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Use of rumination and activity monitoring for the identification of dairy cows with health disorders: Part II. Mastitis

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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 mastitis 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 mastitis by farm personnel; and (3) the daily rumination time, physical activity, and HIS patterns around CD. Holstein cows (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. An 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 an HIS of <86 units 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 also 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 58% [95% confidence interval (CI): 49, 67] for all cases of clinical mastitis (n = 123), and 55% (95% CI: 46, 64; n = 114) and 89% (95% CI: 68, 100; n = 9) for cases of mastitis alone or concurrent with other health disorders, respectively. Among clinical cases, sensitivity was 80.7% (95% CI: 67, 97) for cases caused by *Escherichia coli* (n = 31) and ranged from 45 to 48% for cases caused by gram-positive bacteria (n = 39; *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, *Streptococcus* spp., *Staphylococcus* spp., and *Trueperella pyogenes*), *Staphylococcus aureus* (n = 11), or cases with no bacterial growth (n = 25). Days between the first HIS <86 and CD were −0.6 (95% CI: −1.1, −0.2) for all cases of mastitis. Cows diagnosed with mastitis had alterations of their rumination, activity, HIS patterns, and reduced milk production around CD depending on the type of mastitis case. Cows with mastitis also had some alterations of their calcium and haptoglobin concentrations around calving. The AHMS used in this study was effective for identifying cows with clinical cases of mastitis caused by *E. coli* and cows with another disease occurring during an event of mastitis, but it was less effective in identifying cows with mastitis not caused by *E. coli*.
Key words: rumination, activity, mastitis, dairy cow

INTRODUCTION

Early postpartum health disorders negatively affect cow well-being and are associated with significant economic losses for dairy farms because of alterations to cow health, welfare, and performance (Bareille et al., 2003; Ingvartsen, 2006; Hailemariam et al., 2014). Clinical mastitis is one of the most prevalent disorders affecting cow health and performance (Kaneene and Hurd, 1990; Ingvartsen et al., 2003; Østerås et al., 2007). Mastitis leads to major milk losses (Gröhn et al., 2004; Bar et al., 2007; Schukken et al., 2009) and reduces reproductive performance (Santos et al., 2004; Ahmadzadeh et al., 2009; Hertl et al., 2010); some types of mastitis may severely compromise cow health, leading to increased culling or death (Gröhn et al., 2005; Whist et al., 2009; Hertl et al., 2011).

To detect cows with clinical mastitis, health-monitoring programs include the evaluation of milk characteristics, signs of udder inflammation, and systemic signs of illness (Nash et al., 2002; Wenz et al., 2006). Cases of mastitis caused by certain pathogens such as *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, and *Streptococcus uberis* are more commonly associated with mild changes in milk and udder inflammation (Todhunter et al., 1995; Keefe, 1997; Schukken et al., 2011); cases of mastitis caused by pathogens such as

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Escherichia coli and other gram-negative bacteria are characterized by a severe inflammatory response and systemic compromise (Harmon, 1994; Burvenich et al., 2007; Schukken et al., 2011). Thus, the severity of mastitis may range from mild changes in milk appearance to an important systemic compromise (Sargeant et al., 1998; Bradley and Green, 2001; Nikolić et al., 2003).

Multiple automated data collection systems based on sensors (e.g., daily milk weights, milk composition, electrical conductivity, somatic cell counts) have been tested and are available to detect mastitis through changes in milk production and its attributes (Kamphuis et al., 2008; Koop et al., 2015; Sørensen et al., 2016). Conversely, data about the use of automated rumination time and physical activity monitoring systems to detect cows with mastitis are scarce, because only a few studies have evaluated rumination time in cows with induced clinical mastitis or challenged with LPS (Siivonen et al., 2011; Fogsgaard et al., 2012; Fitzpatrick et al., 2013), and no studies have assessed a combination of both rumination and activity data to identify cows with mastitis. Beyond the potential of using rumination and activity monitoring alone or to complement other methods of mastitis detection, these 2 parameters may provide additional insights into overall cow health that are not provided by other sensor systems that monitor only milk or by clinical examination of cows and milk.

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

MATERIALS AND METHODS

Animals and Study Design

All procedures were approved by the Institutional Animal Care and Use Committee of Cornell University. The study followed an observational prospective cohort design. Details about the animals and study design are provided in a companion manuscript (Stangaferro et al., 2016). Briefly, Holstein cows (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) to monitor rumination and activity from at least 21 d before expected calving until at least 80 d after calving. Of 1,121 cows enrolled in the study, 41 (3.7%) were removed from the data set due to tag malfunction or misplacement during data collection. Thus, 1,080 cows were included in the final data set for analysis. Based on rumination and activity data, an HIS (0 to 100 arbitrary units) for each cow was generated by the system software (DataFlow, Netanya, Israel) using a series of internal algorithms (proprietary to SCR Dairy). An HIS of 100 arbitrary units represents a cow with an ideal pattern of rumination and activity; an HIS value <86 arbitrary units may be indicative of a health disorder. An HIS report was generated daily to include cows with <86 arbitrary units (as determined by SCR) and stored for evaluation by the research group. During the study, farm personnel did not have access to the HIS report or any information generated by the AHMS.

Fresh Cow Monitoring Program and Case Definitions

The fresh cow health-monitoring program and definition of each particular health disorder are provided in detail in a companion manuscript (Stangaferro et al., 2016). In particular, clinical mastitis was defined as swelling or pain in the udder, or milk with abnormal appearance (milk was stripped onto the floor and observed for flakes or clots). Signs of udder inflammation may or may not have been accompanied by depressed attitude, anorexia, and fever. Mastitis monitoring was conducted during milking and during health monitoring of fresh cows. Milk culture was performed on all cows at the beginning of lactation (first milking) and on the day of mastitis diagnosis. Milk samples for pathogen detection were collected aseptically and shipped daily to the Quality Milk Production Services Laboratory at Cornell University (Ithaca, NY). Results were provided to the farm within 24 h of sample retrieval. Culture outcomes were grouped as follows: (1) *E. coli*; (2) *Klebsiella* spp.; (3) gram-positive bacteria (*Strep. agalactiae*, *Strep. dysgalactiae*, *Strep. uberis*, *Streptococcus* spp., *Staphylococcus* spp., *Trueperella pyogenes*); (4) *Staphylococcus aureus*; and (5) no important growth after 48 h. Two consecutives episodes of mastitis were considered separate episodes if they occurred at least 7 d apart or in a different quarter.