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Use of rumination and activity monitoring for the identification of dairy cows with health disorders: Part I. Metabolic and digestive disorders

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ABSTRACT

The objectives of this study were to evaluate (1) the performance of an automated health-monitoring system (AHMS) to identify cows with metabolic and digestive disorders—including displaced abomasum, ketosis, and indigestion—based on an alert system (health index score, HIS) that combines rumination time and physical activity; (2) the number of days between the first HIS alert and clinical diagnosis (CD) of the disorders by farm personnel; and (3) the daily rumination time, physical activity, and HIS patterns around CD. Holstein cattle (n = 1,121; 451 nulliparous and 670 multiparous) were fitted with a neck-mounted electronic rumination and activity monitoring tag (HR Tags, SCR Dairy, Netanya, Israel) from at least −21 to 80 d in milk (DIM). Raw data collected in 2-h periods were summarized per 24 h as daily rumination and activity. A HIS (0 to 100 arbitrary units) was calculated daily for individual cows with an algorithm that used rumination and activity. A positive HIS outcome was defined as a HIS of <86 during at least 1 d from −5 to 2 d after CD. Blood concentrations of nonesterified fatty acids, β-hydroxybutyrate, total calcium, and haptoglobin were determined in a subgroup of cows (n = 459) at −11 ± 3, −4 ± 3, 0, 3 ± 1, 7 ± 1, 14 ± 1, and 28 ± 1 DIM. The sensitivity of the HIS was 98% [95% confidence interval (CI): 93, 100] for displaced abomasum (n = 41); 91% (95% CI: 83, 99) for ketosis (n = 54); 89% (95% CI: 68, 100) for indigestion (n = 9); and 93% (95% CI: 89, 98) for all metabolic and digestive disorders combined (n = 104). Days (mean and 95% CI) from the first positive HIS <86 and CD were −3 (−3.7, −2.3), −1.6 (−2.3, −1.0), −0.5 (−1.5, 0.5), and −2.1 (−2.5, −1.6) for displaced abomasum, ketosis, indigestion, and all metabolic and digestive disorders, respectively. The patterns of rumination, activity, and HIS for cows flagged by the AHMS were characterized by lower levels than for cows without a health disorder and cows not flagged by the AHMS from −5 to 5 d after CD, depending on the disorder and parameter. Differences between cows without health disorders and those flagged by the AHMS for blood markers of metabolic and health status confirmed the observations of the CD and AHMS alerts. The overall sensitivity and timing of the AHMS alerts for cows with metabolic and digestive disorders indicated that AHMS that combine rumination and activity could be a useful tool for identifying cows with metabolic and digestive disorders.
Key words: rumination, activity, metabolic disorder, digestive disorder

INTRODUCTION

Health disorders in the early postpartum period affect a substantial proportion of lactating dairy cows, with negative results for their health, welfare, and performance (Ingvartsen, 2006). Metabolic and digestive disorders such as ketosis, displaced abomasum (**DA**), and indigestion are detrimental to cow well-being and farm profitability because they cause losses in milk production (Gröhn et al., 1998; Bareille et al., 2003; Edwards and Tozer, 2004), increase the risk of culling and death (Gröhn et al., 1998; Pinedo et al., 2010; Seifi et al., 2011), increase treatment costs (Kaneene and Hurd, 1990; Bartlett et al., 1995), and impair reproductive performance (Raizman and Santos, 2002; Ribeiro et al., 2013; Vercouteren et al., 2015).

For dairy operations, the burden of metabolic and digestive diseases is exacerbated by the additional effort and costs associated with implementing the monitoring necessary to identify cows with these disorders (McArt et al., 2015). Although the intensity of health-monitoring programs varies widely among farms, protocols that include a systematic evaluation of cow health status once or twice per day within the

