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Assessment of horse behavior using an activity monitoring device used for cats and dogs

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Including Internet of Things (IoT) technology in horse-rearing management can potentially mitigate problems such as human resource shortages and time limitations in performing daily behavior monitoring. In this study, a small and inexpensive activity meter used to monitor dogs and cats (PLUS CYCLE®, JARMeC, Kanagawa, Japan) was used to monitor the daily behavior of horses. A study was performed to examine the suitability of the PLUS CYCLE® device for monitoring horses and to determine whether it could estimate horse behavior. The device was equipped with an accelerometer and was used to monitor Kiso horses in horse stalls and pastures after installing the devices at specific locations on headcollars and girths. The amount of activity from the accelerometer showed differences among the horses' behavioral types (lying, standing, walking, and feeding) in the stall, suggesting that it functions in horses. In the pasture, the amount of activity was correlated with GPS movement speed. Then, we tried to establish restricted cubic spline regression models to predict the locomotion speed in the pasture based on the amount of activity, but the prediction accuracy was low. This study showed that PLUS CYCLE® can be used to monitor horse activity amount during the daily management of individual horses. However, to achieve higher precision in monitoring detailed behaviors, additional investigation and data pertaining to the amount of activity for each horse during rearing in different environments are needed.

Key words: *activity meter, behavior, Kiso horse*

Observing the daily behavior of horses is essential in horse rearing and management as it helps to understand the health conditions of horses and leads to early detection of abnormalities. However, the human resources and time required to observe the daily behavior of horses are limited, resulting in insufficient behavioral observation of individuals.

The installation of Internet of Things (IoT) devices is being promoted in the livestock industry to solve issues with labor shortages. Furthermore, IoT technologies have been developed for cattle, and devices such as network cameras and motion sensors are being used for daily behavior observation in feeding management [3, 13]. Data from IoT devices, such as daily activity amounts, step counts, and time spent standing and lying, help owners predict estrus terms and parturition periods. The installation of IoT devices in cattle rearing has contributed to overcoming labor shortages and reducing labor costs. Similar IoT devices are used to observe the behavior of companion animals such as dogs and cats [1, 2, 5, 9, 12, 14–17]. When owners are away, they use IoT devices for dogs and cats to remotely monitor the states of their companion animals. For instance, an activity monitor is helpful as an assessment tool for documenting improved activity associated with treatment in dogs and cats with osteoarthritis.

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Based on these precedents, the use of IoT technology for horses may contribute to reducing labor shortages and costs related to rearing management. A few studies on horse activity tracking using accelerometers have suggested that IoT devices that can quantitatively observe horse behavior are helpful in the management of nutritional disorders linked to obesity and in the rehabilitation of horses recovering from injury when movement needs to be restricted [10]. Quantifying the amount of activity in horses might be used to detect abnormalities, such as locomotor disease, and to understand their daily health status when their owners cannot observe their behavior frequently. Moreover, it would be ideal to monitor the type of behavior and amount of time spent on that behavior to understand horse health in detail. However, no suitable IoT device is available for monitoring the daily behavior of individual horses. Furthermore, few studies have verified the relationship between horse behavior quantified using IoT devices and real-time horse behavior monitored in routine rearing environments, such as horse stalls and pastures [4].

Therefore, in this study, we monitored horses using wearable IoT devices previously used for other animals. However, wearable activity meters used for cattle are large and expensive, making their use challenging in horses. Instead, we adopted activity meters already in practical use for dogs and cats because they are lightweight and inexpensive.

The PLUS CYCLE® (Japan Animal Medical Center, Kanagawa, Japan) is an activity meter (diameter, 27 mm; 9.1 mm thick) that was developed to measure the activity of dogs and cats. It weighs 9 g and has a built-in 3-axis acceleration sensor that uses a capacitive sensor. It can output the amount of activity for 1 min from the acceleration data on each axis within a measured range of 2–32 Hz. The activity is zero when the axis acceleration is zero, such as when the device is not moving or moving at a constant speed. The activity data using the PLUS CYCLE® in cats are reported to be correlated with the activity data obtained using an Actical®, a human activity monitor tried in cat research [16].

The main aim of this study was to analyze the applicability and practicality of using a wearable IoT device to observe the daily behaviors of individual horses. The PLUS CYCLE® activity meter, which is already in practical use for monitoring dog and cat activity, was used. Before starting the research, assessments for applicability were performed to determine whether the activity meter for dogs and cats also worked for horses and to examine whether horse behavior was related to the activity data acquired using the IoT device. The relationship between heart rate and speed in racing horses has been well studied [11]. Behaviors such as high-intensity exercise that alter the heart rate might be observed in pastures. Therefore, we also attempted to discern a correlation between the amount of activity and heart rate. When a correlation between activity and behaviors or heart rate was observed, we examined whether the activity data could infer behaviors and heart rate to assess the practicality of the activity meter. Moreover, seasonal changes, including temperature, alter horse behavior [8]. We therefore also examined whether seasonal changes in horse activity could be ascertained based on the data accumulated using the IoT device.

