

Evaluation of the Cardiorespiratory Endurance of Jeju Crossbred Horses according to Exercise Intensity

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Abstract : The present study was conducted to measure the cardiorespiratory endurance of Jeju crossbred horses according to hill tests and exercise intensity, thereby providing foundational data for evaluation of running capability of horses. The nine Jeju crossbred horses were subjected to the hill test with an inclination of around 30° and six out of nine horses were used to measure the cardiorespiratory endurance according to three different exercise intensities (moderate, heavy, and very heavy). The running time for the hill test was 205 sec on average, while high deviation was observed between horses from 167 to 258 sec. In addition, the running time for the hill test was highly correlated with moderate exercise. While no significant difference in average heart rate was found between exercise intensities, a trend of large variation was found in the average heart rate between horses. The heart rate recovery was highly correlated with heavy exercise and very heavy exercise. The results showed that no significant difference in average heart rate was found among three exercise intensities, but there are large individual variations among horses.

Key words : Jeju crossbred horses, hill test, cardiorespiratory endurance.

Introduction

Among sports using animals such as horses, camels, and greyhounds, horses are used in the most diverse contexts. Games using horses include racing, dressage, show jumping, harness racing, and endurance tests, to name a few. Recently, many quantitative evaluation methods for improving the performance of horses in sporting games have been conducted (2,3,7,9,13). Several quantitative methods can be used to measure the horses' exercise capabilities according to parameters such as heart rate (HR), oxygen consumption rate, and blood lactate concentration (LAC). Furthermore, the relationship between the horse's velocity and heart rate (V_{HR}) was measured and it was reported that this method has repeatability and is applicable even in field conditions (4).

The reaction of HR and LAC to exercise is known to be not only related to aerobic exercise capacity, but also influenced by genetic characteristics such as health status, breed, and body composition (6). Heart rate recovery (HRR) is widely used to evaluate physical fitness. It has been reported that HRR and endurance exercise exhibit a considerable correlation in humans, and a person exercising intensively can quickly recover the original HR (8). HR is used to evaluate the running capability of horses used in not only thorough-

bred racing, but also in endurance games, jumping, and harness racing (2,5,7).

In Korea, about 30,000 horses are bred and among them, 20,000 are bred on Jeju Island. Jeju crossbred horses account for 70% of the horses bred here; these are produced by crossbreeding Jeju horses and thoroughbreds. Jeju crossbred horses are used mainly for racing, while some are used for horse riding or meat purposes. Recently, they have participated in equestrian games such as dressage, show jumping, and relay, as well as endurance tests, representing increased utilization of the horses for equestrian games. In this study, we measured the cardiorespiratory endurance of Jeju crossbred horses in different condition of exercise intensity and hill condition. Thereby, the results of this study may provide foundational data for the evaluation of horse capability.

Materials and Methods

Animals

The National Institute of Animal Science (NIAS) disclosed nine Jeju crossbred horses (2-year-old colts).

Hill test

The hill test was conducted on an uphill concrete road an inclination of around 30°. The measurement distance was 800 m and load weight was 82 kg. Before the hill test, five minutes of warming-up exercise was carried out for the horses. The horses moved at a canter with a starting signal and their

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running time on the uphill road was measured for 800 m.

Analysis of HR according to exercise intensity

Six horses of the disclosed animals were used to measure HR with different exercise intensities. Prior to measurement, all tested horses performed warming up in a circle trot for five minutes. The exercise intensity was divided into trotting and cantering for 20 min (moderate exercise, ME), trotting and cantering for 30 min (heavy exercise, HE), and circle trotting for 20 min plus trotting and cantering for 20 min (very heavy exercise, VHE), and HR for each exercise intensity was measured. HR per minute was measured by mounting an automatic heart rate monitor (Polar Equine Inzone TM) on the saddle and attaching a monitor to the wrist of the horse-man to measure average and maximum HR automatically during the exercise. HRR was measured after 10 min once the exercise was completed.

Statistical analysis

Using the R statistical package, the correlation between HR and exercise intensity and analysis of variance were conducted to perform the Duncan test.

Results

The hill test was carried out to see its possibility as an

evaluation item for running capability along with the exercise HR. The running record for the hill test is shown in Table 1. The 800 m running time was 205 seconds on average, whereas individual horses showed wide variance, from 167 to 258 seconds. A high correlation between the hill test and ME is shown in Table 3 ($0.88, P < 0.05$).

Table 2 shows the average HR per exercise intensity (beats/min), maximum HR (beats/min), and HRR (beats/min). The average HR and maximum HR after ME while trotting and cantering for 20 minutes were 179.6 ± 3.7 (mean \pm standard error [SE]) and 195.5 ± 3.0 , so that the difference between

Table 1. Hill test using 800 m concrete slope way in Jeju crossbred horse

Individual No.	Speed handicapping (sec)
1	258(4:18)
2	214(3:34)
3	199(3:26)
5	206(3:26)
6	189(3:09)
7	210(3:30)
8	200(3:20)
9	167(2:47)
Avg.	$205 \pm 25.8(3:25)$

Table 2. The effects of exercise or recovery heart rate on exercise intensity in Jeju crossbred horses

Individual No.	Exercise heart rate (beats/min)						Recovery heart rate ⁴
	Moderate exercise ¹		Heavy exercise ²		Very heavy exercise ³		
	Avg.	Max.	Avg.	Max.	Avg.	Max.	
2	190	202	193	204	195	203	77
5	179	188	172	198	172	191	57
6	181	197	166	186	173	185	62
7	188	205	170	193	176	202	56
8	175	186	160	181	165	178	58
9	165	195	162	185	155	170	53
Avg.	179.6 ± 3.7	195.5 ± 3.0	170.5 ± 4.8	191.1 ± 3.5	172.6 ± 5.4	188.1 ± 5.3	60.5 ± 3.5

Average values are means \pm SE of 6 horses

¹Moderate exercise (A) : cantering with saddle (10 kg) and rider (72 kg) for 20 min.

