January 1978

FACTORS INFLUENCING RACING PERFORMANCE OF THE STANDARD-BRED PACER

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SUMMARY

Generalized least squares solutions were used to estimate effects of post position, track condition, purse within class of race, and breaking stride on time at finish of the Standardbred pacer. A total of 30,181 race records made during the 1972 racing season were analyzed. All effects were found to have a significant influence on time at finish. Differences between effects were generally uniform across age groups. Since post position, track condition, purse within class of race, and breaking stride were found to have a substantial influence on racing performance, these factors should be considered when estimating a horse's racing ability.

Variance components pertaining to horse and driver effects were estimated using Henderson's Method 2. Repeatability estimates of horse and driver performance for the various age groups ranged from .2 to .7, with an average of .43. The average repeatability indicates that horse and driver variances account for 43% of the total variation.

(Key Words: Racing Performance, Repeatability, Standardbred.)

INTRODUCTION

Even though the Standardbred has been bred for racing for many years, little research has been conducted on the possibilities of improving the breed's racing ability through genetic selection. However, in order to identify genetic differences among animals, records need to be adjusted for environmental factors influencing performance. Even though an International Symposium on Genetics and Horse Breeding has been held, little research has been reported on the possibilities of improving the racing ability of the Standardbred pacer (VanVleck and Hintz, 1976). A goal of this study was to examine the influence of post position, track condition, purse within class of race, and breaking stride on time at finish of Standardbred pacers at four tracks. A pacer breaks stride when he breaks his gait and starts to gallop. Environmental effects influencing rank at finish, money won, difference between time at finish and time of winner, and difference between time at finish and racemate average of pacers at these same race tracks have been investigated by Hintz (1977).

MATERIALS AND METHODS

A total of 30,181 race records involving 3,842 horses and 783 drivers made during the 1972 racing season at Batavia Downs, Saratoga Raceway, Scioto Downs, and Vernon Downs were obtained from the United States Trotting Association[3]. Batavia Downs and Saratoga Raceway are half-mile tracks located at Batavia, NY, and Saratoga Springs, NY, respectively. Scioto Downs is a five-eights-mile all-weather track at Columbus, OH. Vernon Downs is a three-quarter-mile track with a chute (a quarter-mile straightway used at the start of a race) at Vernon, NY. Each record was identified by horse, driver, race, track, track length, track condition, post position, class of race, purse, breaking stride, money won, time at finish, and rank at finish. The sex of a horse was not identified. Only the records of pacers in mile races were used. To examine the effects of environmental factors across age, the horses were class-

[1] The authors wish to express their appreciation to Dr. Walter Harvey and Dave Jones, Ohio State University, and Dennis Nolan, United States Trotting Association, for their assistance in obtaining these data. The cooperation of the Dairy Records Processing Laboratory, Ithaca, NY, and the assistance of Robert Anderson and Dr. Harold Hintz, Cornell University, are appreciated.

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ified into five age groups: 2, 3, 4, 5 and 6 years or older.

The data from each age group and track were analyzed separately using the following linear model:

$$\mathbf{Y} = \mathbf{X}\beta + \mathbf{Z}u + \mathbf{e}$$

where $\mathbf{Y}$ is a known Nxl vector of individual race records; $\mathbf{X}$ is a known Nxp design matrix; β is an unknown pxl vector of fixed effects (all levels of post position, track condition, class of race, purse within class of race, and breaking stride (table 1), and a common constant); $\mathbf{Z}$ is a known Nxq design matrix; μ is an unknown qxl vector of random effects (horse and driver effects) having a multivariate distribution with mean zero and nonsingular qxq variance-covariance matrix $\mathbf{G}$, where $\mathbf{G}$ is a diagonal matrix with either horse or driver variance as the diagonal element; e is an Nxl vector having a multivariate distribution with mean zero and nonsingular variance-covariance matrix $\mathbf{R}$; μ and e are assumed to be uncorrelated; N is the total number of observations; p is the total number of levels of fixed effects; and q is the total number of levels of random effects.

Optimum prediction procedures require prior knowledge of the variance components pertaining to the random effects in the model. When this information is unavailable, the variance components need to be estimated from the data. An appropriate procedure for estimating variance components in mixed models not having interactions between fixed and random effects is Henderson's Method 2 (Henderson, 1953; Schaeffer, 1973) and accordingly, the method was applied to these data. The variance component estimates were utilized in calculating the repeatabilities listed in table 4.