Materials and Methods

Animals and rearing environment

This study was approved by the Gifu University Animal Care and Use Committee (accession no. 2021-146). The Kiso horse is one of eight indigenous horse types in Japan. Four female Kiso horses reared at Kisouma-no-Sato (Kaida Kogen, Nagano, Japan) were used in the present study. The average age of the horses was 11 years old; the youngest was 2 years old, whereas the oldest was 21 years old. Thirty-four Kiso horses, including these four horses, were reared in two stables.

The rearing environment for horses in Kisouma-no-Sato stables and pastures was as follows: Kisouma-no-Sato is located at an altitude of 1,153 m above sea level, with two stables and one pasture. Kiso horses grazed during the day and were kept in stables at night. The horse stalls were approximately 2.7 m^2 in area, and each Kiso horse was housed in an individual stall. The stable contained a water bucket that was placed approximately 60 cm from the ground, and the feed was placed on the floor. The pasture area was approximately 15,000 m^2. Each grazing herd comprised 15 horses including the four test horses.

Capturing horse activity data in the stall

The PLUS CYCLE® (Japan Animal Medical Center, Kanagawa, Japan) activity meter for dogs and cats contained an accelerometer that measured the amount of activity every minute (Fig. 1). One activity meter was fixed to the left

Fig. 1. Activity meter used in this study.
The PLUS CYCLE® activity meter that monitors dogs and cats (photo provided by JARMeC).

cheek part of the headcollar, and the other was fixed to the part of the girth on the horse's back (Fig. 2A). All activity meters were covered with a cloth (composition: 80% polyester and 20% nylon) to protect them from dust and dirt. The activity meter measurements were recorded in the stall from 16:00 until 08:00 the next day for 3 days. Simultaneously, a video camera recorded the horse's behavior in the stall. Behavioral records were classified as lying, standing, walking, or feeding behaviors as described below.

For lying, the horse's behavior was classified as lying if, within a one-minute observation period, the recorded behavior predominantly involved lying, with minimal or no occurrence of other behaviors. Specifically, lying was defined as a state in which the observed horse was primarily in a lying position for most of the one-minute observation period and did not engage significantly in standing, walking, or feeding during that time.

For standing, the horse's behavior was classified as standing if, within a one-minute observation period, the horse was observed remaining stationary at a specific location without engaging in walking or feeding activities. Standing was defined as maintaining a stationary position in which the horse did not move from their standing site or participate in other behaviors such as lying, walking, or feeding for one minute.

For walking, the horse's behavior was classified as walking if, within one minute, the horse was observed continuously moving from one place to another. Specifically, walking was defined as ongoing if the horse was continuously in motion during the one minute and if the subsequent one-minute period also included walking. If the subsequent one-minute period did not involve walking (e.g., if the horse was only standing), the behavior was not classified as walking.

For feeding, the horse's behavior was classified as feeding if, within the one-minute observation period, the horse was observed engaging in feeding activities, regardless of other behaviors. Feeding was defined as consuming food, which was categorized as feeding even if the horse exhibited other behaviors (e.g., lying, standing, or walking) during that minute.

Capturing horse activity data in the pasture

Locomotion behavior, especially the movement speed observed in the pasture, differs considerably from stable behaviors. In this study, the focus was on the speed of locomotion behavior, and position information was recorded every 5 sec using a GPS data logger (GL-770, Transystem Inc., Taiwan, ROC). The locomotion speed was calculated using the recorded position and time information. Additionally, heart rate while in the pasture was recorded every second with a horse heart rate sensor (Polar Equine H10, Polar Electro Oy, Kempele, Finland). The GPS data logger and a heart rate sensor were attached to the horse with a girth. The GPS data logger was placed on the back of the horse, and the heart rate sensor was placed near the apex of the sixth intercostal space on the left chest wall (Fig. 2B). One PLUS CYCLE® activity meter was fixed to the left cheek part of the headcollar, and another was fixed to the part of the girth on the horse's back. The parameters were measured in the pasture from 08:00 to 16:00 for 3 days. GPS location data were analyzed using the GL-770 dedicated

