Effects of Handicap Weight, Horse's Body Weight and Weight Change on Racing Performance in Jeju Horses

Young-Hoon Yang[1*], Sung-Soo Lee[2]

[1]College of Applied Life Sciences, Jeju National University ;
[2]National Institute of Animal Science

부담중량, 마의 체중 및 체중변화가 제주마의 경주능력에 미치는 영향

양영훈[1*], 이성수[2]

[1]제주대학교 생명자원과학대학 동물자원과학전공
[2]농촌진흥청 국립축산과학원

ABSTRACT

The effects of handicap weight, horse's body weight and weight gain or loss on racing performances in Jeju horses were studied using a total of 1,483 racing records of 121 horses in Jeju Race Park of KRA. A general linear model used in this analysis included three fixed effects of track condition, season and age, and two random effects of rider and individual, and four regression terms (handicap weight, handicap weight squared, horse's body weight and squared body weight change) and a random error term. All fixed effects included in the linear model were significant ($p<0.01$) and the coefficient of determination (R^2) of the model was 0.698. Regression terms of handicap weight, body weight and body weight change of horses showed statistical significance ($p<0.01$) and improved the coefficient of determination of the linear model by 2.4 percent compared with a model without these regression terms. The amount squared of either body weight gain or loss during the consecutive racings significantly reduced the racing performance ($p<0.01$), and would be comparable to the one sixth of the effect of increased handicap weight, indicating that the body weight change should be considered in genetic evaluation of racing performance.

Key words : handicap weight, horse weight, weight change, racing performance, Jeju horses

INTRODUCTION

It has been seven years since Jeju native horses started to be registered and used for racing at Jeju Racing Park of Korean Racing

* Corresponding author : Dept. of Animal Biotechnology, College of Applied Life Sciences, Jeju National University(e-mail:yhyang@cheju.ac.kr)

Association. Jeju horses, which came close to extinction at one time, have a specific geographically limited habitat of island. The population size of Jeju horses steeply decreased from 15,000 in 1970 to as low as 3,000 in 1985 because of decreasing value of horses for draft or riding. Lately, about 18,000 horses are in Jeju Island, and they are comprised of Jeju horses, Throughbred breed, and crossbreds between some exotic breeds and Jeju native horses. Most crossbreds are being used for riding and cart-pulling purposes in horse-back riding places. After 1985 Throughbred breed horses have been imported into Jeju Island for racing by the Korea Race Association, and so a lots of Jeju horses have been used to crossbreed with Thoughbred breed for racing in Jeju race track. A crossbred group of Jeju horses underwent a more extensive cross-breeding process lately, while the registered propagate under the controlled system of pure breeding.

Racing time, a quantitative measure of performance, is the only direct measure of speed that can be used to genetically evaluate the racing performance of horses. In general, factors affecting the racing performance are the ages of horses and weights that the horses have to carry, including track condition, weather, season and other environmental effects, so the statistical models of track racing records account for fixed effects of year, age, race, breeder, sex, weight carried and distance, and for random effects of rider, permanent environment, animal additive genetics (Sobczynska and Lukaszewicz, 2004; Yang 2005a, b).

The handicap weight, an impost is the weight that must be carried by a horse in a race. A more experienced horse is disadvantaged in order to make it possible for a less experienced horse to participate in the horse racing while maintaining fairness. Horses often carry lead weights during the course of a race as a form of handicap. These weights supplement a rider's weight to give a horse his assigned impost so as to equalize the chances of the competitors. Only a few investigations have been carried out concerning the influence of body weights of horses on racing performance while the effects of handicap weight, track condition, and weather, including age and seasonal effects on racing speed are well established. The effects of body weight changes of horses during the consecutive racings on racing performance have not yet been clearly defined.

The aim of this study was to investigate the effects of handicap weights, body weights and body weight changes of horses on the racing speeds at 800 meter distance race in Jeju horses.

MATERIALS and METHODS

The data used in this study were collected from Jeju Racing Park of KRA. All the racing horses having more than two racing records of distance 800 meters were selected from Jeju native horse group registered at Jeju Institute, and a total of 1,483 racing records of 121 horses were analysed. The statistical package SAS was used to set up the files, to perform descriptive analysis and to evaluate effects of environmental factors on the racing time analysed.

A general linear model used in this analysis included three fixed effects of track condition, season and age of horse, and two random effects of rider and individual, and four regression terms of handicap weight, handicap weight squared, body weight and squared body weight change of a horse, and a random error

Table 1. Descriptive statistics of racing time, handicap weight, body weight and body weight change of horses, and interval between consecutive entries of a horse.

