Effects of initial handling and training on autonomic nervous function in young Thoroughbreds

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Objective—To determine the effects of initial handling and training on autonomic nervous functions in young Thoroughbreds.

Animals—63 healthy Thoroughbreds.

Procedure—All horses were trained to be handled and initially ridden in September of the yearling year and then trained until the following April by conventional training regimens. To obtain the heart rate (HR), electrocardiograms were recorded in the stable before initial handling and training and following 7 months of training; variations in HR were then evaluated from the power spectrum in terms of the low frequency (LF; 0.01 to 0.07 Hz) power and high frequency (HF; 0.07 to 0.6 Hz) power as indices of autonomic nervous activity. To evaluate the fitness, the V_{200} (velocity at HR of 200 beat/min), which is reflective of the aerobic capacity of the horse, was measured.

Results—Mean (± SE) resting HR decreased significantly from 41.5 ± 0.8 to 38.7 ± 0.4 beat/min following 7 months of training. The LF power of horses increased significantly from 1,037 ± 128 milliseconds^2 in September of the yearling year to 2,944 ± 223 milliseconds^2 in the following April. Similarly, the HF power increased significantly from 326 ± 30 milliseconds^2 to 576 ± 39 milliseconds^2 at the corresponding time points. The V_{200} increased significantly following training.

Conclusions and Clinical Relevance—Increases in LF and HF powers indicate that parasympathetic nervous activity increases in horses by 7 months of training. The decrease in resting HR may be dependent on the training-induced increase of parasympathetic nervous activity in Thoroughbreds. (*Am J Vet Res* 2002;63:1488–1491)

Thoroughbreds are considered elite athletes that have a high mass-specific maximal oxygen uptake, big heart size, and low resting **heart rate (HR)**. It is generally believed that training-associated bradycardia in horses is induced by an increase in parasympathetic nervous activity. However, most studies have found either no influence of training or only a slight effect on parasympathetic activity in horses.[1-3] Furthermore, parasympathetic nervous activity, as estimated by power spectral analysis of HR variability, might be fully activated by early spring during conventional training in 2-year-old Thoroughbreds.[4] Initial handling and training, which are undertaken in yearlings in autumn, are thought to exert a tremendous influence on the physiologic functions of yearlings, including an increase in maximal oxygen uptake.[5,6]

The purpose of the study presented here was to determine the effects of initial handling and training on autonomic nervous functions in young Thoroughbreds. We hypothesized that parasympathetic nervous activity might be increased by the initial handling and training undertaken up to the spring in 2-year-old Thoroughbreds. For this purpose, autonomic nervous activity was quantitatively evaluated by power spectral analysis of HR variability, and the **velocity of running at HR of 200 beat/min (V_{200})** was measured for an index of aerobic capacity.

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Materials and Methods

Horses and training—Experiments were performed on 63 healthy Thoroughbreds. In September of the yearling year, horses had a mean (± SE) body weight of 427 ± 2.7 kg. In the following April as 2 year olds, horses had a mean body weight of 456 ± 2.6 kg. Horses included 33 males and 30 females. All horses were purchased at yearling sales from June to August in the Hidaka region of Hokkaido in Japan and were brought to the Hidaka Training and Research Center. Horses were kept in 1- to 4-hectare pastures for 7 to 10 h/d until the initial handling and training period. As yearlings, horses were trained to be handled and initially ridden in September and trained to be ridden at a trot and slow canter until the end of October. From November until April of the subsequent year, horses were trained according to the conventional training schedule (**Appendix**). Speed at a canter was increased gradually throughout the training period. At the final stage of training, horses could canter for approximately 1,000 m at a speed of 800 m/min. All horses were exercised 5 d/wk and were in a paddock (15 m × 15 m) for approximately 3 h/d for the remaining 2 days of the week. Horses were housed in individual stalls and were fed 3 times each day (6 AM, 4 PM, 8 PM). Horses received approximately 23 Mcal of digestible energy/d from October through December and approximately 28 Mcal/d from January to April. Horses were trained on various tracks in the morning and stayed in individual stalls in the afternoon.

