Automated Methods for the Detection of Lameness and Analgesia

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Lameness in dairy cows is a painful condition that decreases productivity and animal well-being. Lameness reduces the number of visits cows make in an automated milking system but this measure lacks specificity (Borderas et al., 2008). Lame cows change the way they distribute their weight between their four legs when standing (Pastell and Kujala, 2007), and spend more time lying down (Chapinal et al 2009b). These behavioral changes can be monitored automatically. Cows with a hoof injury and treated with the local anesthetic lidocaine showed only a moderate improvement in gait but clearly increased the proportion of weight applied to the injured leg and decreased weight shifting between the injured leg and its contralateral leg (Rushen et al., 2007). Subjective gait scoring may not be sensitive enough to detect the effects of analgesic drugs such as NSAIDs (Whay et al., 2005); a combination of measures of lameness, such as measures of weight distribution or activity may be necessary to detect the effect of analgesic drugs. The objective of this study was to assess gait and automated measures of weight distribution among the legs and of daily activity as methods for a) detecting lameness in dairy cows, and b) measuring pain mitigation by NSAIDs.

Materials and Methods

We selected 57 multiparous lactating Holstein cows (mean ± SD; parity = 3.7 ± 1.8; BW = 719 ± 63 kg; DIM= 196 ± 98; 305-d milk production = 12230 ± 1457 kg) housed in sand bedded free-stalls (2.4 m long x 1.18 m wide x 0.40 m deep, at least 1 stall per cow) in groups of 24 to 48 cows per pen. Each animal was randomly assigned to either ketoprofen (Anafen, Merial Canada Inc, Montreal, Canada) or sterile isotonic saline treatment, such that treatment groups were balanced according to initial gait score, BW, parity and DIM. On 2 consecutive days, cows were injected intramuscularly in the neck with a dose of 3.0 mg/kg BW of ketoprofen or the equivalent volume of saline solution. On the day prior to ketoprofen treatment, on the 2 days of treatment (2 h after the injection), and on the day after treatment, cows were gait scored and their walking speed measured as described in Chapinal et al (2009b) and measures of how the cows distributed their weight between their legs while standing on a weighing platform were collected as described in Chapinal et al. (2009a). Lying behavior and steps were continuously monitored with accelerometers (Ice Tag TM , Icerobotics, Edinburgh, UK) over 10 days, starting 3 days before the injections. All statistical analyses were performed by using the MIXED and LOGISTIC procedures in SAS (version 9.1; SAS Institute, 2003), considering the cow as the experimental unit. Receiver operating characteristics (ROC) curves were plotted and the area under the curve (AUC) was used to compare the accuracy of the different models in discriminating lame cows.

Results

Compared to cows that were not lame, lame cows shifted weight between contralateral legs more often (SD of the weight applied to the rear legs: 31.1 ± 2.1 vs. 24.5 ± 1.9 kg; P = 0.02; SD of the weight applied to the front legs: 19.5 ± 1.2 vs. 16.1 ± 1.1 kg; P = 0.05), had a greater asymmetry

in the weight applied to the rear legs (leg weight ratio = 0.78 ± 0.02 vs. 0.87 ± 0.02; P = 0.003), had longer lying bouts (94.0 ± 4.9 vs. 78.2 ± 5.8 mins; P = 0.03), tended to spend more time lying down and walked more slowly (1.28 ± 0.3 m/s vs. 1.42 ± 0.3 m/s; P = 0.004). Variability over time (SD) of the weight applied to the rear legs was the most accurate predictor of whether a cow was lame or not (AUC = 0.71). The AUC increased to 0.76 after adding the average duration of the lying bout, and to 0.83 after adding both the average duration of lying bout and the walking speed The SD of the weight applied to the rear legs decreased on the days when ketoprofen was given compared to the day before and after (18% and 12% decrease for lame and non-lame cows, respectively; P < 0.001).Ketoprofen did not affect any other measure (P > 0.10).

Discussion

Measures of weight distribution show promise as an automated method to detect lameness on farm, especially in association with measures of activity and walking speed. We found a greater SD of weight applied to the rear legs in lame cows, supporting previous studies (Pastell and Kujala, 2007; Rushen et al., 2007), and this measure was the most accurate in identifying lame cows. This measure shows the variability in weight applied to a leg over time, and indicates the amount of weight shifting that occurs. We also found a lower leg weight ratio in the rear legs in lame cows, in agreement with Pastell and Kujala (2007). This measure is an indicator of asymmetry within each pair of legs. Lame cows are reluctant to bear weight on the afflicted leg and therefore, they favor the contralateral leg. We also found a moderate effect of ketoprofen on the SD of the rear legs, that is, ketoprofen decreased weight shifting between the rear legs in agreement with what Rushen et al. (2007) found following injections of local anesthetic (lidocaine). The effect we found was milder, probably because cows were not as lame as in Rushen et al (2007) and because lidocaine blocks the nerve and therefore, it had a more specific and localized effect on the lesion identified as the cause of pain.

Lame cows walked more slowly, tended to spend more time lying down daily and had longer lying bouts, in agreement with other studies (Chapinal et al., 2009a,b) but the duration of the lying bouts was a better predictor than daily lying time. The measures of activity, however, failed to show an analgesic effect of ketoprofen. However, activity measures can be remarkably affected by farm routines that, by causing an increase of variability within cow, might mask any potential small effect of a given treatment. With herds becoming larger and technology more available, a combination of automated methods of lameness detection could become a practical solution for on-farm lameness detection and for the monitoring of treatment effectiveness and recovery. We found that a combination of weight distribution, lying time and walking speed was the best at predicting lameness.

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