Variable	n	Mean±S.E.	Max.	Min.	C.V.	Skewness
Racing time, second	1483	73.22±0.08	86.2	64.2	4.1	0.28
Handicap weight, kg	1483	53.80±0.06	71.0	48.0	4.0	13.18
Body weight, kg	1483	262.41±0.55	316.0	171.0	8.0	0.06
Body weight change, kg	1483	1.06±0.12	21.0	17.0	417.8	1.11
Period between races of a horse, days	1483	17.88±0.29	92.0	0.0	62.65	10.91

term.

The statistical model was as follows:

$$Y_{IJKLMN} = LC_I+SE_J+AG_K+RD_L+IN_M+b_1X_1 +b_2X_2+b_3X_3+b_4X_4+e_{IJKLMN}$$

Where, Y_{IJKLMN} is the time record in seconds, LC_I is the track condition, SE_J is the season, AG_K is the age of horse, RD_L is the rider, IN_M is the individual, X_1 is the handicap weight, X_2 is the handicap weight squared, X_3 is the body weight of horse, X_4 is the squared amount of body weight change, and b_1, b_2, b_3 and b_4 were the regression coefficients, e_{IJKLMN} random effect of residual error.

RESULTS and DISCUSSION

Although some characteristics such as body height and length show similarities to the traits of typical Mongolian horse breed, recent studies (Kim et. al., 1999; Yang et. al., 2002), together with archeological remains of bones which were excavated in Jeju Island, suggested that horses were present on Jeju island prior to the Mongolian introduction in 1276. Even though their small (120-135 cm in height) and hard body conformation, Jeju horses started to be registered and used for racing at Jeju Racing Park of Korean Racing Association seven years ago, and therefore the factor affecting racing ability is a matter of the utmost concerns for the breeders or owners of Jeju horses.

In the descriptive statistics for the racing records of Jeju horses, the mean racing time (mean ± standard error) at the distance of 800 meter race was 73.23 (±0.08) seconds (Table 1). The frequency distribution of racing times showed a slightly positive coefficient of skewness (0.28), which means that the more racing records was concentrated in the left tail than would be expected in a normal distribution, indicating the greater difficulty of horses in reaching faster finish times compared with slower finish times. The coefficient of variation of body weight change during the consecutive racings was comparatively higher than those of other measures. The mean interval between entries of a horse for consecutive racings in Jeju Racing Park was 17.9 (±0.29) in days.

Variance and F statistics of the statistical linear model for the racing records are shown in Table 2. All the fixed effects included in the linear model were significant ($p<0.01$), indicating that these factors were important in evaluating racing horses. Significant effects of the lane condition, season, animal's age, rider and individual on racing speed observed in the present study have also been reported by various investigators for different horse breeds (Hintz & Van Vleck, 1978; Willham & Wilson, 1991; Mota et. al., 2005; Yang Y.H., 2005a,b). In the linear model, the coefficient of

Table 2. Analysis of variance and F statistics for racing records.

Source	DF	SS	MS	F Value	Pr > F
Model	183	9780.65	53.45	17.24	<.0001
Error	1300	4029.95	3.10		
Lane condition	3	322.20	107.40	34.65	<.0001
Season	3	251.70	83.90	27.06	<.0001
Age	8	195.22	24.40	7.87	<.0001
Rider	44	295.38	6.71	2.17	<.0001
Horse	120	5732.11	47.77	15.41	<.0001
Handicap weight	1	27.13	27.13	8.75	0.0031
Handicap weight squared	1	20.17	20.17	6.51	0.0109
Body weight of horse	1	74.66	74.66	24.08	<.0001
Body weight change squared	1	19.92	19.92	6.43	0.0114

determination (R squared), the percent of the variance in the dependent variable that can be explained by all of the independent variables taken together, was 0.698, giving the moderate goodness of fit of the statistical model used in this study.

In covariate terms, the handicap weight, handicap weight squared, body weight and the squared amount of body weight change of a horse showed statistical significance ($p<0.01$). These regression terms improved the coefficient of determination of the linear model by 2.4 percent compared with the model without these regression terms. Average weight that a horse carried in a race was 53.8 kg (Table 1), and an increment of 1.0 kg impost gave the horse an adverse effect on finish time by 1.25 seconds (Fig 1).