Protocol for measurement of V_{200}—To evaluate the effects of training, the V_{200} (velocity at HR of 200 beat/min) of horses was measured in December (after initial handling and training) of the yearling year and in the following April. The V_{200} was measured on a circular indoor oil-sand track (800 m). Heart rate during exercise was recorded by use of an

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HR meter.[a] Running speed was calculated by extrapolation from the known distance traveled (200 m) divided by the total time elapsed as measured by a stopwatch. After warming up over a distance of 800 m at a trot, horses were tested at 4 speeds over a distance of 800 m. Horses ran at 200, 400, 460, 550 m/min during the test in December, and at 200, 460, 550, 670 m/min during the test in April. The V_{200} was calculated from the regression line of the HR and the running speed.

Electrocardiographic recordings— Electrocardiograms were recorded for > 30 minutes by use of a base-apex lead and a Holter-type electrocardiograph.[b] During ECG recordings, horses stood in individual stalls. Between 1 and 3 PM, electrocardiograms were obtained from horses as yearlings in September (before initial handling and training) and from horses as 2 year olds in the following April. A Holter-type ECG recorder was attached to a cloth covering the horses. Horses were free to move within the stall without restriction.

Data analysis—The ECGs were analyzed by use of the ECG processor analyzing system[c] as previously described.[7] The program first detected R waves and calculated the R-R interval tachogram as the raw HR variability in sequential order. From this tachogram, data sets of 512 points were resampled at 200 milliseconds. Tachogram length was selected as the best compromise between the need for a large time series to achieve the greatest accuracy and the ease of short recording periods.[8] Each set of data was applied to the Hamming window and the fast Fourier transform to obtain the power spectrum of the fluctuation. **Low-frequency (LF)** power was set at 0.01 to 0.07 Hz, and **high frequency (HF)** power was set at 0.07 to 0.6 Hz. Power spectrum analysis of HR variability in the HF power is generally thought to reflect primarily parasympathetic nervous functions.[8] The sympathetic and parasympathetic nervous systems have been shown to contribute to the LF power.[8] The HR, LF power, HF power, and LF:HF ratio were obtained from each recording. These values were used as indices of autonomic nervous functions. Results are expressed as mean (± SE) values. Comparisons were made by use of 1-factor ANOVA. A value of $P < 0.05$ was considered significant.

Results

Changes in HR and measurements of HR variability following training were evaluated (**Fig 1**). Overall resting HR decreased significantly following 7 months of training, from 41.5 ± 0.8 beat/min in September of the yearling year to 38.7 ± 0.4 beat/min in the following April. After training, resting HR in males decreased significantly, whereas resting HR of females had no significant change.

The LF power for all horses increased significantly following 7 months of training, from 1,037 ± 128 $milliseconds^2$ in September of the yearling year to 2,944 ± 223 $milliseconds^2$ in the following April. Similarly, the HF power for all horses also increased significantly from 326 ± 30 $milliseconds^2$ in September of the yearling year to 576 ± 39 $milliseconds^2$ in the following April. The LF:HF ratio for all horses increased significantly, from 3.7 ± 0.4 in September of the yearling year to 5.6 ± 0.4 in the following April. In addition, the LF power, HF power, and LF:HF ratio in males and females also significantly changed following 7 months of training.

Changes in the V_{200} in relation to training were measured (**Fig 2**). Values of V_{200} for all horses in December of the yearling year and in the following April were 560 ± 7 and 596 ± 7 m/min, respectively. Values of V_{200} in April of horses as 2 year olds were significantly higher than values of V_{200} in December of horses as yearlings. The V_{200} of males increased significantly from December of the yearling year to the following April. The V_{200} of females, however, did not change significantly during the corresponding period. Significant differences between males and females were observed for measurements of HR, HF power, LF power, LF:HF ratio, and V_{200} at the end of 7 months of training.