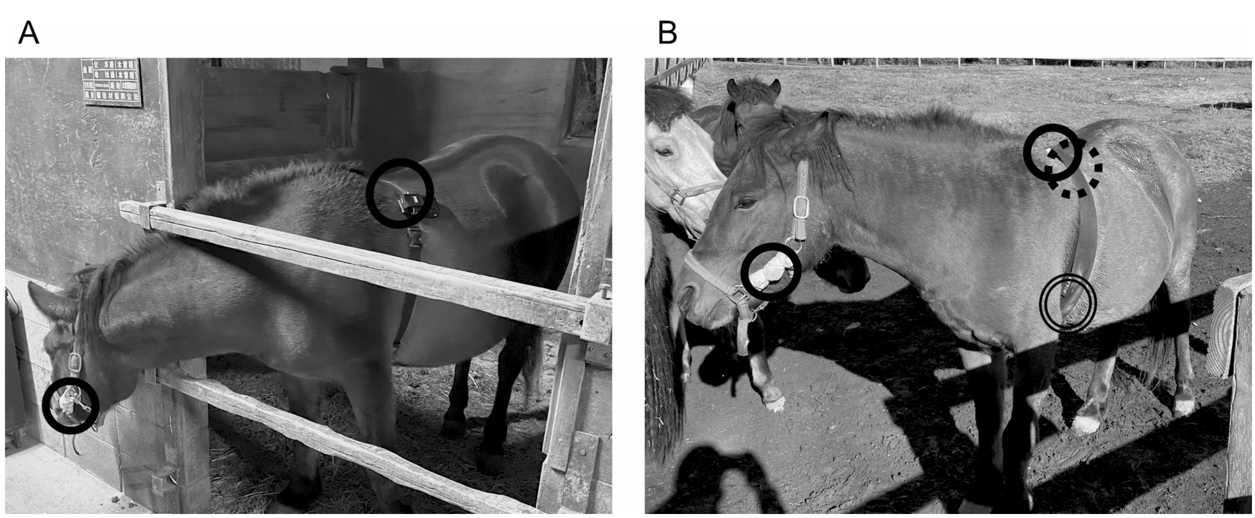

Fig. 2. Device placement sites on the horse.
(A) Data acquisition in the stall. (B) Data acquisition in the pasture. Black circle, activity meter; dotted circle, GPS data logger; double circle, heart rate sensor.

software (GPS Photo Tagger). The average locomotion speed per minute was calculated based on the recorded time. Heart rate was analyzed using the Polar Equine H10 dedicated software (Polar Flow) to obtain the average heart rate per minute.

Capturing seasonal change in horse activity

To examine the effects of seasonal changes on horse activity amount, the activity all day was measured every day for 12 months from November 2021 to October 2022. The PLUS CYCLE® activity meter was fixed to the left cheek portion of the headcollar. The amount of activity was analyzed using the PLUS CYCLE® dedicated software (PLUS CYCLE App) to calculate the average amount of activity per day for each month from the daily activity sums. The mean daily air temperature for each month in the area was obtained by referring to data from the Japan Meteorological Agency (https://www.data.jma.go.jp/stats/etrn/index.php?prec_no=48&block_no=1314).

Statistical analysis

All statistical analyses were performed using the EZR software (version 1.64) [7]. The activity in the stall captured using the video camera and activity meter was analyzed for each behavior type. To confirm the relationship between the behavior type in the stall and the amount of activity, the difference in the amount of activity between each behavior type was analyzed using the Friedman test, and the Bonferroni test was performed as a post-hoc test. Then, Spearman's correlation coefficient (r_s) was obtained for the relationship between the average speed per minute obtained using the GPS data logger in the pasture, the average heart rate per minute obtained using the heart rate sensor, and the amount of activity. Additionally, when correlation with the amount of activity was observed for the average speed per minute and/or the average heart rate per minute, the restricted cubic spline regression model was used to assess whether the average speed and/or the average heart rate could be inferred from the activity data. The restricted cubic spline (rcs) regression model was obtained using the R package "rms" (rms: Regression Modeling Strategies; Harrell Jr (2023); R package version 6.7-1; https://CRAN.R-project.org/package=rms). The rcs regression model was assessed with AIC (Akaike's information criterion) and the RMSE (root mean squared error). Statistical significance was set as a P-value<0.05.

Results

Relationship between the amount of activity and horse behavior in the stalls

Figure 3 shows an example of an analysis that assesses the relationship between the amount of activity and the four behavioral types. The activity amounts varied depending on the attachment location of the device, even for the same time. Table 1 shows the amount of activity classified as lying, standing, walking, and feeding in the stalls. When the accelerometer was attached to the cheek, significant differences were found between the amount of activity measured using the device for lying, standing, walking, and feeding behaviors (P<0.05). On the other hand, when the accelerometer was attached to the horse's back, significant differences were found in each behavior, except for the comparison of lying and standing.

Relationship between the amount of activity and locomotion speed or heart rate in the pasture

Figure 4 shows dot plots of the relationship between the amount of activity, locomotion speed, and heart rate in the pasture. Figures 4A and 4B show the relationship between the amount of activity and the locomotion speed. A weak positive correlation was observed between the amount of activity and locomotion speed when the device was worn on the left cheek region (r_s=0.301, P<0.05; Fig. 4A). However, when worn on the horse's back, a positive correlation was confirmed between the amount of activity and locomotion speed (r_s=0.624, P<0.05; Fig. 4B).

