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Associations between lying behavior and lameness in Canadian Holstein-Friesian cows housed in freestall barns

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ABSTRACT

Lying behavior is an important measure of comfort and well-being in dairy cattle, and changes in lying behavior are potential indicators and predictors of lameness. Our objectives were to determine individual and herd-level risk factors associated with measures of lying behavior, and to evaluate whether automated measures of lying behavior can be used to detect lameness. A purposive sample of 40 Holstein cows was selected from each of 141 dairy farms in Alberta, Ontario, and Québec. Lying behavior of 5,135 cows between 10 and 120 d in milk was automatically and continuously recorded using accelerometers over 4 d. Data on factors hypothesized to influence lying behavior were collected, including information on individual cows, management practices, and facility design. Associations between predictor variables and measures of lying behavior were assessed using generalized linear mixed models, including farm and province as random and fixed effects, respectively. Logistic regression models were used to determine whether lying behavior was associated with lameness. At the cow-level, daily lying time increased with increasing days in milk, but this effect interacted with parity; primiparous cows had more frequent but shorter lying bouts in early lactation, changing to mature-cow patterns of lying behavior (fewer and longer lying bouts) in late lactation. In barns with stall curbs >22 cm high, the use of sand or >2 cm of bedding was associated with an increased average daily lying time of 1.44 and 0.06 h/d, respectively. Feed alleys ≥350 cm wide or stalls ≥114 cm wide were associated with increased daily lying time of 0.39 and 0.33 h/d, respectively, whereas rubber flooring in the feed alley was associated with 0.47 h/d lower average lying time. Lame cows had longer lying times, with fewer, longer, and more variable duration of bouts compared with nonlame cows. In that regard, cows with lying time ≥14 h/d, ≤5 lying bouts per day, bout duration ≥110 min/bout, or standard deviations of bout duration over 4 d ≥70 min had 3.7, 1.7, 2.5, and 3.0 higher odds of being lame, respectively. Factors related to comfort of lying and standing surfaces significantly affected lying behavior. Finally, we inferred that automated measures of lying behavior could contribute to lameness detection, especially when interpreted in the context of other factors known to affect lying behavior, including those associated with the individual cow (e.g., parity and stage of lactation) or environment (e.g., stall surface).
Key words: lying time, automated measures, lameness detection, dairy cattle, welfare

INTRODUCTION

Adequate rest has been positively associated with productivity, health, and welfare of dairy cattle. When access to stalls is restricted, cows prioritize lying down over feeding (Munksgaard et al., 2005), and preventing cows from lying down induces stress (Cooper et al., 2008). As a consequence, measures of lying behavior, such as the daily duration and the frequency and duration of lying bouts, is a measure of cow comfort (Haley et al., 2001; Rushen et al., 2008). Furthermore, changes in lying behavior can be associated with pain and malaise, enabling the use of lying behavior not only as an indicator of present illness, but also as a tool to predict cattle at risk of becoming ill (Weary et al., 2009). These findings contributed to development of automated systems to measure lying time that are less time-consuming than live or video-based observations and that provide a useful measure of health, welfare, and comfort (Rushen et al., 2008; Bewley et al., 2010).

In freestall systems, lactating cows commonly lie down for approximately 11 h/d (Bewley et al., 2010; von Keyserlingk et al., 2012). However, lying duration

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varies considerably among dairy systems, with the shortest duration often in pasture systems (6.7 h/d; Botheras, 2006; 8 h/d; Sepúlveda-Varas et al., 2014) and the longest usually in tiestalls (12.5 h/d; Charlton et al., 2015). Typically, cows have 6 to 13 lying bouts daily, averaging 55 to 90 min each (EFSA, 2009). However, lying behavior is influenced by several factors, including housing system (Hernandez-Mendo et al., 2007; von Keyserlingk et al., 2012), stall dimensions (Tucker et al., 2004), stall surface (Cook et al., 2008), stocking density (Fregonesi et al., 2007), flooring (Haley et al., 2001), parity, stage of lactation (Vasseur et al., 2012), lameness (Ito et al., 2010; Thomsen et al., 2012), and heat stress (Cook et al., 2007). Understanding dynamics of lying behavior provides insight into how cows interact with their environment and what management practices may modify this behavior (Rushen et al., 2008).