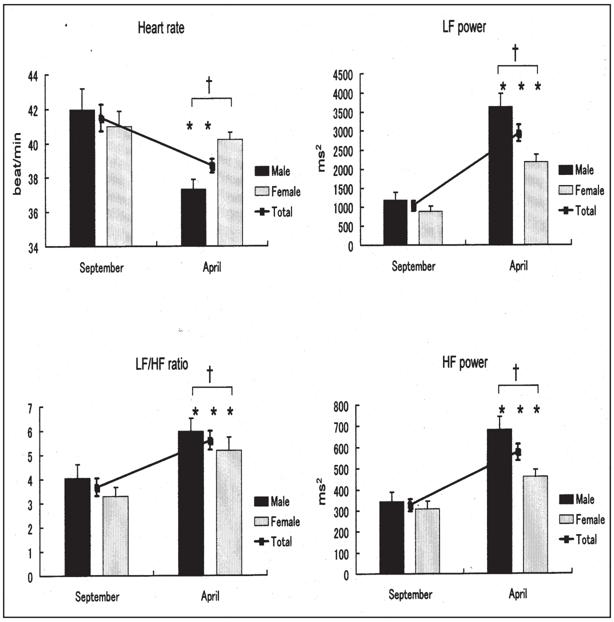

Figure 1—Changes in heart rate (HR), low frequency (LF) power, high frequency (HF) power, and LF:HF ratio of horses in September of the yearling year and the following April. *Significant ($P < 0.05$) difference between September of the yearling year and the following April. †Significant ($P < 0.05$) difference between males and females.

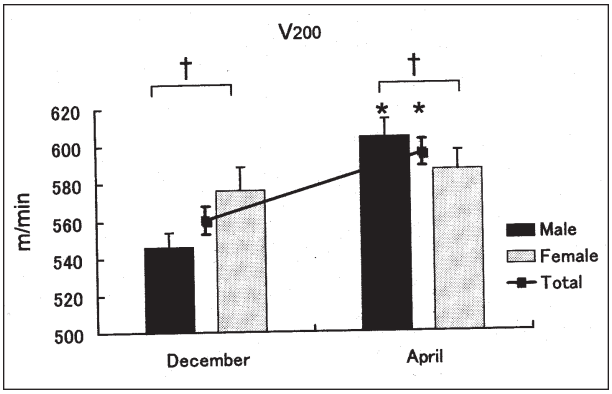

Figure 2—Changes in V_{200} (velocity at HR of 200 beat/min) of horses in December of the yearling year and the following April. *Significant ($P < 0.05$) difference between December of the yearling year and the following April. †Significant ($P < 0.05$) difference between males and females.

Discussion

Findings in our study reveal effects of initial handling and training on the autonomic nervous functions in young Thoroughbreds. The LF power and HF power of horses increased significantly from September of the

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yearling year to the following April. The V_{200} of horses also increased significantly from December of the yearling year to the following April. Moreover, the resting HR decreased significantly from 41.5 ± 0.8 beat/min in September of the yearling year to 38.7 ± 0.4 beat/min in the following April. These results suggest that parasympathetic nervous activity may be increased by 7 months of training. Furthermore, the decrease in resting HR may be dependent on the training-induced increase of parasympathetic nervous activity in Thoroughbreds. These observations were made for males but not females.

Young[9] reported that HR did not change and left ventricular mass significantly increased by 18 weeks of training in 2-year-old Thoroughbreds. Methods used in that study were not sufficiently sensitive to detect training-induced alterations in HR, because HR was measured during an echocardiographic procedure.[9] However, we speculate that a cause of a decrease in HR might be an increase in heart size.

