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Effect of paragenetic factors on race time in a small population of trotters

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Abstract: Based on the information from the Trotting Association of Serbia, we analyzed the effect of paragenetic factors on the race times of trotters born between 1995 and 2005. Data consisted of 3435 observations of 141 trotters. The fixed effects of sex, racetrack, season, age, and distance were used to generate a linear regression model. All the observed factors had a highly significant influence on race times. On average, stallions, compared to mares and geldings, had statistically significantly faster race times ($P < 0.01$), while there was also a statistically significant difference between mares and the slower geldings ($P < 0.05$). Race horses produced their best results in the summer season (May, June, July, and August). The race times of trotters decreased as the age of the horses increased, i.e. between age and race time, there was a statistically significant negative correlation, while between distance and race time there was a statistically significant positive correlation. These results will aid in decision making about which fixed factors should be included in estimation of breeding values, even when the number of horses in the gene pool is relatively small. Incorporation of such data should enable better selection of trotting horses for breeding purposes, as it would be based on measured performance criteria.

Key words: Paragenetic factors, race time, trotters

1. Introduction

Small breeding units are a characteristic of many horse populations. In comparison with other farm animals, horses have very long generation intervals and low rates of reproduction. In these cases, very often only small datasets are available, making it more difficult to ensure genetic progress. The main goals in breeding good trotting horses are that they become successful, durable, and healthy and be able to start early in a junior sport (racing) career, because the earlier they are proven in sport, the earlier they are in demand for reproduction. Evaluation of the breeding value of racehorses is usually based on a few traits: speed or time, money or earnings, number of starts, and finishing ranks. Most horses that have raced have a time record but have not necessarily won money or a record of ranking at the finish. Thus, for purposes of sire evaluation, a measure of performance based on time at finish is more useful than a measure based on the money won or the rank at finish (1). Race time is expressed as the inverse of a speed, i.e. the time taken to cover 1 mile (Standardbreds) or to cover 1 km (in Europe). A horse can be evaluated by its average time or, more commonly, by its lifetime best time (2). The most important trait for selection of racing performance was race time, due to its substantially higher heritability and its high genetic correlation to earnings (3). When trotting performance is measured by time criteria, the horse's age, sex, birth year, race distance, racetrack, track condition, prize money, and racing season are often taken into consideration. The best race times of Finnish trotter populations diminish with age (4). Males had an advantage over females with respect to best times (1.6 s), times at finish (1.2 s), and money won per year (2). However, racetrack factors, resulting from some physical conditions such as the type of ground (grass is slower than sand), could also affect race times. According to research by Ojala et al. (5) into the year, season, and sex factors, only the season statistically significantly influenced horses' best annual race times. In that study, the season effect in the model accounted indirectly for track condition. The effect of the racing distance on speed has been observed in countries having a wide range of differing race distances. Thiruvenkadan et al. (2) observed that this factor can bias the other effects of racehorse age on race times, because younger horses race over shorter distances.

The aim of the current study was to assess the effect that sex, racetrack, season, age, and distance have on the race times of a small population of trotters in Serbia. These results are important for research related to the estimation of the breeding value of stallions, where the impact of these factors cannot be ignored.

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2. Materials and methods

For this research, the database of the Trotting Association of Serbia was used. The study included data for horses that were born in the period from 1995 to 2005 and encompassed 5 mares and 5 stallions from each year, plus all the geldings, amounting to a total of 141 horses. The data for each horse included horse ID, year of birth, sex, racetrack, date of the race, race distance, and the horse's recorded time for the race. The study included only animals with a minimum of 5 races, and all outlying values were excluded. The parameters involved in statistical evaluation were:

- Sex (S) - mares, stallions, geldings;
- Racetrack (R) - the research included racetracks with more than 40 races;
- Season (Se) - the year was divided into 3 seasons:
  Winter - November, December, January, February;
  Spring/autumn season - March, April, September, October;
  Summer season - May, June, July, August;
- Age (A) - the horses were grouped by age such that the groups ranged from 2 (2-year-old horses) through 9 (9-year-old horses) and up to 10+ (horses aged 10 years or more);
- Race distance (D) - ranged from 1600 m to 4080 m;
- Race time (Y) - expressed in seconds.

Statistical analysis was conducted on data downloaded from the Serbian Trotting Association using STATISTICA 10. To determine the average value, the method of least squares (LS) was used, and for impact of sex, racetrack, season, age, and distance on the race times of the trotters, the general linear models with repeated measures were used. Variance homogeneity was tested by Bartlett's test. There was no difference between the variances (P > 0.05). The statistical model was:

$$Y_{ijklmn} = \mu + S_i + R_j + Se_k + A_l + D_{m(\chi-\bar{\chi})} + e_{ijklmn},$$

Y_{ijklmn}: race time
μ: general average,
S: the effect of sex (i = 1...3),
R: the effect of the racetrack (j = 1...12),
Se: the effect of annual season (k = 1...3),
A: the effect age (l = 1...9),
D_{χ}: mean of distance,
$D_{\bar{\chi}}$: average mean of distance,
$D_{(\chi-\bar{\chi})}$: linear regression effect of distance,
e: random error is an error term under the usual assumptions for ANOVA (the error is distributed normally with mean = 0 and a constant variance).

