Reliability of EquiPILOT[®] for Measuring Aerobic Fitness in Racehorses

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In track testing of aerobic fitness in the racehorse, the measurement of heart rate and running speed is essential. In this study, we examined EquiPILOT[®], an automated recording system which measures those two variables, for its reliability during the racehorse training. After some adjustment for fitting, it has been shown that the speed measured by this system is very accurate, and that its measurements of heart rate and running speed are stable. Based on our data, the EquiPILOT[®] has been proved reliable for assessing aerobic capacity of running racehorses on the track.

Key words: EquiPILOT[®], racehorses, aerobic fitness

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At present, the most standardized method for evaluating aerobic fitness in Thoroughbreds is the measurement of maximal oxygen consumption ($\dot{V}O_{2\max}$). The measurement of $\dot{V}O_{2\max}$, however, is limited to a certain range of horses, since it requires large-scale equipments such as a horse treadmill. It also imposes a maximal intensity exercise on tested horses.

Meanwhile, the running velocity at heart rate of 200 beats/min (V_{200}) is suggested for more convenient assessment of aerobic capacity of the horse [4], and its effectiveness has been confirmed by its correlation with $\dot{V}O_{2\max}$ [5]. In this method, horses' aerobic fitness can be calculated from only two variables, heart rate and speed during exercise. As those variables are easily measured, this method is feasible even in field testing, or for a simultaneous measurement in multiple horses. As a fact, V_{200} data in Thoroughbreds derived under various running conditions have been accumulated [2, 3, 6], and application of those data to the training are on trial in horses scheduled for a race.

For the heart rate measurement required for calculation of V_{200} , various methods have been devised to provide an accurate automatic measurement [1]. On the contrary, for the running speed also needed for V_{200} , although an automatic measurement is not impossible, an accurate and affordable device has not

been established. In many cases, in fact, it is still measured manually with a stopwatch.

In recent years, the global positioning system (GPS), in which geological position is measured by the radio signal from a satellite, became available for public, and since then, the positioning devices have been widely used utilizing the GPS. It has been attempted to apply the system to the horse training, and recently in Germany, an automated measurement and recording system for heart rate and running speed (calculated by the GPS) of horses has been manufactured as EquiPILOT[®]. If a stable measurement and accurate automatic recording are possible with this system even on a horse running at a full speed, we could anticipate a wide range of usage of the system including the evaluation of aerobic fitness in racehorses.

EquiPILOT[®], however, has been developed for horses on cross-country or endurance rides, relatively low-speed games. To use the system in the training of racehorses, we needed to examine 1) accuracy and stability of measurement and recording during the high-speed run, and 2) a way of loading the equipment safely on the horse. In this study, therefore, we loaded the EquiPILOT[®] on Thoroughbred horses under various conditions and evaluated its reliability for the racehorse training.

Fig. 1. Placement of the EquiPILOT® main body and HR monitor transmitter on the horse.

EquiPILOT® is an instrument developed especially for the purpose of training of horses on cross-country and for evaluation of their fitness. Its function includes automated measurement and recording of the geographic positioning and heart rate of the horse which is loaded with EquiPILOT®. The system is comprised of:

- 1) main body: the recording system for the position and pulse. Approximately 500 g. Rectangular, $12 \times 7.5 \times 5$ cm in size,
- 2) HR monitor transmitter: the heart rate measurement and transmission. Approximately 100 g, and
- 3) analysis software

The following is a summary of directions and method for use.

Fit a pair of sensors of the HR Monitor Transmitter tightly on the horse's trunk in such a way that it surrounds the heart. Place the main body near the HR monitor transmitter, with the upper part facing to the sky as much as possible. The main body starts recording the heart rate and position as switched on. After measurements, unload the main body and analyze the data on a computer using the analysis software.

Evaluation of the EquiPILOT® loading method

It is recommended by the manufacturer to attach the EquiPILOT® main body to a metal arm connected to the front part of the saddle. This method, however, is not safe at the speed of horseracing, and it may disturb a rider's motion. Therefore, we investigated fitting methods of the device focusing on these four

conditions: 1) the receiver of the main body is facing to the sky to the utmost, 2) the distance between the body and HR monitor transmitter is as small as possible, 3) it does not disturb the horse during exercise, and 4) it does not disturb the rider.

As a result, we found that the method shown in Fig. 1 met all the conditions above, thereby resulted in an excellent recording.