Calculating sampling variances of variance component estimates requires that the true values of the variance components be known. To avoid this problem, approximate sampling variances were obtained by using the variance component estimates as the true values. However, due to computational difficulties, sampling variances of Henderson's Method 2 estimators are rarely obtained when handling large data sets. To obtain an indication of the accuracy of the estimates, sampling variances were estimated as if Henderson's Method 1 had been used on the data. That is, adjustments made for the fixed factors were ignored in calculating the sampling variances.

TABLE 1. LISTING OF FIXED FACTORS STUDIED

Post positions:
- 1–9

Track conditions:
- Fast
- Good
- Sloppy
- Slow
- Muddy
- Heavy

Class of races:
- Maiden races
- Claiming races with claiming price less than $1,000
- Claiming races with claiming price of $1,000 to $1,999
- Claiming races with claiming price of $2,000 to $2,999
- Claiming races with claiming price of $3,000 to $3,999
- Claiming races with claiming price of $4,000 to $4,999
- Claiming races with claiming price of more than $5,000
- Condition races

Purses:
- Less than $1,000
- $1,000 to $1,999
- $2,000 to $2,999
- More than $3,000

Breaking stride:
- Not breaking stride
- Breaking stride

TABLE 2. TOTAL NUMBER OF RECORDS AND NUMBER OF HORSES AND DRIVERS FOR EACH AGE GROUP AT EACH TRACK IN THE 1972 RACING SEASON

Track	All age	6 years or older	5-year-old	4-year-old	3-year-old	2-year-old
Batavia Downs						
Total record count	8641	5205	1504	1108	704	120
Number of horses	1150	656	186	159	116	33
Number of drivers	216	189	122	119	89	26
Scioto Downs						
Total record count	4595	1201	742	1031	1080	541
Number of horses	837	217	112	163	198	147
Number of drivers	201	131	93	130	116	83
Saratoga Raceway						
Total record count	9841	4595	1388	2125	1456	277
Number of horses	956	416	133	185	162	60
Number of drivers	181	147	104	110	101	52
Vernon Downs						
Total record count	7104	3178	1011	1361	1163	391
Number of horses	899	343	106	168	176	106
Number of drivers	185	137	79	109	91	61

For the above class of linear models the solutions to the equations:

$$\begin{bmatrix} X'R^{-1}X & X'R^{-1}Z \\ Z'R^{-1}X & Z'R^{-1}Z+G^{-1} \end{bmatrix} \begin{bmatrix} \hat{\beta} \\ \hat{\mu} \end{bmatrix} = \begin{bmatrix} X'R^{-1}y \\ Z'R^{-1}y \end{bmatrix} \quad \text{namely,}$$

$\hat{\beta}$ and $\hat{\mu}$ are generalized least squares (GLS) solutions of functions of the fixed effects (Henderson *et al.*, 1959; Henderson, 1973) and best linear unbiased predictions (BLUP) of the random effects (Henderson, 1963, 1973), respectively.

In this investigation, it was assumed that $R = I\sigma^2$ where I is an NxN identity matrix which implies that the e's are uncorrelated and that all records have a common variance. The assumption of a common variance may not be appropriate but is convenient from a computing standpoint, and any deviation from equality of variances was not considered an important source of error.

Because of the large number of equations, an iterative solution was obtained since a direct solution to the full set of equations was computationally impossible. To obtain full rank equations, the following solutions were set to zero: (1) the solution for the common constant; (2) the solution for fast track condtion; (3) the solution for not breaking stride; (4) the solution for maiden race; and (5) the solution for the first purse level with observations within each class of race.

