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Changes of lying behavior in Thoroughbred foals influenced by age, pasturing time, and weather conditions

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The lying behavior of Thoroughbred foals on breeding farms was continuously measured using triaxial accelerometers. Accelerometers were attached on the side of the hind limb cannon and under the halter of six foals to record triaxial angle data every 10 sec for a period of 24 hr. Lying behavior was divided into sternal lying and lateral lying based on head angle. Sampling was performed for two consecutive days each week until weaning. Sampling periods were divided into two periods on the basis of pasturing time: daytime pasturing (period A: 7-hr pasturing period, 2–60 days of age) and overnight pasturing (period B: 19-hr pasturing period, 32–152 days of age). Lying duration and frequency were longer and higher, respectively, in period A (44.6% of the time and 26.8 ± 7.4 times per day) than those in period B (27.7% of the time and 15.3 ± 4.2 times per day). In addition, foals spent more time laterally in period A (48.1% of total lying time) than in period B (38.9% of total lying time). Foals lie down longer in stalls than in pastures (Period A, 56.3 vs. 16.0%; Period B, 52.5 vs. 21.1%). Lateral lying was also longer in the stall than in the pasture. Lying duration and frequency changed with age in period A. Wet weather prevented lying behavior in the pasture. These results suggested that age, weather, and pasturing time affected the lying behavior of Thoroughbred foals under management at a breeding farm. Triaxial accelerometers may be useful for monitoring equine lying behavior.

Key words: *equine, foal, lying behavior, Thoroughbred, triaxial accelerometer*

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Thoroughbred race horses are athletes, so foals spend a lot of time on broad pasture and are expected to exercise and rest appropriately for sound growth. On the other hand, breeders worry about issues such as the timing of starting to pasture foals overnight or pasturing on rainy days because of the weakness of foals in the neonatal period. To discuss better management of Thoroughbred foals, objective parameters are necessary.

The resting behavior of foals during the day was reported in feral Przewalski horses [3] and semi-feral ponies [7, 12]; however, that in Thoroughbred foals under management at a breeding farm has been unknown. Live observation or video recording has been used in equine behavioral research traditionally, but these methods require considerable time and effort, so sample numbers have tended to be limited. Recently, the lying behavior of adult horses was evaluated using triaxial accelerometers, which are able to continuously monitor an animal's standing and lying behavior [4, 5, 9, 10], and the predictability was high: >99% [9]. This method has the potential to be able to analyze many samples with less effort.

The aims of this study were 1) to reveal the changes of lying behavior in Thoroughbred foals under typical breeding farm conditions and 2) to reveal the influence of age, sex, pasturing time, and weather on lying behavior. In addition, we divided lying behavior into sternal and lateral lying by head angle, although previous reports using triaxial accelerometer have not divided them.

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Materials and Methods

This research was approved by the Animal Care and Use Committee at Hidaka Training and Research Center.

Animals

Six healthy Thoroughbred foals (four colts and two fillies)

Fig. 1. Triaxial accelerometers were attached to the foal's hind limb (black arrow) and halter (white arrow).

bred at Hidaka Training and Research Center (42°15'N, 142°83'E, Hokkaido, Japan) were used in this study. The foals were born between March 17 and June 19, 2017. They were kept in a pasture for 7 hr (8:30–15:30) until April or until approximately 30 days of age (range, 2–60 days) and then for 19 hr (13:30–8:30) at 32–152 days of age. During the first week, each mare was kept in a small paddock (20 × 18 m) and then in a pasture (205 × 175 m). Creep feeding (i.e., supplemental feeding) was initiated at approximately 2 months of age. After late July, the pasturing time was modified to avoid extreme heat and horseflies, maintaining a duration of 19 hr (15:30–10:30). Foals were weaned in the middle of August.

