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Association of production diseases with motor activity-sensing devices and milk progesterone concentrations in dairy cows

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ABSTRACT

We have previously established that the efficiency of identifying oestrus with activity-sensing devices can be compromised by common production diseases; the present study was undertaken to determine how these diseases may affect device readings. A total of 67 Holstein-Friesian cows, >20 days postpartum, were equipped with activity-sensing neck collars and pedometers, and simultaneous milk progesterone profiles were also monitored twice a week. The influences of common production stressors on maximum activity and progesterone values were analysed. Approximately 30% potential oestrus events (low progesterone value between two high values) remained unrecognised by both activity methods, and progesterone values in these animals were higher on the potential day of oestrus when both activity methods did not detect an event (0.043 ± 0.004 versus 0.029 ± 0.004 ng/mL; $P = 0.03$). Data from a subset of 45 cows (two events each) were subjected to mixed models and multiple regression modelling to investigate associations with production diseases. Cow motor activity was lower in lame cows. Maximum progesterone concentrations prior to oestrus increased as time postpartum and body condition score (BCS) increased. There were also fewer days of low progesterone prior to oestrus associated with increases in BCS and maximum progesterone concentrations prior to oestrus. In conclusion, lameness was associated with lower activity values, but this suppression was insufficient to account for lowered oestrus detection efficiency of either device. However, associations were identified between production diseases and progesterone profiles.

1. Introduction

There has been a decline in oestrus behaviour intensity displayed by dairy cattle world-wide over the past 50 years leading to problems with accurate oestrus detection in many herds [1]. Oestrus normally lasts 15–18 h, although some cattle show signs for as little as 6 h, making identification a challenge for busy farm staff [2].

From a management point of view, being able to efficiently and accurately detect oestrus is still the most important factor in reducing calving intervals [1,3]. Accuracy of oestrus detection should be examined as part of evaluation of herds with low pregnancy rates, especially as a visual heat detection rate of only 38% was recorded across 4550 dairy herds [4]. These days with fewer farm staff on dairy farms, the popularity of activity-sensing devices is increasing. Activity-sensing neck-collars or pedometers both engage continuous radio-transmitted monitoring of cow activity, and have been reviewed across many studies with an average 87% accuracy when compared to visual observations [5,6].

A prior comparison of various simultaneous methods of oestrus detection indicated that the efficiency of identifying oestrus is compromised by common production diseases such as lameness, metabolic disorders as revealed by low body condition score (BCS), and high daily milk yield [7]. The present study aimed to establish if production stressors affected specific components of two types of cow activity devices (neck-collars or pedometers). Associations with parity and milk constituents (somatic cell counts (SSC), % fat, and/or % protein, fat: protein ratio) were also examined.

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2. Materials and methods

2.1. Animals

This study was performed under a UK Home Office license for work on living animals and with the approval of the University of Liverpool Ethical Review Process. Holstein–Friesian cows in their first to eleventh lactation entered the six-month study (March–August) of a 200-cow herd that calved throughout the year on one free-housed commercial UK dairy farm. Mean milk sales per cow were around 11,000 L annually, with average peak yields of 54 L per day. At any one time, a group of approximately 80 cows in the period four months after calving were housed in a cubicle shed with concrete passage-ways. Milking of all cows took place three times a day starting at 05:30 h, 14.00 h and 20:30 h. All animals had continual access to a total mixed ration that was pushed up to a feed-fence five times a day. All cows were monitored after entering the study until confirmed pregnant after ultrasound examination by the farm's veterinarian five weeks after artificial insemination or until the end of the study period. Therefore, many animals had more than one potential oestrus event studied.

Every two weeks, the same member of the research team assessed each cow's body condition score (BCS) using a 1–5 system incorporating 0.5 scores [8], and lameness using a standardised 1–5 system [9]. For statistical analysis, individuals were categorised as not lame (lameness score <1.5) or lame (lameness score >1.6; n = 24 cows). Once a month, individual cow 24 h milk yields (subsequently converted to ECM: energy corrected milk (4% fat and 3.3% protein calculated as 24 h milk production × 0.383 × fat % + milk production × 0.242 × protein % + 0.7832 × milk production/3.1138), somatic cell counts (SCC), % fat and % protein were recorded by Cattle Information Services (CIS; Rickmansworth, UK). The monthly value immediately prior to a potential oestrus event (NEAR_) was used for analysis. Treatments for lameness and mastitis followed normal farm practice: regular or remedial foot-trimming, and antibiotic treatment for udder infections.