Figures 4C and 4D show the relationship between the amount of activity and heart rate in the pasture. No correlation was observed between the amount of activity and heart rate when the activity meter was attached to any site (left cheek, r_s=0.167, P<0.05; horse's back, r_s=0.172, P<0.05).

Estimation of horse locomotion speed in the pasture using restricted cubic spline regression models

Figure 5 shows the rcs regression models for estimating the locomotion speed based on the amount of activity. Figures 5A and 5B show the rcs model with 3 or 4 knots when the activity meter was attached to the cheek. Both models indicated that the amount of activity significantly affected the logarithmically transformed average speed (P<0.01). The AIC and RMSE of the model in Fig. 5A are 22495.74 and 1.730, and those in Fig. 5B are 22245.5 and 1.692. On the other hand, Figs. 5C and 5D show the rcs model with 3 or 4 knots when the activity meter was attached to the horse's back. Both models also indicated that the amount of activity significantly affected the logarithmically transformed average speed (P<0.01). The AIC and RMSE of the model in Fig. 5C are 19893.35 and 1.378, and those in Fig. 5D are 19842.62 and 1.371.

Seasonal changes in horse activity assessed using the activity meter for dogs and cats

Figure 6 shows the seasonal changes in the average daily

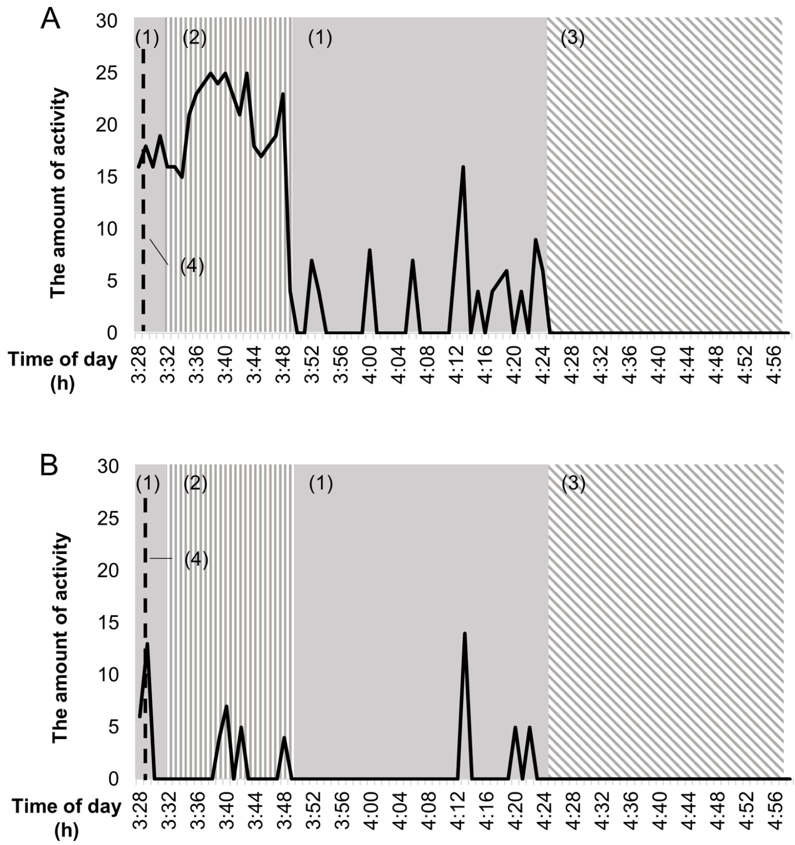

Fig. 3. Horse behavior in the stall and amount of activity detected using the accelerometer.
The line graph shows the amount of activity. (1) The filled area indicates standing behavior. (2) The vertical striped region indicates feeding behavior. (3) The diagonal striped region indicates lying behavior. (4) The vertical dashed line indicates walking behavior. (A) Amount of activity when the device was attached to the cheek. (B) Amount of activity when the device was attached to the horse's back.

Table 1. Statistical values of activity amounts classified according to observed behavior

Activity meter position	Behavior	Statistical values for amount of activity				Significant difference (P<0.05)
		n	Median (IQR)	Minimum	Maximum	
Cheek	Lying	758	0 (0–0)	0	40	Standing, walking, feeding
	Standing	4,756	0 (0–0)	0	52	Lying, walking, feeding
	Walking	289	16 (10–23)	0	54	Lying, standing, feeding
	Feeding	2,832	22 (16–26)	0	51	Lying, standing, walking
Horse's back	Lying	758	0 (0–0)	0	39	Walking, feeding
	Standing	4,756	0 (0–0)	0	47	Walking, feeding
	Walking	289	0 (0–10)	0	44	Lying, standing, feeding
	Feeding	2,832	0 (0–0)	0	44	Lying, standing, walking