Equipment

Triaxial accelerometers (HOBO Pendant G Data Logger, UA-004-64, Onset Computer Corporation, Bourne, MA, U.S.A.) were scraped and smoothed (5 × 3 × 1 cm) to be attached to the foals. Each accelerometer was packed into a small zipper bag to protect it from water and was vertically placed on the metacarpal bone of the right hind limb using elastic bandages and electrical tape (Fig. 1). The accelerometer was maintained on the underside of the halter using electrical tape to measure the angle of the foal's head (Fig. 1). For each foal, the accelerometer was set to record data every 10 sec.

Sampling

The Sampling period was divided into two periods on the basis of pasturing time: daytime pasturing (period A: 7-hr pasturing period, 2–60 days of age) and overnight pasturing (period B: 19-hr pasturing period, 32–152 days of age). In addition, the data were also divided according to location: pasture and stall.

Behavioral analysis

Data from accelerometers placed on the foals' legs and halter were transferred to a computer using the HOBOware Lite Software and saved as comma-separated value files. Triaxial angle data were displayed in graphic form using Microsoft Excel (Microsoft Corp., Redmond, WA, U.S.A.) and categorized as standing, lateral lying, or sternal lying. Based on a pilot study, a long axis angle of the hind limb to the horizontal plane of 160–180° was defined as the standing position, and that of 80–100° was defined as a lying position. The lying position was further divided into sternal and lateral lying based on the halter angle. Sternal lying was defined as the position with the halter angle in the same range as standing (X-axis, 120–180°; Y-axis, 80–100° on our setting), and lateral lying was defined as the position with the halter lied down (X-axis, 80–100°; Y-axis, 0–40° or 140–180°). The duration and frequency of lying behavior and lateral lying were measured. Changes in position within a minute were not counted. Sampling was performed on two consecutive days every week until weaning. Hourly lying time was averaged to evaluate lying time throughout a day. To consider the influence of weather, rainy days with wet ground were referred to as "wet weather", and other days, such as sunny, cloudy, or light rainy days, were referred to as "dry weather".

Table 1. Duration and frequency of lying behavior and the ratio of lateral to sternal lying during the 7-hr pasturing period

		Pasture		Stall		Total	
		Mean	SD	Mean	SD	Mean	SD
Duration* (min/day)	Total	67.2	64.1	574.7	76.8	641.9	75.4
	(%)	(16.0)		(56.3)		(44.6)	
	Lateral	23.5	29.8	279.1	123.5	309.1	124.9
	(%)	(5.6)		(27.4)		(21.5)	
Frequency (times/day)	Total	5.4	4.5	21.4	4.6	26.8	7.4
	Lateral	2.4	2.9	20.0	4.6	22.3	5.5
Lateral/sternal		35/65		49/51		48/52	

*The ratio of duration to spending time under each condition (i.e., 7 hr in pasture, 17 hr in stall, and 24 hr in total) is presented as a percentage. SD, standard deviation.

