J. Dairy Sci. 93:954–960
doi:10.3168/jds.2009-2385

Measures of weight distribution of dairy cows to detect lameness and the presence of hoof lesions

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ABSTRACT

There is increasing interest in automated methods of detecting lame cows. Hoof lesion data and measures of weight distribution from 61 lactating cows were examined in this study. Lame cows were identified with different numerical rating scores (NRS) used as thresholds (NRS >3 and NRS ≥3.5) for lameness. The ratio of weight applied to a pair of legs (LWR) when the cow was standing was calculated using a special weigh scale, and the cows were gait scored using a 1 to 5 NRS. Hoof lesions were scored and the cows placed into 1 of 4 mutually exclusive categories of hoof lesion: a) no lesions, b) moderate or severe hemorrhages, c) digital dermatitis, and d) sole ulcers. Regression analysis and receiver operating characteristic (ROC) curves were used to analyze the relation between hoof lesions and LWR. A clear relationship was found between NRS and LWR for the cows with sole ulcers ($R^2 = 0.79$). The LWR could differentiate cows with sole ulcers from sound cows with no hoof lesions [area under the curve (AUC) = 0.87] and lame cows from nonlame cows with lameness thresholds NRS >3 (AUC = 0.71) and NRS ≥3.5 (AUC = 0.88). There was no relationship between LWR and NRS for cows with digital dermatitis. Measurement of how cows distribute their weight when standing holds promise as a method of automated detection of lameness.
Key words: dairy cattle, lameness, automated detection, hoof lesion

INTRODUCTION

Although lameness is one of the most costly health and welfare problems affecting dairy cows, surveys show that dairy producers consistently underestimate the number of lame cows on their farms (Whay et al., 2003; Espejo et al., 2006), which emphasizes the need for better methods of detecting lameness on farms. The increasing size of dairy farms results in reduced time available for producers to observe their cows, so automated methods of detecting lameness are being developed. Measure of cow visits to automated milking systems (Borderas et al., 2008) and of ground reaction force when cows are walking (Rajkondawar et al., 2006) can help detect lameness, but these measures suffer from low specificity or sensitivity (Bicalho et al., 2007).

Lame cows reduce the weight they place on the lame leg when standing, and measures of how cows distribute their weight between their legs have been used to identify lame cows (Pastell et al., 2006; Rushen et al., 2007). Repeated measures of weight distribution of individual cows accumulated over a long period of time showed high specificity and sensitivity in identifying lame cows being milked in an automated milking system (Pastell and Kujala, 2007). But, there have been only small scale studies of the ability of such measures to distinguish between lame and healthy cows using measures taken during a short period of time (Rushen et al., 2007), as might occur when new animals enter the herd or when lameness prevalence is being estimated in an animal welfare audit, for instance. Further application of this method of lameness detection requires that the method be tested on a wider number of farms.

The objective was to examine the ability of measures of weight distribution, taken over a short period of time, to identify lame cows and cows suffering from a variety of hoof lesions

MATERIALS AND METHODS

Animals and Housing

Lactating Holstein cows were housed in groups of 12 to 48 cows with at least 1 sand-bedded freestall (2.4 m long × 1.18 m wide × 0.40 m deep) per cow at the University of British Columbia's Dairy Education and Research Centre (Agassiz, Canada). Cows were supplied with fresh TMR twice daily at 0700 and 1600 h formulated to meet requirements for lactating dairy

Received May 15, 2009.
Accepted November 23, 2009.
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cows (NRC, 2001). Water was freely available from self-filling troughs. Lactating cows were milked twice daily at approximately 0800 and 1700 h. From the herd of 220 lactating cows, 68 lactating cows (mean ± SD: parity = 2.6 ± 1.7, range: 1 to 9; BW = 672 ± 82 kg; DIM = 181 ± 65; daily milk production = 35.1 ± 7.1 kg) were randomly selected from an unsorted list of cow numbers supplied by the barn manager.