²Heavy exercise : cantering with saddle (10 kg) and rider (72 kg) for 30 min.

³Very heavy exercise : cantering with saddle (10 kg) and without rider for 20 min. plus cantering with saddle (10 kg) and rider (72 kg) for 20 min

⁴Recovery heart rate : 10 min. after end of exercise

Table 3. Correlation coefficients between exercise average heart rate and recovery heart rate

	Moderate exercise	Heavy exercise	Very heavy exercise	Recovery heart rate
Hill test	0.88*	0.63	0.80	0.53
Moderate exercise		0.73	0.92*	0.66
Heavy exercise			0.92**	0.88*
Very heavy exercise				0.89*

* $p < 0.05$, ** $p < 0.01$

average HR and maximum HR was 15.9. Average HR and maximum HR after HE while trotting and cantering for 30 min were 170.5 ± 4.8 and 191.1 ± 3.5 , so that the difference between average HR and maximum HR was 20.6. The average and maximum HR after VHE were 172.6 ± 5.4 and 188.1 ± 5.3 , respectively. Therefore, the difference between average and maximum HR was 15.5. While there was no statistically significant difference between average HR and maximum HR according to different exercise intensities analyzed in this test, a difference in HR was found among the horses. The differences in the average HRs of individual horses after the ME, HE, and VHE were 25, 31, and 40, indicating an increasing trend of a difference in HRs revealed in individual horses according to exercise intensity. The HRR measured after 10 min once exercise was completed was 60.5 ± 3.5 , and the HRR also showed individual difference.

The correlation between HRR and exercise intensity group is shown in Table 3. The average HR for the ME was highly correlated with that of VHE ($P < 0.05$), while average the HR for HE was highly correlated with the HR ($P < 0.01$) and HRR ($P < 0.05$) of VHE. In addition, it was found that the average HR for VHE was highly correlated with its HRR ($P < 0.05$).

Discussion

The horse is the fastest among animals that participate in games with humans; horses interact with humans in various games include horse racing, dressage, show jumping, harness racing, cross country, and endurance tests (2,5,7).

Many studies of HR and blood tests had been conducted to evaluate horses' capability (2,7,15). White *et al.* (15) reported changes in HR according to the intensity of cross-country running conducted by the United States Combined Training Association (USCTA). The USCTA divided the intensity of cross-country running (running distance, running speed, the number of jumps, and height of jump) into Novice, Training, Preliminary, Intermediate, and Advanced to perform the cross country running. The average HR (beats/min, mean \pm standard deviation) according to the cross-country running intensity showed that Novice was 154.4 ± 19.2 ; Training, 160.4 ± 28.1 ; Preliminary, 160.6 ± 33 ; Intermediate 181 ± 26.6 ; and Advanced 194.6 ± 4.2 . The HR difference between the cross country running intensities revealed that Intermediate and Advanced were larger than those of Novice, Training, and Preliminary, reporting an HR difference according to cross country running distance and speed. The average HR of the exercise intensities measured in the present study was 170.5 to 179.6 (beats/min), showing no significant difference in HR between exercise intensities. However, the average HRs of individual horses were 160 to 195 (beats/min), showing a large difference between individual horses. A significant difference in HRR between the Good performance group and Average performance group was reported, and the difference proposed that measurement of HRR could be an important

parameter to evaluate running capability (2). The average HRR measured 10 min after the completion of exercise was 60.5 (beats/min) in the present study, and the average HRRs of individual horses ranged between 53 and 77 (beats/min), showing a large difference between individual horses. Moreover, it was found that the average HR during exercise and HRR had a high positive correlation.

The results of present study showed that differences in the average HR and HRR between individual horses were revealed. And, it was determined that the average HR and HRR can be used for indexes to evaluate the running capability of horses. It will be necessary to study horse capability evaluation methods such as endurance test or cross-country running

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제주산마의 운동강도별 심폐지구력 측정

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요 약 : 본 연구는 제주산마의 hill test 및 운동 강도별 심폐지구력 측정으로 승용능력 평가를 위한 기초 자료로 활용하기 위해 수행하였다. 분석에 이용된 제주산마 9두는 경사도 30도 내외의 경사로 800 m를 주행하는 hill test를 실시하였으며, 이 중 6 두는 운동 강도별(moderate, heavy, very heavy) 심폐지구력을 측정하였다. Hill test 주행시간은 평균 205 초였으며, 개체간 편차는 큰 것으로 확인 되었고, moderate exercise와 높은 상관관계를 보였다. 운동 강도별 평균 심박수는 유의적인 차이가 없었으나, 개체간 평균 심박수는 차이가 큰 것으로 나타났다. 회복 심박수는 heavy exercise와 very heavy exercise에서 높은 상관관계를 확인할 수 있었다. 본 실험결과, 운동 강도별 평균 심박수 차이는 확인 할 수 없었으나, 개체간의 차이는 큰 것으로 확인되었다.

주요어 : 제주산마, hill test, 심폐지구력.