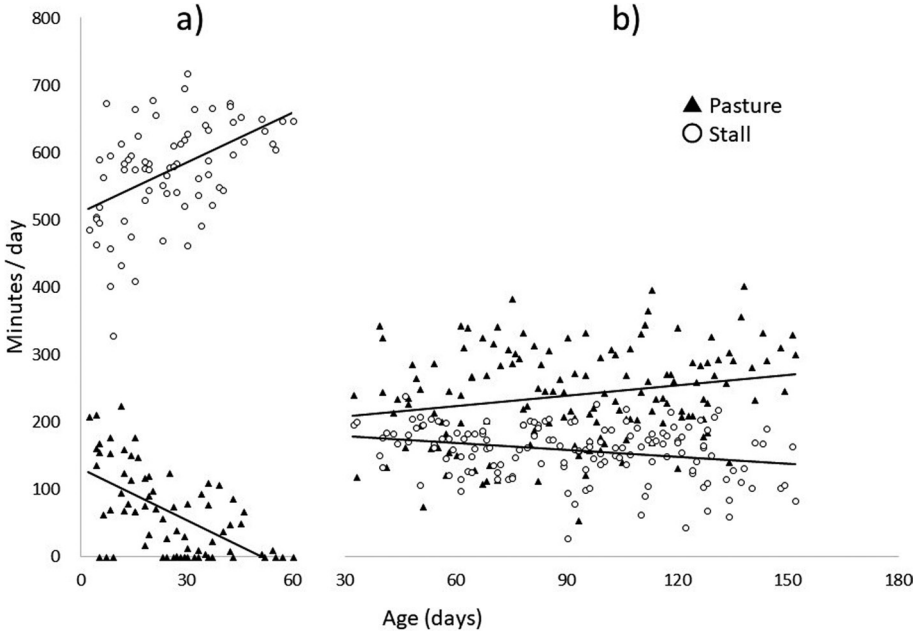

Fig. 2. Lying duration as a function of age for 7-hr (a) and 19-hr (b) pasturing periods.

Statistical analysis

Statistical analyses were conducted with JMP® 9 (SAS Institute Inc., Cary, NC, U.S.A.). All experimental data are shown as means ± standard deviations and were considered significant at a 95% confidence level ($P<0.05$). To evaluate the factors affecting lying behavior, foal gender and weather were analyzed using Student's *t*-test, and location (pasture vs. stall) was analyzed using a paired *t*-test. To evaluate the influence of foal's growth, correlation coefficients between foal age and lying parameters were calculated.

Results

Lying duration and frequency during the day were significantly different between period A and B ($P<0.05$). Not only resting behavior but also behavior patterns such as activity or grazing patterns were also expected to be largely different, so the results are shown separately

Daytime pasturing period (period A)

Duration and frequency of lying behavior are shown in Table 1. The changes in lying duration and frequency with age are shown in Figs. 2a and 3a. The correlation coefficients between foal's age and lying duration were −0.61

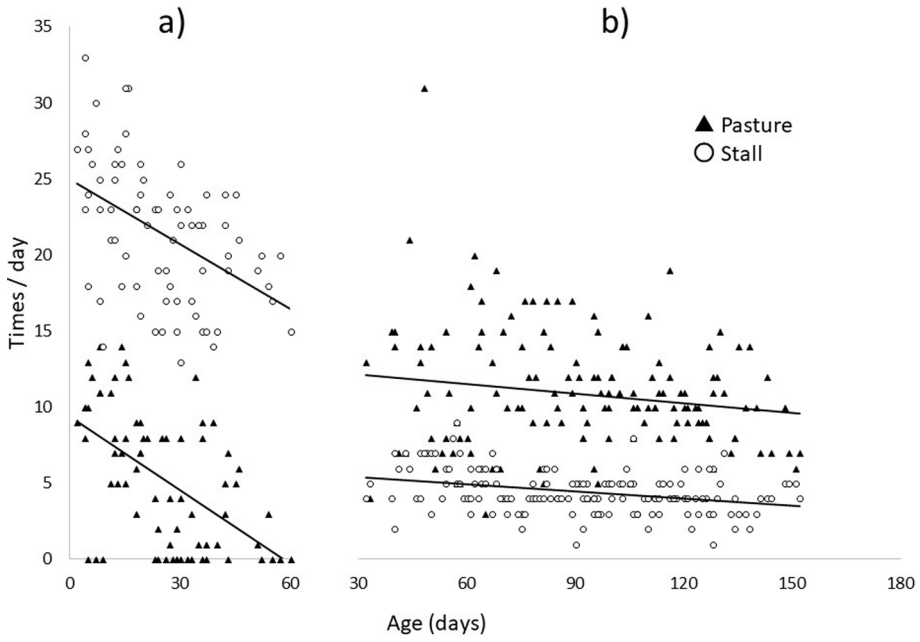

Fig. 3. Lying frequency as a function of age for 7-hr (a) and 19-hr (b) pasturing periods.