2.2. Activity-sensing devices

On entry into the study, all cows were fitted with an activity-sensing neck-collar (Heatime™; SCR Engineers, Netanya, Israel; distributed by FabDec, Ellesmere, UK) with data being downloaded to a dedicated program (Dataflow, SCR Engineers) in 2-h blocks at the milking parlour exit. As designated by the equipment provider, a value of greater than 4.7 standard deviations above the mean activity of the previous eight two-hourly blocks was used to indicate oestrus - this algorithm precluded assessment of baseline values. Also at recruitment, a leg pedometer (Afitag; SAE Afikim, Israel; distributed by Fullwood, Ellesmere, UK) was placed on all cows as an additional measure of cow activity. The pedometer data were also collated remotely by a computer in 8-h blocks at milking using a dedicated program (Crystal; Fusion Electronics, Fullwood). The algorithm used to identify an oestrus was based on an increase in steps per hour greater than 70% of the average for the previous 10 days.

2.3. Hormone analyses

Milk samples for progesterone analysis were collected each Tuesday and Friday throughout the study. All samples were taken immediately before milking and promptly stored at −20 °C without preservative. Progesterone concentration was analysed as pregnane metabolites in 50 μl whole milk samples using an established EIA assay [10]. For the present study, the minimum detectable amount was 0.02 ng/mL, and the intra- and inter-assay coefficients of variation were 9.7 and 15.8%, respectively. When values were less than 0.2 ng/mL, luteal tissue was considered to be absent, whereas values greater than 0.3 ng/mL indicated the presence of luteal tissue [10]. Progesterone profiles were produced for each study animal and used to indicate potential oestrus periods to be identified by neck-collars or pedometers. The term “potential oestrus event” used in data analysis was defined as each time milk progesterone concentration was below 0.2 ng/mL for 2–6 days, preceded and followed by an increase above 0.3 ng/mL for a minimum of 7–10 days.

2.4. Data analyses

Sixty-seven cows were studied providing 164 potential oestrus events for consideration. Data from four cows were excluded because the progesterone profiles were very irregular. Data were also excluded from 34 potential events due to obvious false positives within the neck collar or pedometer data (which mainly occurred during the luteal phase). The neck collar system malfunctioned in 31 (18%) and the pedometers malfunctioned in 17 (10%). These malfunctions were due to mixtures of human error, e.g., power outage, malfunction of the equipment, failure to correctly enter information on the computers. Statistical analysis allowed for these missing data.

Milk progesterone concentrations during all potential oestrus events identified by either neck collars or pedometers were initially compared by Students *t*-test. Due to possible bias and problems introduced either by over-representation or under-representation of some cows while running Mixed Models, subsequent analyses were performed using the first two potential oestrus events in a total of 45 cows which contributed to the final balanced data-set. This comprised 10 primiparous animals, 14 cows that had had 2 calvings, 11 had 3 calvings, 4 had 4 calvings and six cows had had 5 or more calvings).

All statistical analyses were performed with SAS software version 9.3, using the MIXED procedure for linear Mixed Models, unless stated differently. A repeated effect of time (day postpartum) within animals was tested. The correlations between test days were accounted for by specifying a correlation structure (spatial power)

Table 1
Efficiencies of detection for neck-collars, pedometers or combined device data, with accompanying milk progesterone concentrations on day of potential oestrus (mean ± SEM).

Device	Total potential events (n)	Events recorded (n)	Efficiency (%)	Milk progesterone (ng/mL) for recorded event	Milk progesterone (ng/mL) for missed event	P (between progesterone concentrations)
Neck-collar	137	92	67	0.035 ± 0.004	0.051 ± 0.007	0.090
Pedometer	151	106	70	0.032 ± 0.003	0.042 ± 0.007	0.059
Combined	164	72	45	0.029 ± 0.004	0.043 ± 0.004	0.028