Statistical values of the four horses from the activity data for each behavior are shown.
n, number of times each behavior was observed (n also represents time spent (minutes) on each behavior.); IQR, interquartile range shown as first quartile − third quartile. Significant difference (P<0.05): the corresponding behavioral types are shown for significant differences observed using the Friedman test and Bonferroni test. The total number for n was 8,635, excluding other behaviors that could not be classified into the four behaviors. Other behaviors: n=17.

horse activity per month. Continuous data on the amount of activity could not be collected from one of the Kiso horses for reasons privy to the owner. The PLUS CYCLE® device acquired equine activity data for 12 months from three horses. Moreover, some devices were found to have malfunctioned during the study period, resulting in a lack of

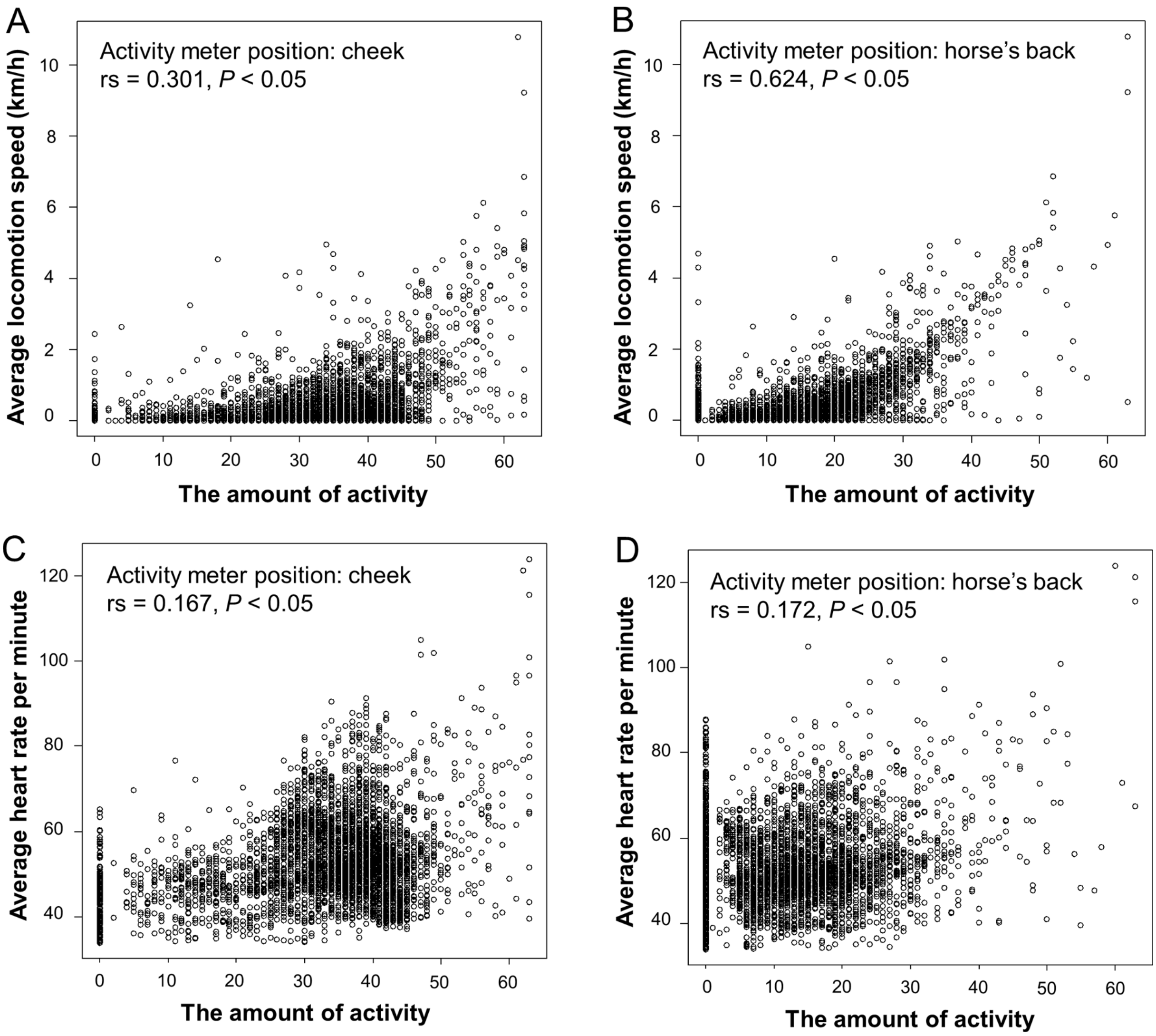

Fig. 4. Amount of activity, locomotion speed, and heart rate in the pasture when the accelerometer was attached to left cheek or horse's back.