To determine the difference between the average values of individual groups, the Duncan test was used.

3. Results

Table 1 shows the effect of sex, racetrack, annual season, age, and distance on race time; we see that all these factors had a highly significant influence on trotting horse race times.

The achieved average race times of the horses when grouped by sex are shown in Table 2. According to these data, stallions, on average, ran the fastest and achieved the quickest race times, while the slower mares still achieved faster race times than geldings. There were statistically

Table 1. The effect of the studied factors on race time.

Source of variability	DF	SS	MS	F	P
Sex	2	170.15	85.08	11.23	0.0000**
Racetrack	11	2175.37	197.76	26.11	0.0000**
Season	2	102.86	51.43	6.79	0.0011**
Age	8	10,569.73	1321.22	174.42	0.0000**
Distance	1	2159.68	2159.68	285.10	0.0000**

DF: Degrees of Freedom; SS: sum of squares; MS: mean square; F: f-value;
P: probability; P < 0.01; **: highly significant effect.

Table 2. LS mean (LSM) and standard error of mean (LSE) for trotting horse race times when grouped by sex.

Sex	n	LSM	LSE
Mares	1345	82.09^{b}	0.109706
Stallions	1347	81.94^{A}	0.106188
Geldings	743	82.55^{c}	0.120673

Different large and small letters: (P < 0.01); different small letters: (P < 0.05).

highly significant differences between stallions and mares and stallions and geldings ($P < 0.01$) and a statistically significant difference between mares and geldings ($P < 0.05$).

Table 3 presents the achieved average race times of the horses at each of the 12 racetracks. Statistically highly significant differences were found between most racetracks, so special attention should be given to improving physical conditions at the tracks because these differences are primarily the result of an inadequate racetrack substrate.

The achieved average race times of the horses, grouped according to the annual season when the race was held, are shown in Table 4. The race horses produced their best results in the summer season, which was also when the largest number of races was held. Race times were, on average, statistically significantly shorter during the summer than at other times of the year ($P < 0.05$).

Table 5 shows the achieved average race times of horses grouped by age, and horses of 10 years of age or more achieved, on average, the fastest race times. From Figure 1, it can be seen that horse age and achieved race time were statistically significantly negatively correlated. There was also a statistically significant positive correlation between race distance and race times (Figure 2). For every unit increase in race distance, race times increased by 0.00140 s (using the coefficients of linear regression; Table 6).

4. Discussion

Highly significant effects of all the factors mentioned above on trotting horse speed were found by Bugislaus et al. (6), Röhe et al. (3), and Katona and Distl (7). It is thought that by using individual race information, environmental factors (rather than just pure genetic factors) will be able to be estimated much more accurately, and the information from each record will be more appropriately weighted in the final breeding value.

Much research has shown that male horses do better in races than females. Research by Jukic et al. (8) reported that stallions achieved statistically significantly faster race

Table 3. LS mean (LSM) and standard error of the mean (LSE) by racetrack.

Racetrack	n	LSM	LSE
1	1455	81.56^{A}	0.085328
2	883	83.67^{B}	0.108800
3	84	81.08^{C}	0.308139
4	179	80.76^{abcdfG}	0.213950
5	132	81.53^{D}	0.252170
6	142	82.88^{E}	0.234631
7	65	$83.99^{abcdeFh}$	0.347606
8	52	$85.65^{abcdegh}$	0.397203
9	79	$80.65^{ABCDEFG}$	0.316671
10	112	$82.91^{abcdeFh}$	0.267821
11	210	80.36^{abcdeh}	0.197354
12	42	83.32^{Fh}	0.440890

The same small letters: $P < 0.01$; the same large letters: $P < 0.05$; different large letters: $P > 0.05$.

Table 4. LS mean (LSM) and standard error of mean (LSE) by season.

Season	n	LSM	LSE
Winter	477	82.29^{a}	0.145050
Spring/autumn	1225	82.34^{a}	0.108640
Summer	1733	81.96^{b}	0.099271

Different small letters: $P < 0.05$.

Table 5. LS mean (LSM) and standard error of mean (LSE) by age.

Age	n	LSM	LSE
2	133	88.57[a]	0.253284
3	445	84.25[b]	0.151939
4	707	82.66[c]	0.127130
5	694	81.38[D]	0.128734
6	524	80.81[d]	0.138525
7	373	80.64[D]	0.158188
8	217	80.80[d]	0.196430
9	190	80.69[d]	0.210513
10+	152	79.97[E]	0.232939

Different small letters: P < 0.01; different large letters: P < 0.05; same small letters: P > 0.05.

