mare), m_{tk} = fixed effect of the k^{th} year of age (k = 2, 3, …, more than 7 yr), c_{tl} = fixed effect of the l^{th} contemporary group (l = 1, 2, …, 5,459), a_{tm} = random additive genetic effect of the m^{th} animal (m = 1, 2, …, 7,645), p_{tm} = permanent environmental effect of individual animals (m = 1, 2, …, 4,200), $e_{tijklmn}$ = random residual effect, Var(u) = $A\sigma^2_u$, Var(p) =$I\sigma^2_p$, Var(e) = $I\sigma^2_e$, where, A = numerator relationship matrix and I = identity matrix. In the model, contemporary group means that the racehorses ran together at the same racetrack in the same race on the same date.

RESULTS AND DISCUSSION

Simple correlation

The S1F, representing starting ability, and the phenotypic correlation between finished time records decreased as the race distance increased (Table 2). The same results were found in the correlation with the placing order, i.e., the order of crossing the finish line. The starting ability was found to be an important trait in short distance races of less than 1,400 m, and especially in 1,000 m the highest correlation of 0.55 was found between starting ability and finished time. The average speed per hour was highest at 56 km/h in 1,000 m and lowest at 53.2 km/h in 1,700 m. The highest speed for the last one furlong (or the 201 m sprint) was 65.2 km/h in 1,400 m. Figure 3 shows a comparison between time at finish and furlong time by race distances.

Genetic parameters

Table 3 shows the estimates of variance components and genetic parameters for racing time traits. Heritability and repeatability for finished time were estimated to be 0.331 and 0.448, respectively. These results were slightly lower in repeatability but almost similar in heritability, compared to the repeatability of 0.70 and heritability of 0.30 reported by Ojala and Van Vleck (1981). On the other hand, these figures are slightly lower in heritability but almost similar in repeatability, when compared to the ranges of heritability and repeatability for finished time reported by Thuneberg-Selonen et al. (1999) as between 0.23-0.28 and 0.50-0.57, respectively. In heritability, the measured values are also nearly consistent with a range of 0.27-0.30 estimated by Park and Lee (1999). For start one furlong time, last three and last one furlong time, heritabilities were estimated to be 0.337, 0.245 and 0.210, respectively, and repeatabilities were 0.452, 0.353 and 0.309, respectively.

Phenotypic and genetic correlation

Table 4 shows the genetic and phenotypic correlations among racing time traits. Phenotypic and genetic correlations between S1F and L1F were negative at -0.141 and -0.155, respectively. This suggests that runners of good starting ability may lack the staying power for the last spurt on the homestretch. When the track is in poor condition, or

Table 3. Additive genetic (σ^2_a), permanent environmental (σ^2_{pe}), error variance (σ^2_e) components, heritabilities (h^2) and repeatabilities (r) for racing time traits

Racing traits	σ^2_a	σ^2_{pe}	σ^2_e	h^2	r
Finished time (FT)	0.63161	0.22367	1.05536	0.331	0.448
Start one furlong (S1F)	0.06642	0.02291	0.10812	0.337	0.452
Last three furlong (L3F)	0.33873	0.14873	0.89464	0.245	0.353
Last one furlong (L1F)	0.09981	0.04708	0.32794	0.210	0.309

Table 4. Genetic and phenotypic correlations among racing time traits

Racing traits	FT	S1F	L3F	L1F
Finished time (FT)		0.561	0.819	0.680
Start one furlong (S1F)	0.407		0.035	-0.141
Last three furlong (L3F)	0.798	-0.077		0.956
Last one furlong (L1F)	0.646	-0.155	0.877	

Upper: phenotypic correlation, Lower: genetic correlation.

when there is a lot of water on the track, the runners of better starting ability are said to be more likely to win the race. In long distance races under normal track conditions, it would be necessary to have the staying power (L3F and L1F) for the last spurt as well as the starting ability (Lee and Park, 2000).

CONCLUSION

There are a variety of measures available for racehorse breeding including finished time, best time, earnings, placing order and furlong times as in this study. Further studies should be focused on what measures to use for better racehorse breeding. Application of economic weight for these measures may give us an orientation. Finished time is generally considered as an important trait. However, as shown in this study, the use of furlong times in addition to other racing time traits would be helpful for the breeding of racehorses with the superior abilities of running fast from the start and the staying power for the last spurt.

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