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Deviations in behavior and productivity data before diagnosis of health disorders in cows milked with an automated system

M. T. M. King,* K. M. Dancy,* S. J. LeBlanc,† E. A. Pajor,‡ and T. J. DeVries*[1]
*Department of Animal Biosciences, and
†Department of Population Medicine, University of Guelph, Guelph, Ontario, N1G 2W1, Canada
‡Faculty of Veterinary Medicine, University of Calgary, Calgary, Alberta, T2N 1N4, Canada

ABSTRACT

To explore potential changes in behavior and productivity useful for early detection of health disorders in cows milked with automated milking systems (AMS), we collected longitudinal data throughout lactation of 57 dairy cows housed in a freestall barn with an AMS. Health problems were recorded, including subclinical ketosis (SCK; n = 19), metritis (n = 11), hoof disorders (n = 14), pneumonia (n = 7), and displaced abomasum (DA; n = 5). Data on rumination, activity, milking frequency and yield, and lying behavior were recorded electronically. Using repeated-measures mixed linear regression models, these data were analyzed for the days before the day of diagnosis/treatment (d 0) for each disorder separately, controlling for days in milk and parity. Analyses were performed between the day on which each outcome variable deviated significantly from baseline (up to d −14) and the day before diagnosis (nadir at d −1, before treatment and recovery). Outcomes tested were 3-d rolling averages of milk yield, milking frequency, and AMS supplement intake, in addition to daily rumination time (DRT), body weight, milk temperature, activity (measure of head/neck motion), and 3 lying behavior variables. From d −8, −6, and −5 before diagnosis of DA, SCK, or pneumonia, respectively, DRT declined by 45, 25, and 50 min/d. From d −14 to −1 before diagnosis of hoof disorders, DRT declined by 3 min/d. Body weight declined from d −4 before pneumonia (−14 kg/d) and metritis (−13 kg/d), from d −6 before SCK (−10 kg/d), and from d −5 before hoof disorders (−5 kg/d). Milk yield declined by 4.4 and 4.1 kg/d from d −4 before DA and pneumonia diagnoses, respectively, and by 1.2 kg/d from d −5 before SCK diagnosis. Activity levels declined before diagnosis of DA, pneumonia, SCK, or metritis. Lying behavior changed before diagnosis of DA, pneumonia, or metritis. Our results provide evidence that rumination behavior often deviated before milk yield and that several variables could contribute to earlier or automated identification of disorders. Behavior and productivity changed differently in association with various health disorders, suggesting the potential to distinguish among health problems. These variables merit further investigation in larger studies of cows milked with AMS.
Key words: robotic milking, behavior, productivity, health disorder, detection

INTRODUCTION

Automated milking and behavior monitoring systems are gaining popularity worldwide. To improve the welfare and productivity of both dairy cows and producers, these technologies must be thoroughly tested and validated before being relied upon. Automated milking systems (**AMS**) record a vast amount of data and are often coupled with electronic monitors of behavior, including rumination and general cow activity. Many alerts and reports (i.e., attention lists) are generated using these data, either helping producers or, in other cases, overwhelming them with partially reliable or actionable information. Health alerts often flag cows showing deviations in their milk yield, rumination time, and other variables, but it is imperative that these reports be precise, efficient, and validated. Although many AMS attention lists are supported by research, others remain untested or are undisclosed under patents or commercial property. Therefore, users must combine field experience with science-based recommendations to generate illness attention reports and to select settings for each farm.

The negative implications of lameness for cow welfare and productivity in AMS have been well documented (e.g., Bach et al., 2007; Deming et al., 2013; King et al., 2016), but fewer data are available to describe changes in behavior and productivity that precede other health disorders in AMS. Furthermore, little work has evaluated the use of behavior and productivity monitoring for early detection of health issues in AMS specifically.