Figures 4A and 4B show a scatter plot of the amount of activity and the average locomotion speed. (A) The data were obtained when the accelerometer was attached to the left cheek. A weak positive correlation was found between the amount of activity and the mean locomotion speed (r_s=0.301, P<0.05). (B) The data were obtained when the accelerometer was attached to the horse's back. A positive correlation was found between the average locomotion speed and locomotion (r_s=0.624, P<0.05). Figures 4C and 4D show a scatter plot of the amount of activity and average heart rate. (C) The data were obtained when the accelerometer was attached to the left cheek (r_s=0.167, P<0.05). (D) The data were obtained when the accelerometer was attached to the horse's back (r_s=0.172, P<0.05).

data. The average daily activity of all three horses increased from April to July.

Discussion

In this study, we first attempted to confirm whether the dog and cat activity meter functioned satisfactorily for horses for daily behavioral observation. The activity amount output from the device attached to the cheek and horse's back differed depending on the behavioral types in the stalls. This suggests that among the built-in sensors of the PLUS CYCLE® device, the acceleration sensor can measure horse behavior in stalls as the amount of activity. However, there was no significant difference in activity between lying and standing when the device was attached to the horse's back, and the median activity was zero for lying, standing, walking, and feeding, implying that the horse's back did not move most of the time for the four behaviors in the stalls. Hence, there was a possibility that the behavioral types could not be estimated from the amount of activity