Estimable functions of interest to this investigation were the differences between the levels of the fixed effects such as the difference between the effects of two different post positions. The inverse of the coefficient matrix

TABLE 3. ESTIMATES OF VARIANCE COMPONENTS FOR TIME AT FINISH IN SECONDS AND SAMPLING STANDARD DEVIATIONS OF THE VARIANCE COMPONENTS FROM RECORDS IN 1972 RACING SEASON[a]

Variances	Batavia Downs	Scioto Downs	Saratoga Raceway	Vernon Downs
All age				
Horse	2.793 (.170)	2.043 (.146)	2.825 (.214)	1.493 (.117)
Driver	.981 (.197)	.409 (.114)	1.156 (.289)	.703 (.170)
Error	4.056 (.066)	2.162 (.056)	8.893 (.088)	3.153 (.053)
6 years or older				
Horse	3.462 (.269)	3.055 (.434)	2.541 (.303)	1.409 (.172)
Driver	.975 (.236)	.643 (.340)	1.412 (.403)	.627 (.191)
Error	4.054 (.098)	1.895 (.159)	8.568 (.129)	3.185 (.071)
5-year-old				
Horse	1.988 (.321)	2.025 (.408)	3.281 (.757)	.999 (.233)
Driver	.486 (.251)	.052 (.262)	2.605 (.951)	.182 (.162)
Error	3.950 (.117)	2.365 (.136)	9.344 (.299)	3.362 (.090)
4-year-old				
Horse	1.939 (.398)	1.894 (.336)	3.485 (.568)	1.836 (.326)
Driver	.743 (.364)	.677 (.304)	1.251 (.510)	.616 (.274)
Error	4.227 (.134)	2.114 (.121)	8.453 (.201)	3.421 (.124)
3-year-old				
Horse	1.611 (.428)	1.828 (.289)	1.774 (.399)	1.289 (.247)
Driver	1.633 (.540)	.570 (.251)	.102 (.269)	.573 (.240)
Error	3.174 (.179)	1.978 (.110)	9.973 (.146)	2.735 (.100)
2-year-old				
Horse	2.720 (1.327)	.979 (.290)	2.732 (.936)	1.918 (.490)
Driver	.851 (1.175)	.745 (.305)	1.355 (.882)	.662 (.415)
Error	4.480 (.556)	3.066 (.156)	3.513 (.354)	2.600 (.219)

[a]The sampling standard deviations are in parentheses.

needed for computing variances of estimable functions was not obtained since the equations were solved iteratively. However, approximate variances of differences were estimated using the following equation:

$$\text{Estimated variance of difference} = \left(\frac{1}{n_1} + \frac{1}{n_2}\right) \text{(TSS-Red)/(N-S)}$$

where n_1 and n_2 are the number of observations of the levels involved in the difference, TSS is the total sum of squares, Red is the reduction in sum of squares due to fitting the complete model, N is the total number of observations, and S is the rank of the coefficient matrix. Approximate t statistics with N-S degrees of freedom were calculated by dividing the difference by the square root of the variance of the difference.

RESULTS AND DISCUSSION

Repeatabilities, differences between levels of fixed effects, and variance components were estimated separately for each of the four tracks. Table 2 lists the number of records, horses, and drivers for each age group at each track.

Estimates of variance components and their sampling standard deviations are listed in table 3. Variance component estimates were similar across age groups. Between horse variance ranged from .98 to 3.49 squared seconds. Driver variance ranged from .05 to 2.60, and error variance ranged from 1.90 to 9.97. The sampling standard deviations of driver variances ranged from one-half to three times the size of the driver variances, indicating a large amount of variation in the estimates. Sampling standard deviations of the between horse variances ranged from one-fourteenth to one-half the size of the between horse variances. Sampling standard deviations of the error variances were

TABLE 4. ESTIMATED REPEATABILITIES OF PERFORMANCE FOR TIME AT FINISH IN SECONDS FROM RECORDS IN THE 1972 RACING SEASON

Performance	Batavia Downs	Scioto Downs	Saratoga Raceway	Vernon Downs
All age				
Horse	.36	.44	.22	.28
Driver	.12	.09	.09	.13
Horse and driver	.48	.53	.31	.41
6 years or older				
Horse	.41	.55	.20	.27
Driver	.11	.11	.11	.12
Horse and driver	.52	.66	.31	.39
5-year-old				
Horse	.31	.47	.22	.22
Driver	.08	.0[a]	.17	.04
Horse and driver	.39	.46	.39	.26
4-year-old				
Horse	.28	.40	.26	.31
Driver	.11	.15	.10	.11
Horse and driver	.39	.55	.36	.42
3-year-old				
Horse	.25	.42	.15	.28
Driver	.25	.13	.01	.13
Horse and driver	.50	.55	.16	.41
2-year-old				
Horse	.34	.20	.36	.37
Driver	.10	.16	.18	.13
Horse and driver	.44	.36	.54	.50

[a]Negative variance estimate of −.052 was obtained.

one-thirtieth to one-twentieth the size of the error variances.