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[1]Corresponding author: tdevries@uoguelph.ca

Research in conventional milking systems has identified associations of biological and behavioral changes leading up to, and in response to, mastitis (Fogsgaard et al., 2012), milk fever (Liboreiro et al., 2015), metritis (Huzzey et al., 2007; Gáspárdy et al., 2014; Liboreiro et al., 2015; Schirmann et al., 2016), retained placenta (Liboreiro et al., 2015), subclinical ketosis (Goldhawk et al., 2009; Gáspárdy et al., 2014; Liboreiro et al., 2015; Kaufman et al., 2016a,b; Schirmann et al., 2016), clinical ketosis (Gröhn et al., 1999; Itle et al., 2015), and lameness (Bicalho et al., 2008). Additionally, lameness detection models for conventional systems have included milk yield, as well as daily patterns of rumination behavior and a commercial measure of activity in the days leading up to diagnosis (Van Hertem et al., 2013). Patterns of data for cow activity and a commercial index of milking performance were also used to predict lameness in AMS (Garcia et al., 2014). Most recently, Stangaferro et al. (2016a,b,c) evaluated an alert system using a health index score that comprised rumination and activity in a conventional milking system. Those authors assessed alerts for various types of illness and reported that the models for displaced abomasum, ketosis, and indigestion had the greatest specificity, sensitivity, and accuracy, whereas performance of alerts for mastitis and metritis depended on the cause and severity of cases. No study has yet described the changes in these measures preceding different types of health disorders in AMS, nor has any study evaluated the use of lying behavior to detect lameness or hoof disorders in AMS.

Therefore, the objective of this explorative, pilot study was to examine potential changes in productivity and behavior associated with, and preceding, various types of naturally occurring health disorders in a herd of cows milked with an automated system. Outcome variables tested were daily milking frequency, milk yield, AMS supplement intake, BW, daily rumination time (**DRT**), activity (a unitless measure of head/neck motion), and lying behavior (lying time, bout frequency, and bout duration). We hypothesized that these variables would begin to deviate 1 to 3 d before diagnosis and that the response could vary based on the type of disorder; in contrast, the null hypothesis was that such variables would not deviate before diagnosis and, therefore, not aid in detection.

MATERIALS AND METHODS

Animals, Facilities, and Management

At the University of Guelph, Kemptville Campus Dairy Education and Innovation Center (Kemptville, ON, Canada), we monitored 57 Holstein dairy cows (19 primiparous, 15 in their second lactation, and 23 in their third to sixth lactation). Cows were managed according to the standard operating procedures for this facility, which included limiting the number of cows in the facility to no more than the number of lying stalls. The use of cows and experimental procedures complied with the guidelines of the Canadian Council on Animal Care (CCAC, 2009) and were approved by the University of Guelph Animal Care Committee (AUP#2709). All cows in the research herd (maximum 52 lactating cows at any one time) were sampled to provide data for all lactating animals present at the facility. Exclusion criteria were that cows must not be enrolled in any other trial and, therefore, were managed only according to protocols for the milking herd. If a cow was enrolled in another research trial, any data past that point were removed.

At least 1 wk before their expected calving date, cows were housed in straw-bedded box stalls (3 isolation stalls approximately 15 m^2 each) with outdoor access and enrolled in the study. Within 24 h after calving, cows were moved to the main herd, provided that no severe health complications had developed during that time. The milking herd was housed in a freestall facility with free cow traffic to a single AMS unit (Lely Astronaut A3 Next, Lely Industries N.V., Maassluis, the Netherlands). Barn staff fetched cows 2 times per day to ensure that cows did not go without milking for >10 to 12 h since their last AMS visit. The facility had 52 freestalls with water mattress bases (DCC Waterbeds, Advanced Comfort Technology Inc., Reedsburg, WI), arranged in 2 head-to-head rows. Lying stalls had a mean bed length of 2.74 m and measured 1.16 m wide, center to center, with the neck rail positioned 1.27 m above the stall bedding surface and 1.81 m from the rear curb. The mean distance from the brisket board to the back of the stall was 1.94 m and the curb height was 0.20 m. Freestalls were bedded with wooden shavings once per week and raked twice daily. Cows had access to 2 water troughs (180 × 35 cm), one at each end of the pen. All flooring was made of scarified concrete, including the alley near lying stalls, the feed alley, and crossover alleys. Alley floors were cleaned using a cable-driven automated scraping system (GEA Houle Inc., Drummondville, QC, Canada), which removed manure 12 times per day.

Cows were fed a partial mixed ration containing, on a DM basis, 15% high-moisture corn, 31% corn silage, 41% haylage, and 13% protein concentrate. Feed was mixed once per day in a TMR mixer wagon (Jaylor 4425, Jaylor Fabricating, East Garafraxa, ON, Canada) and delivered once per day at approximately 1030 h. At least one headlock with feedbunk access was available for each cow at any time (a total of 55 headlocks