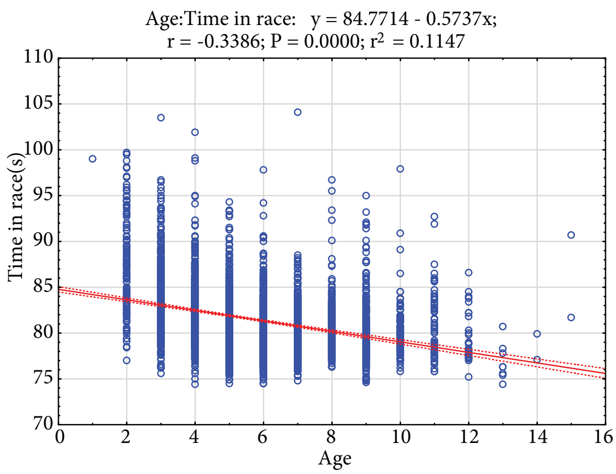

Figure 1. Relationship between race times and age.

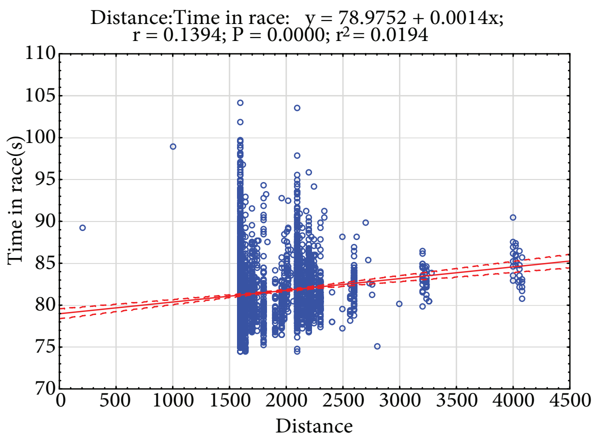

Figure 2. Relationship between distance and race times.

Table 6. Coefficient of linear regression of distance versus race time.

	b	SE_b	t-value	P-value
a	78.97523	0.301632	261.8265	0.00
Distance	0.00140	0.000158	8.8363	0.00

a: intercept; b: coefficient of linear regression; SE_b: standard error of b.

times compared to mares. Röhe et al. (3) found that stallions were 0.8 and 0.7 s/km faster than mares and geldings, respectively. Similar results were found by Ojala and Hellman (9), who stated that males were superior to females, with stallions being faster by an average of 1.05 to 2.29 s. Additionally, stallions and geldings are, in general, easier to work with and train when 2 years old. It appears that they enjoy work more and more easily submit to the effort of training. While the fillies do compete at 2 years old, they need much more patience and attention to be trained to the same standard as their brothers. The current study has confirmed the results of previously published studies, showing that stallions, in comparison to mares, on average produce statistically significantly greater speeds when racing. This is probably a consequence of exposure to more intensive training, differences in physiological processes in the bodies of male and female horses, and the length of each horse's racing career. Career length, as found in the current study, positively correlates with the results achieved in racing. Mares, due to reproductive factors, simply cannot replicate the intensity and length of a racing career that stallions are able to have.

Racetrack effects result from some physical conditions such as the type of ground; the weather also affects track assessment, as wet tracks are heavier than dry ones. Effects also result from the reputation of the racetrack, as those with better reputations can attract higher quality horses (2). Racetrack and length-of-race factors did not account for much of the variation in best annual racing time (5).

Racing time per kilometer improved by 3 s when age of the trotters increased from 2 to 9 years (3). Horses starting their racing career early have been reported to be superior to other racehorses and to have longer careers (10). Saastamoinen (11) observed that trotters broken in at 1 or 1.5 years of age and racing by 3 years of age were significantly faster (by 2.1 s) and had a greater number of starts and higher earnings by 5 years of age than those broken in at 2 or 3 years of age.

Based on the research of Mota et al. (12), the difference in mean velocity over race distances of 1000 and 2000 m was 0.24 m/s (15.3 m/s at 1000 m and 15.06 m/s at 2000 m). Considering the quadratic contribution, those authors pointed out that when race distance increased from 1000 to 2000 m, there was a 2.16 s increase in best race time. Leyten and Vandepitte (13) reported similar results.

The results obtained in the current study, based on only a small population of trotting horses, are in agreement with literature data, which are based mainly on research of larger datasets. Therefore, these results will aid in decision making about which fixed factors should be included in evaluation of breeding values, even when the number of horses in the gene pool is relatively small. Incorporation of such data should enable better selection of trotting horses for breeding purposes, as it would be based on measured performance criteria.

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