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first 1 to 3 wk after calving are common (Risco and Melendez Ratamal, 2011; Espadamala et al., 2015). Such protocols may include evaluation of attitude, appetite, locomotion, and rectal temperature, as well as auscultation, palpation, and collection of bodily fluids for cow-side or laboratory testing (LeBlanc, 2010; Risco and Melendez Ratamal, 2011). Performing these evaluations and diagnostic tests for a large number of cows can be time-consuming and labor-intensive. Moreover, cow behavior and time budgets are disrupted, because in free-stall herds, cows are examined while restrained in self-locking head gates or in palpation rails after they have been sorted from their herd mates. In this regard, automated monitoring of cow behavior and physiological parameters using non-invasive sensors may help reduce the burden of health-monitoring programs. Sensor-generated data could be used alone or with traditional health-monitoring protocols to identify cows with health disorders (Rutten et al., 2013; Lukas et al., 2015). Furthermore, continuous monitoring of behavior and physiological parameters may allow for the detection of subtle changes before evident clinical signs appear. Earlier disease detection may benefit cows by preventing progression and improving response to treatment.

In recent years, multiple devices have been developed and implemented by the dairy industry to automatically monitor behavior and physiological parameters (Rutten et al., 2013; Ferrero et al., 2014; Barkema et al., 2015). Physical activity levels and rumination time are 2 parameters that are currently available for monitoring cow health. Cows with health disorders would be expected to demonstrate alterations in their activity and rumination patterns of sufficient magnitude to be detected by specific algorithms or visual inspection of data. Indeed, previous studies have found that rumination time and activity were associated with clinical and subclinical health disorders (Soriani et al., 2012; Gaspardy et al., 2014; Liboreiro et al., 2015). These studies have documented general trends and changes in rumination and activity patterns for some disorders, but the performance of automated health-monitoring systems (**AHMS**) that use rumination and activity to detect cows with metabolic and digestive disorders has not been well documented. In addition, more information is needed about the patterns of rumination and activity around the timing of clinical diagnosis (**CD**) of metabolic and digestive disorders in dairy cows.

We hypothesized that an AHMS that continuously monitors rumination and activity would be able to identify cows with metabolic and digestive disorders. Also, we expected that changes in rumination and activity before evident clinical signs of disease would result in earlier identification of disease. The objectives of this study were to evaluate (1) the performance of an automated rumination and physical activity monitoring system to identify cows with metabolic and digestive disorders; (2) the interval between the AHMS alert based on a health index score (**HIS**) and the day of CD by farm personnel; and (3) the rumination, activity, and AHMS-generated alert pattern for cows with the disorders of interest. We also used markers of energy status [nonesterified fatty acids (**NEFA**) and BHB], mineral status (total plasma Ca), and systemic inflammation (haptoglobin) to complement the diagnosis of health disorders and the performance of the AHMS alert.

MATERIALS AND METHODS

Animals and Management

All procedures were approved by the Institutional Animal Care and Use Committee of Cornell University. This study was conducted from November 2013 to October 2014 at a commercial dairy operation in Cayuga County, New York State. Holstein cows (n = 1,121; 451 nulliparous and 670 multiparous) were enrolled in the study at approximately 240 to 250 d of gestation. During the prepartum period, cows were grouped by parity (nulliparous vs. parous) and housed in a freestall barn with pens that had 3 rows of stalls. Cows were monitored for signs of calving every 45 min by farm personnel. At the first signs of calving (visualization of the allantoic sac through the vulva, restlessness, discomfort), cows were moved to a loose housing pen to evaluate and assist calving, or both. Immediately after calving, cows were moved to another loose housing pen with straw bedding for 1 d. Thereafter, cows were moved to a postpartum pen if farm personnel considered them healthy. Primiparous and multiparous cows were commingled in the postpartum pen for about the first 30 DIM. Thereafter, cows were moved to pens based on lactation number (first, second, third and fourth or more) for the rest of their lactation. Cows with health disorders that were treated with antibiotics and required milk withdrawal were placed in a separate pen, and their milk was discarded until it was saleable.

Cows were milked 3 times per day, and individual milk yield and conductivity were recorded at each milking (Afimilk, Kibbutz Afikim, Israel). The projected 305-d milk production for cows that calved during the study period was 13,036 kg. Cows had ad libitum access to feed and water and were fed a TMR once daily. A detailed description of the diets fed during the study is presented in Table 1.