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Ovulation timing and conception risk after automated activity monitoring in lactating dairy cows[1]

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ABSTRACT

Using 1 market-available activity monitor, 3 experiments were conducted in dairy cows to determine timing of ovulation, compare within-herd conception risk of cows inseminated based on activity monitors versus timed artificial insemination (AI), and determine conception risk of cows inseminated at various intervals after achieving an activity threshold. In experiment 1, ovaries were scanned every 3 h by transrectal ultrasonography to determine the time of ovulation beginning 14 ± 0.5 h after the achieved activity threshold (n = 132) or first standing event (n = 59), or both (n = 59). Progesterone at the first ovarian scan (0.1 ± 0.01 ng/mL) and ovarian structures [1 or 2 preovulatory-sized follicles (16.5 ± 0.2 mm)] confirmed that 88.6% of cows identified by activity were in estrus. The remaining 15 cows (11.4%) with a corpus luteum and elevated progesterone concentration (5.3 ± 0.5 ng/mL) were classified as false positives. The average interval from first standing event to ovulation (n = 59) differed slightly from the interval after the achieved threshold (26.4 ± 0.7 vs. 24.6 ± 0.7 h, respectively). In 97 cows fitted with activity monitors, that interval was 25.7 ± 0.4 h. In experiment 2, the conception risk in 394 cows in 1 herd fitted with activity monitors was compared with that of 413 cows submitted to a timed AI program through 3 AI services. Days to first AI were reduced in cows fitted with activity monitors, and conception risk after activity threshold was less than that for timed AI at first service because of differing days in milk at first AI. Both median and mean days to pregnancy, however, were reduced in activity-group cows by 10 and 24 d, respectively, compared with timed AI cows. In experiment 3, 4,019 cows in 19 herds were inseminated after achieving the activity threshold. Conception risk was determined for cows inseminated at various intervals after the achieved activity threshold. A curvilinear conception risk curve peaked at 47.9% for primiparous cows inseminated between 13 and 16 h, whereas conception risk in multiparous cows was steady at 34% through 12 h and decreased thereafter. These experiments demonstrate that time of ovulation after activity threshold closely resembles the time of ovulation after first standing estrus. Time of insemination up to 12 h after the activity threshold produced similar conception risks for multiparous cows, whereas intervals shorter than 13 and greater than 16 h in primiparous cows seemed to compromise their conception risk. Although conception risk may not be improved at individual inseminations after achieving an activity threshold, the rate of achieving pregnancy is hastened. Activity monitors can accurately predict ovulation and time of AI.
Key words: activity monitor, conception risk, insemination time, ovulation time

INTRODUCTION

Several significant physiological changes occur in cows during the periestrual period (Lewis and Newman, 1984; Roelofs et al., 2010; Saint-Dizier and Chastant-Maillard, 2012), thus enabling detection of estrual behaviors and other correlated traits. Some of these changes include physical activity, vaginal cytology and pH, electrical resistance of vaginal mucus and genital tissues, body temperature, pulse and heart rates, blood flow, pheromones or odors, blood metabolites and hormones, milk yield, and DMI.

Accurate prediction of ovulation is the goal of a successful estrus-detection program. Improvement in AI service rate required for a 100% estrus-detection-based AI program to have the same economic net present value as a superior 100% timed AI program was 12% (Giordano et al., 2011). Furthermore, adding detection of estrus to a 100% timed AI program was beneficial only for a timed AI program with the lowest conception risk. Thus, reducing costs associated with timed AI programs by improving efficiency and accuracy of detected estrus (increased AI service rate) should reduce the cost per pregnancy in most herds because interinsemination intervals are reduced from 40–50 d to

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20–24 d when nonpregnant cows are identified at the first possible post-AI estrus.

Several technologies can serve as ovulation prediction aids, including heat mount-detection patches and pressure-sensitive rump-mounted radiotelemetric devices that identify cows that have received mounts from herd mates (Firk et al., 2002). These technologies assess mounts received by the targeted cow but require visual inspection of the cow to determine if other signs of estrus validate the trigger. Monitoring activity has formed the basis for many pedometer or neck-mounted monitoring systems marketed to the dairy industry because increased activity (e.g., motion, movement, and walking) is a trait correlated with estrus, with activity increasing up to 400% in 93% of estrous periods (Kiddy, 1977). One challenge limiting any system is the lesser activity associated with estrus for cows maintained in tie-stalls compared with freestalls (Roth, 1987), or for cows in total confinement on concrete compared with dirt lots (Vailes and Britt, 1990).