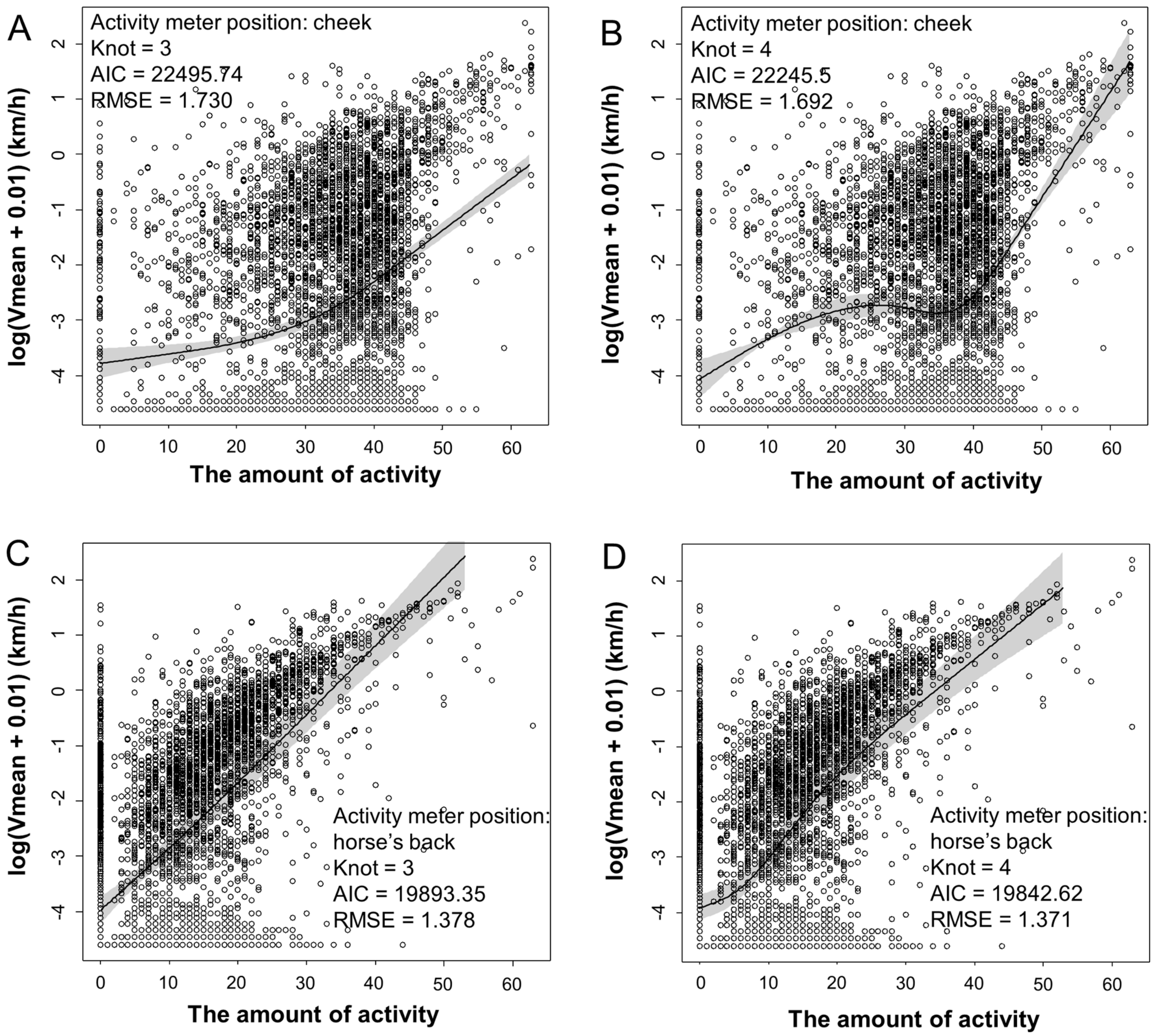

Fig. 5. Restricted cubic spline regression models for estimation of locomotion speed in the pastures.
Log (Vmean+0.01): The logarithmically transformed value of average locomotion speed after adding 0.01. The grey areas around the regression curves represent 95% confidence intervals. We performed an ordinary least squares regression analysis using a 3- or 4-knot spline transformation. The position of the attached activity meter, knot number, AIC (Akaike's information criterion), and RMSE (root mean squared error) are shown in each figure. (A) The amount of activity and its nonlinear effect significantly influenced the average speed ($P<0.01$, respectively). (B) The amount of activity and its nonlinear effect significantly influenced the average speed ($P<0.01$, respectively). (C) The amount of activity showed a statistically significant effect ($P<0.01$). However, the nonlinear effect was not statistically significant ($P=0.5936$). (D) The activity amount and its nonlinear effect significantly influenced the average speed ($P<0.01$, respectively).

when the device was attached to the horse's back. In this study, the estimation of behavioral types from the amount of activity in the stalls was conducted only in the case of the cheek. However, it was impossible to infer the behaviors from the amount of activity per minute because there were some activity data indicating that different behaviors could show the same amount of activity. Specifically, as in the case of the horse's back, the median amount of activity did not show a large difference between lying and standing or walking and feeding when the device was attached to the cheek, although statistically significant differences were observed in the amount of activity between each behavior. Further investigation is required to develop an algorithm for estimating the behavior based on the amount of activity, including the consideration of additional factors, such as the time spent on behaviors

In the pasture analysis, locomotion speed influenced the amount of activity output from the device attached to the cheek and horse's back. This suggests that the locomotion speed could be estimated from the amount of activity output

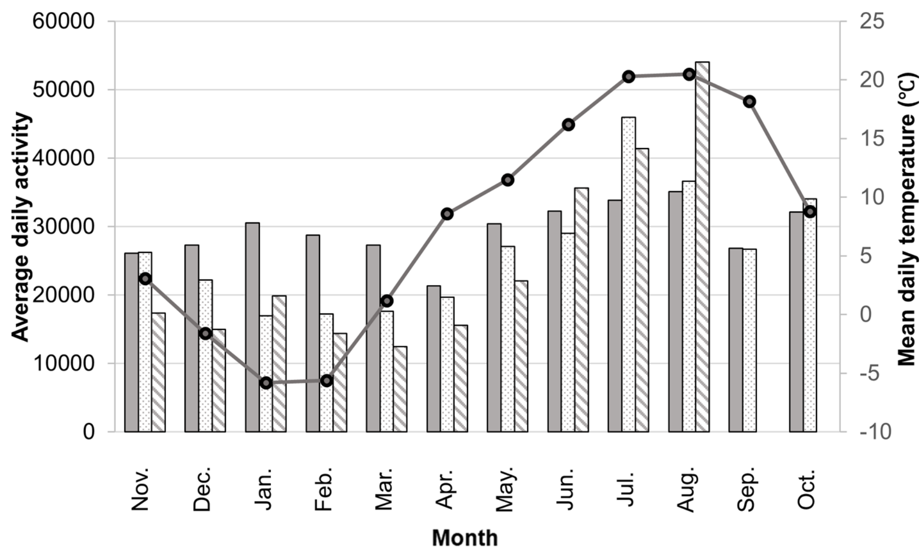

Fig. 6. Monthly difference in average daily activity when the accelerometer was attached to the cheek.
Bar plots indicate the average amount of activity for daily exercise per month in each horse (n=3) when the accelerometer was attached to the left cheek. The line indicates the average daily temperature for each month. The left axis indicates the amount of activity, and the right axis indicates the temperature (°C).

from the device. Furthermore, we attempted to estimate the locomotion speed in the pasture based on the amount of activity using the rcs models. All models showed that the locomotion speed affected the amount of activity. However, none of the models accurately estimated locomotion speed based on the amount of activity, as the RMSE of each model was relatively large compared with the estimation range of log speed. Although models might be constructed to fit the data better, considering that each model reflected the limited data of four horses in this study, additional investigation would be required. On the other hand, no relationship between heart rate and amount of activity was observed. The reason for this might be that horses in the grazing area do not generally intend to act spontaneously in a manner that evokes an increase in heart rate, contrary to that observed in racing horses during training. Heart rate estimation based on the amount of activity would not be suitable for daily monitoring.

The average daily activity of the Kiso horses increased from April to July. This result suggests that the PLUS CYCLE® can be used to understand seasonal changes in the amount of activity. An experiment using a GPS data logger reported that the daily walking distance was lowest in winter [6]. Although further investigation would be needed to clarify the seasonal increase in the amount of activity, the change in the amount of activity observed in this study may have been affected by seasonal changes in walking behavior. However, the amount of activity in the stall, such as feeding, might also have increased.

