The Effect of Training Intensity on Cardiopulmonary Function in 2 Year-Old Thoroughbred Horses

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We investigated the effect of training intensity difference on cardiorespiratory parameters in twelve 2 year-old Thoroughbred horses during 8 weeks of training (5 days/week). Six horses were trained according to conventional training method including cantering (Canter group), while other 6 horses were exercised only by walking and trotting throughout the same period (Trot group). Each horse performed an incremental exercise test on a treadmill before (Pre-test) and after (Post-test) the training period. In the Pre-test, there were no significant differences between the Canter group and the Trot group regarding $\dot{V}O_{2max}$ (154.7 ± 7.8 ml/kg/min in the Canter group, 147.2 ± 7.5 ml/kg/min in the Trot group). After the training period, $\dot{V}O_{2max}$ was significantly higher in the Canter group (165.0 ± 11.6 ml/kg/min) compared to the Trot Group (150.3 ± 14.7 ml/kg/min). There were no differences in either group regarding the relationship between HR and speed, or L_a and speed in the Pre-test. During the Post-test, changes in HR in relation to the speed tended to be lower in Canter group, and L_a was also slightly lower in this group. Peak values of PCV increased significantly in both groups after the training, however, there were no differences between the groups. These results suggest that even low intensity training such as trotting can maintain $\dot{V}O_{2max}$. This indicates that higher intensity training involving cantering is not necessarily required merely to maintain cardiorespiratory function of 2 year-old Thoroughbred in early stage of training. However the findings also indicates that higher intensity training is required to substantially improve cardiorespiratory function in 2 year-old Thoroughbred horses.

Key words: training intensity, young Thoroughbred, $\dot{V}O_{2max}$

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After breaking, young horses intended to become racehorse are trained in consideration of local climate and available training facilities. In most cases, the initial training is endurance training with submaximal intensity exercise. There have been reports on the effects of submaximal intensity training on the cardiorespiratory function of adult horses [1, 6, 10]. These reports have described an increased maximal oxygen uptake ($\dot{V}O_{2max}$). Other reports on the effects of submaximal intensity training on the cardiorespiratory function of 2 year-old horses in the process of training [7, 14], do not clearly demonstrate the effects of various training intensities.

In the initial stage of training, trotting or cantering is applied to young Thoroughbreds. However, in Hokkaido, the main production area for Thoroughbreds in Japan, the period from breaking to initial training comes during cold and snowy season when it is often difficult to perform endurance training involving cantering. Therefore, it is important to know how the cardiorespiratory parameters of 2 year-old Thoroughbred are affected by differences in training intensities with or without cantering during this period. Although training intensities are usually defined by % $\dot{V}O_{2max}$ or % HR_{max} , we regulated training intensities in the present study by using trot or canter according to practical training method in Japan.

In this study, we observed the effects of training intensity differences on cardiorespiratory function by

comparing training consisting only of trotting and that including cantering.

Materials and Methods

Horses and training

Twelve 2 year-old Thoroughbred horses were used in this study (Table 1). All horses were broken to handling and riding in November of their yearling year and then trained in a riding hall (40 m square) at the trot and slow canter until the end of December. From January of their 2 year-old year, 8 weeks of training were performed, 6 horses were trained according to the conventional training schedule described in Table 2 (Canter group). Speed of cantering was increased gradually throughout the training period. At the final stage of training, the horses could canter about 1000 m at a speed of 800 m/min. The other 6 horses were exercised with approximately 10 min of trot (about 2000 m) and 30 min of walk throughout the same 8 week period (Trot group). All horses were exercised 5 days per week, and were pastured about 7 hours/day for the other 2 days. The feeding regime was the same for both groups throughout the study. Heart rate (HR) during the training was monitored at the 8th week of the training period by using HR monitor (Bandage-XL, Pollar, Finland).