Diseased animals often exhibit abnormal or reduced activity; therefore, changes in lying behavior have been used in dairy cattle as potential indicators and predictors of health issues, including dystocia (Proudfoot et al., 2009), postpartum disorders (i.e., metritis and retained placenta; Sepúlveda-Varas et al., 2014), and lameness (Ito et al., 2010; Blackie et al., 2011; Alsaaod et al., 2012). The latter is one of the most important welfare and productivity problems in the dairy industry. That it causes pain (Rushen et al., 2007) and reduces both milk yield (Green et al., 2002) and reproductive performance (Hernandez et al., 2001) makes it extremely costly (Ettema and Ostergaard, 2006). Early recognition and treatment of lameness is fundamental to mitigate its negative effects. Therefore, changes in measures of lying behavior have been identified as a potential behavioral indicator of lameness, based on differences in lying responses of lame and nonlame cows (Ito et al., 2010). However, changes in lying time can be both a risk factor for and a consequence of lameness, as lameness can be preceded by reduced duration of lying, and once clinically lame, cows tend to have longer lying bouts and longer total lying time per day (Chapinal et al., 2009; Ito et al., 2010). Reports on lame cows' lying behavior vary among studies. For example, some authors reported that the length and variability of lying bouts were greater in lame cows compared with nonlame cows (Chapinal et al., 2009; Ito et al., 2010), whereas others reported no difference in bout duration between lame and nonlame cows (Gomez and Cook, 2010). Furthermore, there were interactions of certain stall design features (e.g., stall surface) with the severity of lameness, relative to lying behavior (Cook et al., 2008). Hence, it is expected that lying behavior and its association with lameness are related to housing conditions, as well as management and cow factors.

Lameness detection is a challenge for dairy producers; therefore, its prevalence is often underestimated (Espejo et al., 2006). Automated detection systems based on changes in lying behavior could alert the farmer of the onset of lameness or a high probability of the presence of lameness and would be of great benefit to farm productivity and cow well-being (de Mol et al., 2013). Although lying behavior has potential as an indicator of lameness, automated technologies that provide real-time lameness detection based on changes in lying behavior have not proven to be highly accurate (Alsaaod et al., 2012; de Mol et al., 2013). Unfortunately, most research on lying behavior has been conducted with limited sample sizes, on experimental dairy farms, or focused on limited individual (e.g., DIM, parity) or management factors (e.g., stall surface; Bewley et al., 2010; Gomez and Cook, 2010; Ito et al., 2010). Therefore, the objectives of our study were to determine (1) individual and herd-level risk factors associated with measures of lying behavior and (2) associations between lying behavior and lameness; doing so allowed us to determine whether measures of lying behavior can be used to detect lameness.

MATERIALS AND METHODS

Farms

A total of 141 Canadian freestall dairy farms were enrolled as part of a larger study characterizing dairy cow comfort and longevity (Charlton et al., 2014; Vasseur et al., 2015). Farms were located in 3 Canadian provinces: Alberta [(**AB**); n = 81], Ontario [(**ON**); n = 40], and Québec [(**QC**); n = 20]. Data were collected between May 2011 and July 2012 by 6 trained graduate students and research assistants. Three of the observers were from the University of Calgary (Calgary, AB, Canada), 2 from University of Guelph (Guelph, ON, Canada), and 1 from Université Laval (Québec City, QC, Canada). All methods were approved by the Animal Care Committees and Research Ethics Boards of each participating academic institution.

The farm selection process has been described in detail (Zaffino Heyerhoff et al., 2014; Solano et al., 2015). In short, eligible farmers from all 3 provinces were recruited via mail and participation was voluntary. In AB, farms already enrolled in a collaborative study, the Alberta Dairy Hoof Health Project (Alberta Milk, 2013), were invited to participate (n = 158). The subpopulation of farms enrolled in the Alberta Dairy Hoof Health Project was representative of the average AB dairy farm in terms of herd size, breed, type of dairy barn, and longevity (Zaffino Heyerhoff et al., 2014). In ON and QC, farms invited to participate were selected