In conclusion, the dog and cat activity meter can be used to monitor the daily amount of activity of horses. To increase the accuracy of monitoring the daily activities of each horse using the device, the relationship between the amount of activity and horse behavior needs to be clarified. Furthermore, the mounting sites for the device must be analyzed to ascertain the most suitable site for observing each behavior and accumulating data on the amount of activity required for each application.

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References

1. Brown, D.C., Boston, R.C., and Farrar, J.T. 2010. Use of an activity monitor to detect response to treatment in dogs with osteoarthritis. *J. Am. Vet. Med. Assoc.* **237**: 66–70. [Medline] [CrossRef]
2. Dow, C., Michel, K.E., Love, M., and Brown, D.C. 2009. Evaluation of optimal sampling interval for activity monitoring in companion dogs. *Am. J. Vet. Res.* **70**: 444–448. [Medline] [CrossRef]
3. Duncan, N.B., and Meyer, A.M. 2019. Locomotion behavior changes in peripartum beef cows and heifers. *J. Anim. Sci.* **97**: 509–520. [Medline] [CrossRef]

4. Fries, M., Montavon, S., Spadavecchia, C., and Levionnois, O.L. 2017. Evaluation of a wireless activity monitoring system to quantify locomotor activity in horses in experimental settings. *Equine Vet. J.* **49**: 225–231. [Medline] [CrossRef]
5. Hansen, B.D., Lascelles, B.D., Keene, B.W., Adams, A.K., and Thomson, A.E. 2007. Evaluation of an accelerometer for at-home monitoring of spontaneous activity in dogs. *Am. J. Vet. Res.* **68**: 468–475. [Medline] [CrossRef]
6. Hildebrandt, F., Krieter, J., Büttner, K., Salau, J., and Czycholl, I. 2020. Distances walked by long established and newcomer horses in an open stable system in Northern Germany. *J. Equine Vet. Sci.* **95**: 103282. [Medline] [CrossRef]
7. Kanda, Y. 2013. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. *Bone Marrow Transplant.* **48**: 452–458. [Medline] [CrossRef]
8. Keller, G.A., Nielsen, B.D., Vergara-Hernandez, F.B., and Robison, C.I. 2022. Tracking the impact of weather on equine activity while pastured. *J. Equine Vet. Sci.* **116**: 104052. [Medline] [CrossRef]
9. Lascelles, B.D., Hansen, B.D., Thomson, A., Pierce, C.C., Boland, E., and Smith, E.S. 2008. Evaluation of a digitally integrated accelerometer-based activity monitor for the measurement of activity in cats. *Vet. Anaesth. Analg.* **35**: 173–183. [Medline] [CrossRef]
10. Maisonpierre, I.N., Sutton, M.A., Harris, P., Menzies-Gow, N., Weller, R., and Pfau, T. 2019. Accelerometer activity tracking in horses and the effect of pasture management on time budget. *Equine Vet. J.* **51**: 840–845. [Medline] [CrossRef]
11. Manohar, M. 1994. Pulmonary vascular pressures of thoroughbreds increase rapidly and to a higher level with rapid onset of high-intensity exercise than slow onset. *Equine Vet. J.* **26**: 496–499. [Medline] [CrossRef]
12. Morrison, R., Penpraze, V., Greening, R., Underwood, T., Reilly, J.J., and Yam, P.S. 2014. Correlates of objectively measured physical activity in dogs. *Vet. J.* **199**: 263–267. [Medline] [CrossRef]
13. Stewart, M., Wilson, M.T., Schaefer, A.L., Huddart, F., and Sutherland, M.A. 2017. The use of infrared thermography and accelerometers for remote monitoring of dairy cow health and welfare. *J. Dairy Sci.* **100**: 3893–3901. [Medline] [CrossRef]
14. Yam, P.S., Penpraze, V., Young, D., Todd, M.S., Cloney, A.D., Houston-Callaghan, K.A., and Reilly, J.J. 2011. Validity, practical utility and reliability of Actigraph accelerometry for the measurement of habitual physical activity in dogs. *J. Small Anim. Pract.* **52**: 86–91. [Medline] [CrossRef]
15. Yamada, M., and Tokuriki, M. 2000. Spontaneous activities measured continuously by an accelerometer in beagle dogs housed in a cage. *J. Vet. Med. Sci.* **62**: 443–447. [Medline] [CrossRef]
16. Yamazaki, A., Edamura, K., Tanegashima, K., Tomo, Y., Yamamoto, M., Hirao, H., Seki, M., and Asano, K. 2020. Utility of a novel activity monitor assessing physical activities and sleep quality in cats. *PLoS One* **15**: e0236795. [Medline] [CrossRef]
17. Yashari, J.M., Duncan, C.G., and Duerr, F.M. 2015. Evaluation of a novel canine activity monitor for at-home physical activity analysis. *BMC Vet. Res.* **11**: 146. [Medline] [CrossRef]