Exercise test and parameters

The exercise tests were performed before (Pre-test) and

after the training period (Post-test) on the treadmill (Mustang-2200, Kagra, Switzerland). Prior to exercise testing, all horses were acclimatized to exercise on the treadmill while wearing a respiratory gas collection mask. A standardized exercise protocol was used. Following 5 min of level trotting at 4.0 m/s (Warm-up) and 5 min rest, each horse began the exercise test at 1.8 m/s for 1 min, followed by 1 min step increments at 2.7, 3.4, 4.5, 5.4, 6.8, 9.0, 10.8, and 11.6 m/s with the treadmill inclined to 10% [12]. The exercise test was terminated when it was obvious that the horse could not maintain its position without assistance from the holder. After completion of incremental exercise, the horse was walked 1.0 m/s for 15 min at the same incline (10%).

Measurements of $\dot{V}O_2$ uptake ($\dot{V}O_2$) and $\dot{V}CO_2$ production ($\dot{V}CO_2$) were performed continuously during the exercise test using a bias flow ventilatory system for horses calibrated at each exercise test [4]. HR was monitored continuously with a HR monitor and calculated during the last 30 s at each step.

Prior to the exercise test, an intravenous catheter was aseptically inserted into the left jugular vein and secured by suture. The catheter was flushed regularly with heparinized saline to maintain patency throughout the exercise test. Blood samples were collected via this catheter during the last 15 s of each step for measurements of blood lactate concentration (La) and packed cell volume (PCV). La was measured using an automated blood lactate analyzer (YSI-1500 Sport, Yellow Spring Instruments, Ohio). PCV was measured by the micro-hematocrit

Table 1. Experimental horses

	Pre		Post	
	Age (month)	Body weight (kg)	Age (month)	Body weight (kg)
Canter group	21.7 ± 0.7	449.2 ± 32.6	23.6 ± 0.6	439.4 ± 24.7
Trot group	21.5 ± 1.1	461.3 ± 45.7	22.5 ± 1.1	470.5 ± 45.1
Mean ± SD				

Table 2. Training Program (Canter group)

December	Indoor wood-tip course (1000 m)	W-2200 m, T-1200 m, C-1000 m (5 days/week)
January	Indoor wood-tip course (1000 m)	W-2000 m, T-1400 m, C-2000 m (4 days/week)
	Indoor dirt course (600 m)	W-3700 m, T-1300 m, C-2000 m (1 day /week)
February	Indoor wood-tip course (1000 m)	W-2000 m, T-1400 m, C-2000 m (2 days/week)
	Indoor dirt course (600 m)	W-3700 m, T-1300 m, C-2000 m (3 days/week)
March	Indoor wood-tip course (1000 m)	W-2000 m, T-1400 m, C-2000 m (1 day /week)
	Indoor dirt course (600 m)	W-3700 m, T-1400 m, C-2400 m (2 days/week)
	Indoor dirt course (600 m)	W-3400 m, T-1100 m, C-1800 m (1 day /week)

W: walk, T: trot, C: canter

method. Data from Pre and Post test were compared by analysis of variance for repeated measurements ($p < 0.05$). The results were presented as mean $\pm$ S.D.

Results

HR during exercise at the 8th week of training period was 190–210 beats/min when the speed was about 600 m/min in the Canter group, on the other hand, the HR was 110–120 beats/min in the Trot group. After the training period, the mean body weight in the Canter group was decreased about 10 kg, while in the Trot group, about 10 kg increase in the mean body weight was observed (Table 1).

In the Pre-test, there were no significant differences between Canter group and Trot group regarding mean $\dot{V}O_{2\max}$ (154.7 ± 7.8 ml/kg/min, 147.2 ± 7.5 ml/kg/min, respectively; Fig. 1). After the 8 weeks of training, $\dot{V}O_{2\max}$ had increased in both group but was significantly higher for the Canter group (165.0 ± 11.6 ml/kg/min) than the Trot group (150.3 ± 14.7 ml/kg/min; Fig. 1). There were no significant differences regarding the $\dot{V}O_2$ -speed relationship in either of the groups or in either of the tests (Fig. 2).