Estimates of the horse and driver repeatabilities, which ranged from .2 to .7, with an average of .43, are given in table 4. Repeatability estimates of horse performance provide an upper limit for the size of heritabilities. Minkema (1975) calculated heritability estimates ranging from .17 to .5 for time records of Dutch trotters. Rönningen (1975) calculated heritability estimates of time records to be .12 for North-Swedish trotters. As far as the authors are aware, no heritability estimates for the pacer have been reported.

Post position had a clear effect on time at finish. Differences due to post position are given in table 5. At Batavia Downs and Saratoga Raceway, the positions 1 to 5 generally had an advantage over positions 6 to 8. The positions 1 to 6 had an advantage over the positions 7 to 9 at Scioto Downs. Sola (1969) also found that times at finish indicated a large disadvantage for horses starting in outside post positions at Scioto Downs. At Vernon Downs, the positions 1 to 5 had an advantage over the positions 6 to 8. However, a slight advantage for positions 4 and 5 relative to positions 1 to 3 is apparent in the Vernon analysis. At all four tracks, the outside positions had a marked disadvantage relative to the other positions. The general

TABLE 5. EFFECTS OF POST POSITION ON TIME AT FINISH IN SECONDS

Differences[a]	All age	6 years or older	5-year-old	4-year-old	3-year-old	2-year-old
Batavia Downs						
2–1	-.02	-.09	.29	.00	-.21	-.56
3–1	.09	-.10	.43*	.67*	.37	-.17
4–1	.07	-.07	.40*	.43*	.00	.37
5–1	.11	.05	-.03	.59*	-.03	-.80
6–1	.30*	.23*	.59*	.32	.38	-.10
7–1	.32*	.11	.69*	.70*	.49*	.29
8–1	.48*	.41*	.58*	.42*	1.00*	.40
Saratoga Raceway						
2–1	.14*	.14	-.29	.47*	.01	.19
3–1	.18*	.16	.19	.25	.12	.37
4–1	.18*	.26*	.15	.36*	-.10	-.12
5–1	.21*	.16	.38*	.42*	.18	-.57
6–1	.36*	.55*	-.39*	.51*	.42*	.26
7–1	.60*	.64*	.58*	.35*	.97*	-.13
8–1	.70*	.67*	.64*	.81*	.86*	-.29
Scioto Downs						
2–1	.06	-.03	.05	.07	.22	.02
3–1	.04	-.20	.11	.04	.28	-.11
4–1	.18*	.16	-.05	.15	.34*	.29
5–1	.05	-.12	.04	.03	.31	.02
6–1	.13	.20	.16	-.09	.24	.02
7–1	.42*	.36*	.38	.54*	.41*	.30
8–1	.50*	.43*	.77*	.32	.74*	.16
9–1	.53*	.54*	.86*	.10	.58*	.88*
Vernon Downs						
2–1	.10	-.01	.14	.39*	.23	-.29
3–1	.07	.08	-.24	.15	.29	.24
4–1	.00	.03	-.05	.22	-.01	-.56*
5–1	-.03	-.01	.18	.01	-.27	.15
6–1	.16*	.18*	.11	.30	.15	-.13
7–1	.18*	.06	.57*	.26	.26	.10
8–1	.14*	.05	.14	.57*	.02	-.08

[a]Post position differences: 2–1 is effect of post position 2 minus effect of post position 1, et cetera.

*$P<.05$.

trends in differences due to post position were similar across age groups.

Post position differences may be due to the drivers seeking a position along the rail to avoid being parked out at a turn. A horse is parked out when he paces more than a sulky width from the rail. For instance, at the beginning of a race, drivers starting in the outer post positions often restrain their horses to avoid being parked out at the first turn. The middle post position advantage at Vernon Downs may have resulted from there being a quarter-mile straightaway with a slight elevation in the middle.

The track condition categories were fast, good, sloppy, slow, muddy and heavy. Because of its all-weather track, fast and good were the only track conditions at Scioto Downs. Differences in time at finish according to track conditions are given in table 6. A horse's time at finish was superior on fast or good tracks relative to a horse's time at finish on muddy or heavy tracks. Since dry tracks offer less resistance, times are expected to be less on fast and good tracks. The same general trends occurred across age groups.