Table 2. Duration and frequency of lying behavior and the ratio of lateral to sternal lying during the 19-hr pasturing period

		Pasture		Stall		Total	
		Mean	SD	Mean	SD	Mean	SD
Duration* (min/day)	Total	240.0	70.3	157.6	39.1	399.0	67.8
	(%)	(21.1)		(52.5)		(27.7)	
	Lateral	61.2	36.9	94.4	40.3	155.3	57.1
	(%)	(5.4)		(31.5)		(10.8)	
Frequency (times/day)	Total	10.8	4.0	4.4	1.4	15.3	4.2
	Lateral	7.4	4.3	6.4	2.5	13.7	4.1
Lateral/sternal		26/74		60/40		39/61	

*The ratio of duration to spending time under each condition (i.e., 19 hr in pasture, 5 hr in stall, and 24 hr in total) is presented as a percentage. SD, standard deviation.

(P<0.0001) in the pasture and 0.48 (P<0.0001) in the stall, and those between foal's age and lying frequency were −0.55 (P<0.0001) in the pasture and −0.46 (P<0.0001) in the stall. Lying duration in colts (45.6%) was longer than in fillies (42.5%) (P<0.05), and that under wet conditions (0.05%) was lower than under dry conditions (20.0%) (P<0.05).

Overnight pasturing period (period B)

Duration and frequency of lying behavior are shown in Table 2. The changes in lying duration and frequency with age are shown in Figs. 2b and 3b. The correlation coefficients between foal's age and lying duration were 0.20 (P=0.0145) in the pasture and −0.22 (P=0.0056) in the stall, and those between foal's age and lying frequency were −0.16 (P=0.0514) in the pasture and −0.33 (P<0.0001) in the stall. Lying duration in colts (28.5%) was longer than in fillies (26.0%) (P<0.05), and that under wet conditions (18.2%) was lower than under dry conditions (21.8%) (P<0.05).

Lying by time period

Lying periods throughout the day during periods A and B (13:30–8:30 hr) are shown in Fig. 4. Lying behavior was more affected by location than by time period. Foals spent more time lying down in stalls than in the pasture, particularly at night.

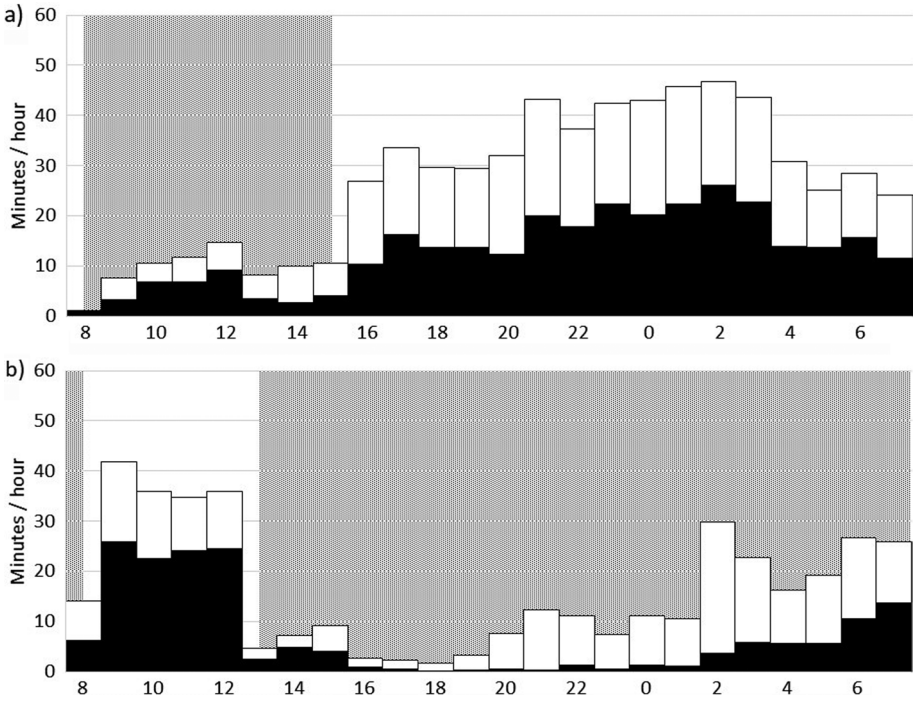

Fig. 4. Relative frequency of lying periods for 7-hr (a) and 19-hr (b) pasturing periods. Lying durations divided into lateral position (■) and sternal position (□) are shown separately. Background shading indicates the periods during which foals were in the pasture.