There were no difference in either group regarding the relationships between HR and speed, or La and speed in the Pre-test (Figs. 3, 4). On the other hand, changes in HR in relation to the speed tended to be lower in Canter

group, and La was also slightly lower in this group (Figs. 3, 4). Peak values of HR and La obtained during exercise test were not significantly different between two groups or between the two tests (Table 3).

In the Pre-test, peak values of PCV during the exercise test was not significantly different between the two groups. After the training, peak values of PCV increased significantly in both groups, however, there was no difference between the groups (Table 3).

Discussion

Cardiorespiratory function was compared between the Canter group, in which the conventional training including cantering was carried out, and the Trot group, in which training consisted only of walking and trotting was conducted during the same period. Based on HR measured during training, it was inferred that exercise at an intensity of 80–90% $HR_{\max}$ was carried out at least 1–2 times per week in the Canter group. In the Trot group, the intensity of exercise was considered to be approximately 40% $HR_{\max}$ throughout the same period.

Knight *et al.* [10] compared the effects of training at 40% $\dot{V}O_{2\max}$ and 80% $\dot{V}O_{2\max}$ intensities on adult horse

Fig. 1. Changes in $\dot{V}O_{2\max}$ during training.

Fig. 2. Mean $\dot{V}O_2$ uptake ($\dot{V}O_2 \pm$ S.D.) as a function of speed.

Fig. 3. Mean heart rate ($HR \pm S.D.$) as a function of speed.

and reported that the increase in $\dot{V}O_{2max}$ was similar for both groups. This indicates that low intensity training also increases $\dot{V}O_{2max}$. They suggested that reason for the lack of difference in the increase in $\dot{V}O_{2max}$ between 40% $\dot{V}O_{2max}$ and 80% $\dot{V}O_{2max}$ intensities was the influence of the correlation between the intensity of the exercise and duration of the exercise. In our study, the $\dot{V}O_{2max}$ after training was significantly higher in the Canter group, indicating that training involving cantering at 80–90% HR_{max} intensity, which was used in Canter group, was most effective. Art and Lekeux [1] found that only low-intensity aerobic training induced no significant change in $\dot{V}O_{2max}$, but that a subsequent three week period of high intensity interval training induced a substantial and significant change. The results of present study support these findings that training of a sufficiently high intensity induces a significant physiological change. In a previous study, the effect of difference in the distances of cantering on cardiorespiratory function, during which a heart rate is approximately 140–150 beats/min, was examined among Thoroughbreds at the same age. It was found that prolonged distances of low intensity cantering had little effect on the increase in $\dot{V}O_{2max}$ [7]. In the present study, the training intensity used in the Canter group was much higher than in the previous study [7], which may have contributed to the substantial increase in $\dot{V}O_{2max}$.

Fig. 4. Mean blood lactate concentration ($La \pm S.D.$) as a function of speed.

In this study, $\dot{V}O_{2max}$ was significantly higher in the Canter group than in the Trot group at the Post-test, and the rate of increase in $\dot{V}O_{2max}$ of Canter group (6.7%) was higher than that of Trot group (2.1%). However, these increases were lower than those found in previous studies [1, 6, 10]. One possible reason of this is that the horses in this study were not detrained horses, but were young and in the process of training. The Pre-test $\dot{V}O_{2max}$ value for horses in this study was similar to that for Thoroughbreds at the same age [7], but higher than that for detrained adult horses [6].

In the Trot group, in which the exercise intensity was approximately 40% HR_{max} throughout the training period, $\dot{V}O_{2max}$ was virtually unchanged. This differs from the results of a previous study in which there was a significant increase in $\dot{V}O_{2max}$ during the first 2 weeks of training at an intensity of 40% $\dot{V}O_{2max}$ [10]. This may have been partly due to the difference in the Pre-test $\dot{V}O_{2max}$ value. In other words, through the exercise during the breaking process before the Pre-test, our horses may have already experienced the increased $\dot{V}O_{2max}$ which was observed during breaking period in the Thoroughbred yearlings [8]. The results of this study