In our study, V_{200} was used as the index of aerobic capacity in young Thoroughbreds, as this variable has been reported to provide useful information on the aerobic work capacity in horses.[10] Moreover, V_{200} has also been reported to be highly correlated with the maximal oxygen uptake during treadmill exercise testing in horses.[11] Because 7 months of training significantly increased the V_{200} of young Thoroughbreds in our study, we conclude that training probably increases the aerobic capacity of our horses. In other studies,[5,6] maximal oxygen uptake of Thoroughbred yearlings increased significantly from September (134.8 mL/kg/min) to the following April (165.0 mL/kg/min) following typical conventional training.

Significant differences between males and females were observed in the V_{200} in December of the yearling year. This result suggests females may have already developed aerobic capacity before or during the initial handling and training phase. Significant increases in the measurements of V_{200}, LF power, and HF power in males in response to 7 months of training indicate that training beyond the initial phase is necessary in the development of physiologic functions. We speculate that training protocols necessary to increase the aerobic performance may differ between males and females.

Power spectrum analysis of HR variability has been shown to serve as an index of the relative magnitude of autonomic nervous tone in dogs and humans.[8,12,13] The HF power is generally thought to reflect primarily parasympathetic nervous functions. Furthermore, the LF:HF ratio is considered as an index of the cardiac sympathovagal balance. We have established the power spectral analysis of HR variability as a method to assess autonomic nervous functions in Thoroughbreds.[7] Moreover, we have recently applied the power spectral analysis of HR variability to evaluate the influence of training on autonomic nervous functions in 2-year-old Thoroughbreds.[4] Trained horses with low resting HR could be expected to have HR variability findings that reflect increased parasympathetic nervous activity. However, training did not change the parasympathetic nervous functions. In our study, a significant increase in the HF power was observed in trained horses. These results suggest that parasympathetic nervous activity in Thoroughbreds probably increases with initial training during the yearling year. This possibility is supported by results of our previous studies, in which the HF power after training was almost identical in 2-year-old[4] and 3- to 5-year-old[7] horses.

It is noteworthy that significant differences were observed between males and females in the resting HR, HF power, LF power, and LF:HF ratio at the end of 7 months of training. One of the possible explanations for this is that the effects of training on the autonomic nervous activity differ between males and females, even when the same training programs are used. Another possibility is that the development of autonomic nervous functions is dependent on changes in the aerobic capacity induced by training. The latter possibility is likely, because the changes in the HF power and V_{200} were similar in both sexes. Moreover, training did not significantly change the resting HR or the V_{200} of females. The LF and HF powers of females were significantly lower than those of males in April, although LF and HF powers in females increased by 7 months of training. Parasympathetic nervous activity in females may not develop adequately to decrease the resting HR. However, further studies will be needed to clarify the different effects of training on the autonomic nervous functions and aerobic capacity between males and females.

[a]Accurex Plus, Polar Electro Oy, Kempele, Finland.
[b]SM-60, Fukuda Denshi Co. Ltd., Tokyo, Japan.
[c]ECG processor analyzing system, Softron Co Ltd., Tokyo, Japan.

Appendix

Conventional training program in young Thoroughbreds

	Gaits and distances		
Month	Walk (m)	Trot (m)	Canter (m)
November	1,600	1,600–2,000	1,200–1,600
December	2,000	1,600	1,600–2,400
January	2,000	1,600	2,400–3,200
February	2,400	1,600	2,400–4,000
March	2,400	1,600	2,400–4,000
April	2,400	1,600	2,400–4,000

Horses were trained to be handled and initially ridden in September of the yearling year and then trained to be ridden at the trot and slow canter until the end of October. From November until the following April, horses were trained according to the conventional training schedule. Speed at the canter was increased gradually throughout the training period. At the final stage of training, horses could canter for approximately 1,000 m at a speed of 800 m/min. Horses were exercised 5 d/wk, and were in a paddock (15 m X 15 m) for approximately 3 h/d for the remaining 2 days of the week.

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