Evaluation of the accuracy for the running speed measurement

To examine the accuracy of the running speed recording, we performed a track testing at the Equine Research Institute (Tochigi, Japan). EquiPILOT® was placed on horses, then the horses were made to run on a racetrack. We compared recordings between EquiPILOT® and the "Racetrack Timing System". The Racetrack Timing System, which has been used at the Equine Research Institute, is a device to record the time when a horse passes an electric field that repeats every 200 m along the track. It is capable for a very precise automatic calculation of the running speed. The heart rates of the horse are recorded by the system simultaneously.

Comparative analysis of those records showed high correlations (Speed: $R^2 = 0.997$, Heart rate: $R^2 = 0.982$) between the two systems (Figs. 2, 3). As the slope of the regression line calculated from the recordings was close to 1, we concluded that the recording of the running speed by EquiPILOT® is reliable for its accuracy.

Examples for data analysis using EquiPILOT®

In this section we provide two cases as examples of the analysis we obtained using EquiPILOT®. The test was performed on a dirt, good conditioned racetrack.

Case 1: Two-year old Thoroughbred, male, in pre-race training

Horse: A male, two-year and two-month old Thoroughbred horse was used. The body weight was 430 kg. The horse was on training toward a breeze-up sale.

Exercise performed for the recording (Fig. 4): After saddled in the stable, the horse was taken to the ground at a walk (1). The horse was warmed up at a trot (approx. 2 min) (2), and then moved to the racetrack at a walk (3). The horse went 500 m at a canter at 7.8 m/sec (25 sec/furlong) on average (4), followed by a

Fig. 2. The relationship of the recorded speed using EquiPILOT® and the racetrack timing system ($y = 0.975x + 5.66$, $R^2 = 0.997$).

Fig. 3. The relationship of the recorded heart rate using EquiPILOT® and the racetrack timing system ($y = 1.044x - 3.54$, $R^2 = 0.982$).

Fig. 4. The example record of the two-year old horse in pre-race training (the change in the speed and pulse with time).

200-m walk and a 600-m canter averaging 10 m/sec (20.1 sec/furlong) (5). After another 200-m walk, the horse run 600 m at 10.1 m/sec on average (19.8 sec/furlong) (6), then slowed down to a walk (7).

Recording analysis: The change in speed and heart rate of the horse recorded by EquiPILOT® during the exercise is shown in Fig. 5.

The relationship between the speed and the heart rate during trot and canter at steady state is shown in

Fig. 5. V_{200} of the horse calculated from the regression line was 10.86 m/sec (651.6 m/min).

Case 2: Adult horses before and after training

Horses: Two male Thoroughbreds were used. The horse G was 8 years old, and R, 7 years old. Both had been raised mainly by pasture for more than half a year.

Fig. 5. The example record of the two-year old horse in pre-race training (the relationship between the speed and the heart rate).

Training and measurement: Both horses were trained for 5 days a week for 3 weeks. The training consisted of a gallop of 3,200 m a day, and intensity was incremented from 26 to 16 sec/furlong. The recording was performed before and after the training.

Exercise at the recording: After a trot, the horse was made to gallop 800 m at 8.3 m/sec (24 sec/furlong) on the track, then the speed was incremented to 10.0 m/sec (18 sec/furlong) for another 800 m.

Recording analysis: The body weight of R was 508 kg and 490 kg, while G weighed 490 kg and 485 kg before and after the training, respectively. Both horses showed a reduced weight after the training.

Fig. 6 shows the regression line calculated from the speed and the heart rate of R at the recordings before and after the training. The regression line shifted slightly to the right after the 3 weeks of training. V_{200} also increased from 9.99 m/sec (599.4 m/min) to 10.59 m/sec (635.4 m/min).

The regression line of G calculated from the recorded speed and heart rate is shown in Fig. 7. The regression line showed little change after the training as well as V_{200} , which was 12.33 m/sec (739.8 m/min) and 12.23 m/sec (733.8 m/min) before and after the training.

Those results suggested that the training was mild, and that each horse responded differently to the training.

As described above, EquiPILOT® is accurate at high

Fig. 6. The regression line of the speed and heart rate of the horse R before and after training (Before training: $y = 0.246x + 41.5$, $R^2 = 0.930$; After training: $y = 0.259x + 35.32$, $R^2 = 0.962$).

Fig. 7. The regression line of the speed and heart rate of the horse G before and after training (Before training: $y = 0.194x + 56.6$, $R^2 = 0.950$; After training: $y = 0.194x + 57.4$, $R^2 = 0.950$).

speed, and stable for recording the change in heart rate and speed. The system has therefore been proved greatly reliable for the measurement of aerobic fitness of racehorses.

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