Discussion

In this study, we analyzed over 200 days worth of data from 6 Thoroughbred foals and revealed the changes in lying behavior on a breeding farm. Triaxial accelerometers measured foal position without injury or obvious discomfort. Recently, some studies regarding resting behavior of adult horses have used accelerometers to evaluate the configuration of stables [5, 10] and space availability in stalls [4]. In the present study, lying behavior was analyzed using triaxial angle data; DuBois *et al.* previously analyzed behavior using automatically obtained G-force values [9]. Our study constitutes the first report evaluating lateral lying positions using triaxial accelerometers attached on the head. Occasionally, the head angle indicated a lying position for approximately 1 min despite the hind limb angle indicating a standing position, reflecting suckling behavior. These instances were excluded from the study by comparing hind limb and halter angles.

In neonatal foals (<1 week of age), lying time was 32% in Welsh ponies [7] and 35% in Przewalski horses [2]. In Camargue horses, foals lie down 15% of the time after birth and 2% of the time after weaning [1]. In the present study, foals (<60 days of age) spent more time lying down than in previous reports. Time spent in single stalls (19 hr) may explain these results.

Less time is lying down in pastures than in stalls (13 vs. 21%) in mature ponies [8]. This tendency was also observed in the present study. Thus, lying duration decreased with increasing pasturing time (from 9 to 17 hr). Our results suggest that approximately 10.5 hr spent in a lying position during period A may be excessive for neonatal health. Lying duration and frequency changed with age in period A but did not change clearly in period B. The suckling frequency decreased with age between 0–10 weeks of age and then remained steady [13]. Prolongation of the suckling interval might extend the resting duration and decrease the resting frequency. These results suggested that the behavior of foals changed remarkably within 60 days of age.

In addition, the percentage of time spent lying and the ratio of lateral to sternal lying positions were lower in the pasture than in stalls. The presence of other horses and harsh weather conditions in the pasture may prevent foals from lying down. Conversely, foals in stalls may lie down as a result of boredom. Fillies tended to spend more time lying down than colts (42 vs. 20%) in a previous study [11]; however, our results did not confirm this trend.

In period A, lying behavior in the pasture was inhibited in wet weather. Lying duration during wet weather in period B was also significantly shorter than that in dry weather, but

the differences were smaller than in period A. These slight differences may be explained by discontinuous rainfall throughout the 19-hr measurement period and the presence of shelters in the pasture.

Horses are not nocturnal or diurnal animals but instead are polyphasic resting animals that tend to sleep at night [3, 5, 8, 9], particularly from 00:00 to 02:00 [8]. The foals in our study also tended to lie down at midnight. On a sunny day, the foals preferred to lie down in comfortable conditions under sunlight even immediately after they were turned out to pasture. This behavior pattern, which was reported previously [8], showed a slight increase from 12:00 to 14:00 in our results (Fig. 4b).

Resting, including lying down, is essential for mammals and particularly for their young. Foals spend more time lying down than adults [6]. Monitoring resting behavior would be useful for evaluating foal health and management methods at breeding farms. However, the association between lying behavior and growth or health remains unknown, and further studies are imperative to elucidate such an association. The present study had a significant limitation in that equine resting behavior was divided into three positions (standing, lateral lying, and sternal lying) but standing rest was not evaluated.

The lying behavior of Thoroughbred foals was monitored using triaxial accelerometers under common conditions at a breeding farm in Japan. Lying duration and frequency differed between pasture and stalls, indicating the influence of pasturing time on lying behavior. Monitoring using triaxial accelerometers may be useful for evaluating equine lying behavior.

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