Maiden, various claiming, and conditional races with different purse sizes were studied. Conditional races are composed of horses that meet certain criteria to be entered in a race. The differences between classes of races with different purse levels for time at finish are given in table 7. Times decreased as purse size increased and as claiming price increased at all four tracks. These results are to be expected since better quality horses would be expected to run for larger purses and in higher claiming races. Times were less for maiden races, which are races involving horses that have not won a race at time of starting, relative to lower claiming price races.

As the results in table 8 indicate, breaking stride had an obvious effect on time at finish. The advantage of not breaking stride was constant across age groups. Sola (1969) also found similar results concerning breaking and not breaking stride at Scioto Downs. Since a horse that breaks stride must be restrained while regaining its gait, the advantage of a horse not breaking stride is understandable.

TABLE 6. EFFECTS OF TRACK CONDITION ON TIME AT FINISH IN SECONDS

Differences[a]	All age	6 years or older	5-year-old	4-year-old	3-year-old	2-year-old
Batavia Downs						
2–1	1.82*	1.90*	1.60*	1.90*	1.32*	1.28*
3–1	4.46*	4.61*	4.13*	4.62*	3.93*	3.13*
4–1	3.84*	3.84*	4.01*	4.09*	3.10*	3.92*
6–1	18.71*	17.90*	20.73*	21.66*	23.48*	–
Saratoga Raceway						
2–1	1.06*	1.15*	.87*	1.09*	1.09*	.24
3–1	5.74*	5.94*	5.72*	5.35*	5.64*	5.13*
4–1	4.01*	4.52*	4.33*	3.57*	2.60*	2.65*
5–1	11.96*	11.52*	12.18*	11.96*	14.40*	8.76*
6–1	6.86*	7.13*	7.31*	6.43*	6.06*	3.90*
Scioto Downs						
2–1	2.42*	2.32*	2.62*	2.66*	2.25*	2.25*
Vernon Downs						
2–1	1.60*	1.55*	1.62*	1.44*	1.72*	1.61*
3–1	3.68*	3.74*	3.77*	3.66*	3.26*	4.79*
4–1	3.76*	3.76*	3.56*	3.78*	3.49*	4.29*
5–1	6.01*	5.89*	6.17*	6.16*	6.20*	5.51*
6–1	7.70*	7.74*	7.78*	7.83*	7.38*	8.71*

[a]Track condition differences: 2–1 is effect of track condition 2 minus effect of track condition 1, et cetera. A dash indicates a lack of observations in a class. Codes for track conditions are: 1 is fast; 2 is good; 3 is sloppy; 4 is slow; 5 is muddy; 6 is heavy.

*$P<.05$.