Accelerometers now used in activity monitors were first developed for the military, aerospace, and automotive industries. They have the capacity to detect motion in all 3 spatial planes. Increased walking activity that is associated with estrus (Roelofs et al., 2010) led to the development of pedometry as a means of detecting estrus as early as the 1970s. Pedometers affixed to the leg or neck quantified cow movement or counted the number of steps taken by the cow. Increase in physical activity of the cow provided 70 to 80% accuracy of detected estrus (Roelofs et al., 2010). Cows housed in freestalls were approximately 2.75 times more active during estrus than when not in estrus; furthermore, relatively little within-cow variation in activity occurred from day to day when cows were not in estrus. Therefore, activity monitors may be acceptable predictors of sexual and other behaviors associated with estrus.

Relationships between increased activity, time of ovulation, and fertility have been investigated with the help of activity monitors (López-Gatius et al., 2005; Roelofs et al., 2005; Hockey et al., 2010a). In general, ovulation takes place an average of 29 to 33 h after the onset of increased activity and 17 to 19 h after the end of increased activity in lactating Holstein cows (Roelofs et al., 2005; Hockey et al., 2010a). In previous studies (López-Gatius et al., 2005; Roelofs et al., 2005; Hockey et al., 2010a), predicted time of ovulation was in reasonable agreement with that in the study of Walker et al. (1996), in which ovulation occurred at 27.6 ± 5.4 h (mean ± SD) after the onset of estrus. It seems likely that increased activity was largely correlated with the onset of standing estrus in studies where simultaneous measurements were made.

One of the limitations of activity monitors is knowing when ovulation occurs relative to increased activity. Large-scale studies determining when ovulation occurs, proper timing of ovulation, and subsequent conception risk, and comparisons of this technology with proven timed AI programs are not available. Using a market-available automated activity monitor [Select Detect (**SDet**) accelerometer; Select Sires Inc., Plain City, OH], our objectives were 3-fold: to (1) determine the time of ovulation in lactating dairy cows after achieving an activity threshold, (2) compare within-herd reproductive traits in cows submitted to AI based on either activity monitors or a strict timed AI program, and (3) determine actual conception risk of cows inseminated at various intervals after achieving activity thresholds in multiple herds.

MATERIALS AND METHODS

Experiment 1

Experimental Cows. This experiment was approved by the Kansas State University Institutional Animal Care and Use Committee (Manhattan). Lactating Holstein cows were housed at the Kansas State University Dairy Teaching and Research Center in covered freestalls and fed twice or 3 times (summer) daily a TMR calculated to meet nutrient requirements for lactating dairy cows producing 50 kg of 3.5% milk (NRC, 2001). The diet consisted of alfalfa hay, corn silage, soybean meal, whole cotton seed, corn or milo grain, corn-gluten feed, vitamins, and minerals.

To determine when ovulation occurred relative to achieving an activity threshold (identified by the activity software), cows were enrolled in a study beginning at 50 DIM. Cows were administered i.m. either 25 mg of $PGF_{2\alpha}$ (Lutalyse; Pfizer Animal Health, New York, NY) or 100 μg of GnRH (Factrel; Pfizer Animal Health) that preceded the $PGF_{2\alpha}$ injection by 7 d to induce estrus. Observations of $PGF_{2\alpha}$-induced or spontaneously increased activity were identified before or after first AI. Primiparous and multiparous cows were fitted with neck-collar-mounted automated activity monitors (SDet; Select Sires Inc.). In addition, 66 of the 132 cows also were fitted with rump-mounted, pressure-sensitive transmitters [HeatWatch (**HW**); Cow Chips LLC, Manalapan, NJ]. Combining technologies allowed comparisons of the onset of estrus (first mount received per HW) with onset of the achieved activity threshold as determined by the activity system. The threshold of physical activity detection was set at the factory at 290 and never changed during the entire experiment. Monitors use a microelectronic motion-sensing accelerometer that measures 3-dimensional movement