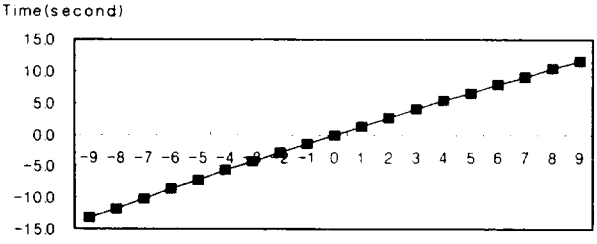

Fig 1. Rgression of racing time on handicapped weight at the distance of 800 m

$Y = 1.38*hwt - 0.0106*hwt^2$ ($p<0.01$)

The racing speed of Jeju horse increases with age, and reaches the fastest point of 72.1 seconds at the age of five in the 800-meter race (Table 3), while the speed of Thoroughbred breed has been reported about 66.3 seconds in the 1,000 meter race (Park et al., 1992). The least-squares estimate of the regression coefficient for body weight of horse showed positive value ($b=0.027$, $p<0.01$), indicating that Jeju horses may eat far more than they need. Excess weight and over-nutrition would be a number of potentially negative effects on racing performance, including more strain on feet, joints and limbs. Maintaining an ideal weight is to supply food and exercise in proper amounts to keep horses fit and healthy (Deborah, 1999). Ponies like Jeju horses, in particular, seem to store excess energy as fat. From these point of view, an adjustment of feeding strategy may be required to control the overweight due to overfeeding or reduced activity and excercise. The amount of energy being fed should meet the energy requirement to maintain good body condition for racing.

Table 3. Least squares means in seconds of fixed effects and regression parameters of 800m racing distance.

Item	LS Mean	S.E.
Lane Condition		
Humid	71.97	0.23
Poor	73.08	0.23
Good	72.21	0.21
Saturated	73.42	0.25
Season		
Spring	72.06	0.22
Summer	72.37	0.25
Autumn	73.09	0.23
Winter	73.16	0.21
Age(year)		
2	74.24	0.33
3	73.43	0.25
4	72.27	0.25
5	72.14	0.27
6	72.58	0.33
7	72.06	0.45
8	72.31	0.62
9	72.10	1.09
Over 10	72.90	1.18
Regression Parameters		
Handicap weight	1.3803	0.4666
Handicap weight squared	0.0107	0.0042
Body weight of horse	0.0270	0.0055
Body weight change squared	0.0036	0.0014

The amount squared of either body weight gain or loss during the consecutive racings significantly reduced the racing performance ($p<0.01$) and showed the equal amount of one sixth of the effect of increased handicap weight (Fig 2), indicating that the body weight changes between two entries in a resting period of days could be included in a statistical model as a covariate in the genetic evaluation of racing records.

In conclusion, covariates of handicap weight, horse's body weight and weight change should be considered in the genetic evaluation for the data with various environmental effects because of their significant effects on racing performance.

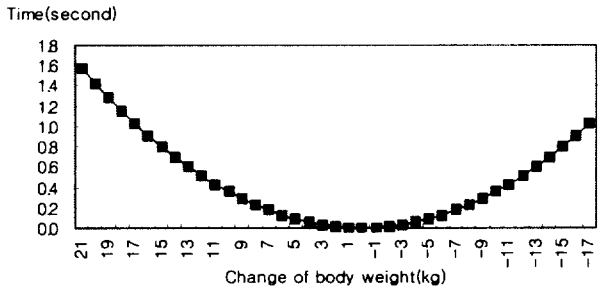

Fig 2. Regression of racing time on body weight change from the previous racing event
$Y = 0.003559 \times ch^2$ ($p=0.011$)

적 요

제주마의 경주능력에 있어서 부담중량, 출주마의 체중과 체중변화의 영향력을 평가하기 위하여 한국마사회 제주경마공원의 제주마 121두로부터 1,483개의 경주기록을 수집 분석하였다. 경주기록의 분석은 경주로상태, 계절, 경주마의 나이를 고정효과로 하고, 기수와 경주마 개체를 임의효과로, 그리고 부담중량, 마체중, 체중변화량을 회귀항으로, 임의의 오차항을 포함하여 선형모형을 설정한 후 SAS의 GLM으로 분석을 하였다.

선형 모형에 포함된 고정효과인 경주로상태, 계절, 경주마의 나이는 모두 고도로 유의했으며 ($p<0.01$), 이 선형모형의 결정계수 (R^2)는 0.698이었다. 부담중량, 출주마의 체중과 체중변화량에 대한 회귀항 역시 고도로 유의($p<0.01$) 하였다. 결정계수의 증가에 의하면 회귀항이 없는 모형에 비해 이들 회귀항이 추가된 모형이 2.4%나 선형모형의 설명력을 증진시키고 있었다. 또한 연속되는 경주에서 출주마의 휴지기 체중변화량(전번 출주부터 금번 출주시기 사이에 체중변화량)은 체중이 증가하거나 감소함은 모두 경주능력에 불리하게 작용하고 있었다($p<0.01$). 이의 효과는 부담중량 효과의 1/6에 달하고 있었는데, 이와 같은 영향을 고려한다면 경주마의 유전적 능력 평가에 있어서 휴지기의 체중변화는 반드시 검토되어야 할 부분으로 사료되었다.

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