Table 3. Peak values during exercise test

Parameters (unit)			Pre	Post
$\dot{V}O_2$ (l/min)	Canter group :	Range	69.4 ± 4.8 (64.9–79.4)	71.5 ± 2.5 (68.4–75.6)
		Trot group :	68.8 ± 5.1 (62.1–76.0)	70.3 ± 4.9 (66.9–76.9)
	Canter group :	Range	154.7 ± 7.1 (141.2–164.3)	165.0 ± 10.4 (145.8–176.0)
		Trot group :	147.2 ± 6.7 (138.4–158.8)	150.3 ± 13.4 (136.2–173.6)
$\dot{V}O_2$ (ml/kg/min)	Canter group :	Range	90.2 ± 4.5 (84.6–97.0)	90.8 ± 4.6 (85.4–97.4)
		Trot group :	90.5 ± 7.3 (78.6–97.8)	90.3 ± 6.6 (82.7–99.7)
	Canter group :	Range	201.6 ± 11.6 (181.4–214.2)	209.5 ± 15.4 (182.7–220.4)
		Trot group :	193.8 ± 13.0 (187.1–216.4)	192.9 ± 17.7 (166.4–221.7)
$\dot{V}CO_2$ (l/min)	Canter group :	Range	228.4 ± 8.1 (217.3–234.3)	234.3 ± 9.4 (224.8–250.0)
		Trot group :	230.1 ± 6.7 (221.7–238.0)	230.3 ± 5.9 (220.2–236.0)
	Canter group :	Range	18.5 ± 2.8 (14.21–22.75)	17.1 ± 2.3 (14.51–20.16)
		Trot group :	21.1 ± 4.3 (14.59–22.97)	17.6 ± 5.3 (9.38–23.94)
$\dot{V}CO_2$ (ml/kg/min)	Canter group :	Range	55.4 ± 2.7 (51.0–59.0)	58.2 ± 3.0 (53.0–61.0)
		Trot group :	55.7 ± 2.6 (53.0–59.0)	58.0 ± 4.0 (52.0–65.0)
	Canter group :	Range		
		Trot group :		
HR (beats/min)	Canter group :	Range		
		Trot group :		
	Canter group :	Range		
		Trot group :		
La (mmol/l)	Canter group :	Range		
		Trot group :		
	Canter group :	Range		
		Trot group :		
PCV (%)	Canter group :	Range		
		Trot group :		
	Canter group :	Range		
		Trot group :		

show that the $\dot{V}O_{2\max}$ of Thoroughbreds at this age cannot be increased, but can be maintained by continuing trotting at a 40% $HR_{\max}$ intensity.

It has been suggested that there is close relationship between increases in the peak values of $\dot{V}O_2$ and peak values of PCV [12]. In this study, the peak values of PCV was increased through training, but no difference was found between the two groups. In addition, the absolute value of $\dot{V}O_{2\max}$ (l/min) was similar for the two groups, and increased after the test. On the other hand, mean body weight decreased in the Canter group but increased in the Trot group, partly because the diets for both groups were the same. These different changes in body weight between the two groups may have made a substantial contribution to the Post-test significant difference in relative value of $\dot{V}O_{2\max}$ (ml/kg/min).

Although the difference between groups was not significant, the relationship between speed and HR was slightly lower in the Canter group than in the Trot group. This resemble the effect of training on yearlings [11],

and that of submaximal training on adult horses [6]. The correlation between speed and La at the Post-test tended to be lower in the Canter group. All of these findings suggest the improved cardiorespiratory function of the Canter group.

The result of present study showed some important points concerning the actual training of young Thoroughbreds of this age. First, even low intensity training such as trotting can maintain $\dot{V}O_{2\max}$. This indicates that higher intensity training is not necessarily required merely to maintain cardiorespiratory function of 2 year-old Thoroughbreds in early stage of training. However, the findings also indicates that higher intensity training involving cantering is required to substantially improve cardiorespiratory function. A previous study showed that it is important for racehorses to increase their tolerance for exercise of the muscle [5], bone and tendon [2, 9] through higher intensity training. The results of our study may support these findings.

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