TABLE 7. EFFECTS OF CLASS OF RACE/PURSE ON TIME AT FINISH IN SECONDS

Differences[a]	All age	6 years or older	5-year-old	4-year-old	3-year-old	2-year-old
Batavia Downs						
11–82	5.08*	5.10*	4.95*	4.17*	3.67*	...
12–82	1.33*	.31*	2.05*	1.58*	1.21*	1.23*
31–82	2.47*	2.44*	3.11*	1.25*	1.99*	...
42–82	1.00*	1.08*	.94*	.88*	1.51*	...
52–82	.48*	.57*	.53*	.28*	...	...
62–82	-.22*	-.16	-.19	-.09	...	...
72–82	-.44*	-.19	-1.09*	-2.31*	...	...
73–82	-1.47*	-1.22*	-1.91*	-2.31*	...	...
81–82	.56*	.78*	.94*	-.09	.27	-1.02
83–82	-1.77*	-1.58*	-2.05*	-2.60*	-1.33*	...
84–82	-2.82*	-2.20*	-3.43*	-3.75*	-3.67*	...
Sratoga Raceway						
11–82	6.53*	...	...	9.04*	8.15*	...
31–82	3.98*	4.36*	4.81*	4.47*	...	...
32–82	3.45*	1.27*	1.92*	...	...	...
41–82	1.95*	2.46*	2.40*	1.33*	2.94*	...
42–82	2.58*	3.33*	2.76*	2.02*	1.57*	...
51–82	1.16*	2.09*	2.21*	-.17	1.30*	...
52–82	1.06*	1.70*	.78*	.58*	2.37*	...
62–82	.63*	1.25*	.66*	-.17	...	...
72–82	-.83*	-.34*	-.94*	-.94*	...	...
81–82	1.79*	2.08*	2.26*	1.46*	1.82*	7.11*
83–82	-1.56*	-1.57*	-1.04*	-1.77*	-2.78*	-2.65*
84–82	-1.57*	-1.14*	.22	-2.01*	-2.98*	-3.76*
Scioto Downs						
11–82	1.39*	.46*	.47	1.62*	1.55*	1.28*
42–82	2.50*	2.41*	2.20*	2.43*	2.88*	...
52–82	1.25*	1.20*	1.07*	.79*	1.41	...
62–82	.60*	.38*	.22	.94*	.92*	...
72–82	-.12	-.27	-.08	-.20	.34	...
74–82	-1.77*	-1.88*	-1.62*	-1.62*	-2.55*	...
81–82	3.01*	...	...	...	...	3.16*
83–82	-1.03*	-.30	-2.16*	-1.22*	-1.23*	...
Vernon Downs						
11–82	1.92*	1.69*	2.53*	2.44*	2.03*	1.34*
41–82	3.57*	3.33*	4.03*	3.93*	3.22*	...
42–82	1.97*	1.83*	2.06*	2.28*	...	...
51–82	3.16*	...	...	3.12*	3.36*	...
52–82	1.28*	1.06*	1.82*	1.25*	1.32*	...
61–82	2.87*	...	...	...	3.29*	...
62–82	.88*	.57*	.94*	1.60*	1.36*	...
72–82	.14*	-.11	-.09	.31*	.59*	3.59*
73–82	-1.33*	-.93*	...	-2.40*	...	...
81–82	1.07*	1.10*	1.14*	1.24*	1.19*	.77*
83–82	-2.08*	-2.26*	-2.22*	-2.14*	-1.59*	...
84–82	-3.00*	-3.22*	-3.36*	-2.95*	-2.63*	...

[a]Class of race/purse differences, 11 to 82 is effect of purse 1 within class 1 minus effect of purse 2 within class 8. Dots indicate a lack of observations in a class. Codes for class of races are: 1 is maiden race; 2 is claiming race with claiming price of less than +1,000; 3 is claiming race with claiming price of $1,000 to $1,999; 4 is claiming race with claiming price of $2,000 to $2,999; 5 is claiming race with claiming price of $3,000 to $3,999; 6 is claiming race with claiming price of $4,000 to $4,999; 7 is claiming race with claiming price of more than $5,000. Codes for purse levels are: 1 is less than $1,000; 2 is $1,000 to $1,999; 3 is $2,000 to $2,999; 4 is more than $3,000.

*$P<.05$.

TABLE 8. EFFECTS OF BREAKING STRIDE ON TIME AT FINISH IN SECONDS[a]

Ages	Batavia Downs	Saratoga Raceway	Scioto Downs	Vernon Downs
All age	2.93	2.85	2.82	2.87
6 years or older	2.89	2.90	2.49	2.80
5-year-old	3.31	2.66	2.84	3.15
4-year-old	2.87	2.69	2.90	2.90
3-year-old	2.28	2.90	2.89	2.89
2-year-old	2.71	2.13	2.87	2.83

[a]All differences, which are effect of breaking stride minus effect of not breaking stride, are significant ($P<.05$).

For obtaining an evaluation of a horse's past performance, knowledge of the influence of fixed effects on race performance should be useful to horse owners, trainers, racing secretaries, and bettors. In deciding to race their horses, owners and trainers could more ably ascertain racing ability of other horses in races. Racing secretaries, who have the responsibility to establish criteria for a race so that the horses entered should cross the finish line at the same time, could use the information to help organize races involving horses with more uniform racing abilities. Bettors could use the information to help predict the outcome of a race more accurately.

The main goal of Standardbred research should be to develop procedures to measure objectively racing performance. Available data should be adjusted for environmental fixed factors known to influence racing performance. Such adjusted records can then be used to predict a horse's true racing performance. Such adjusted records can then be used to predict a horse's true racing ability and breeding value. Further research is necessary to develop optimum procedures for determing breeding value of sires and dams. This analysis was in no way a complete examination of the factors influencing racing performance. However, it is hoped that this study is a first step in the development of better selection procedures.

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