Weighing Platform

The cows stood on a platform (Neveux et al., 2006; Chapinal et al., 2009a) situated at the end of a passageway that was used for gait scoring (described below) to measure how cows distributed their weight between their legs. The cows stood individually on the platform for 3 min during each measurement for a total of 1 to 4 measurements. All measurements were taken within a period of 3 to 7 d. Cows were familiarized with the platform by making them stand on it 4 times/d for at least 4 d before they were recorded. The platform contained 4 independent recording units (each 56 × 91 cm) fitted in a 1.9- × 1.3-m enclosure. The weight placed on each leg was recorded at a rate of 6 Hz. The platform was calibrated periodically during the experiments using dead-weight calibration with standard weights.

Gait Score

Immediately after the morning milking, the cows were videotaped while walking down the 13-m long by 1.3-m wide nongrooved concrete passageway that led to the weighing platform. A handler walked immediately behind the cows encouraging them when necessary to walk in a consistent manner. Cows were habituated to the procedure by being repeatedly walked down the passageway for at least 4 d (4 passages/d) before gait scoring. Each cow was videotaped during each passage at normal speed from her right side with a color digital camera (30 frames/s, Sony DCRSR100 HDD Handycam Camcorder, Sony Corp., Park Ridge, NJ) placed 8 m from the cow to allow recording of at least 4 complete strides during each passage. These video recordings were used to gait score the cows. A second video camera (Panasonic CCTV WV-BP310, Matsushita Electric, Mississauga, Ontario, Canada) connected to a time-lapse videocassette recorder (Panasonic Time-Lapse VCR, AG-6740, at normal speed in 2-h mode, 25 frames/s) was mounted 2.7 m above the floor and pointed toward the posterior of the cow, which enabled scoring of the abduction/adduction of the rear legs. An experienced observer watched the videos and evaluated 7 specific gait attributes (abduction/adduction of the rear legs, back arch, head bob, tracking-up, joint flexion, asymmetric gait, and reluctance to bear weight) as described in Flower and Weary (2006) and Chapinal et al. (2009b). Individual overall gait score was assessed by using a 1 to 5 numerical rating score system (**NRS**; where 1 = perfect gait and 5 = severely lame) based on the 7 specific gait attributes. If a cow exceeded the requirements of a particular score, a half-integer score was allocated. The gait scoring was done without knowledge of the hoof quality scores and vice versa.

Clinical Examination of the Hooves

Between 1 and 6 d after completion of the measurements of weight distribution and gait scoring, the soles of the hooves were pared minimally by a trained hoof trimmer to expose a clean surface and examined for the presence of various hoof lesions. An experienced observer examined the front and rear hooves of the cows and recorded the presence and severity of hemorrhages, sole ulcers, and digital dermatitis. Hemorrhages and ulcers were scored on a 1 to 8 scale as described by Leach et al. (1998; 1 = diffuse red or yellow; 2 = stronger red; 3 = deep dense red; 4 = port coloration; 5 = red, raw, 6 = ulcer, corium exposed; 7 = severe ulcer, major loss of horn; and 8 = infected ulcer). Hemorrhages were scored wherever they occurred on the base of the claw and were not limited to the sole. Digital dermatitis was scored on a 1 to 5 scale as described by Manske et al. (2002; 1 = reddened area with erect pili; 2 = moist, discharge, reddened area with intact epidermis; 3 = exudative area, exposed corium, no signs of healing; 4 = exposed corium, but in process of healing, dried up lesion; and 5 = dark brown scab, completely almost/completely healed lesion).

Data and Statistical Analysis

Sometimes the cows did not stand directly on the balances, which resulted in errors in the data. The erroneous data points were located as changes in the measured total weight of the cows and were removed using an automatic algorithm described in Pastell et al. (2008). If less than 90 s of the original weight measurement remained after the error correction, then the measurement was not used in further analysis. After the error correction, data from 61 cows remained for statistical analysis.

After removing erroneous values from the data, the average weight placed on each leg, the standard deviation (over time) of the weight placed on each leg, and the number of leg lifts for each leg were calculated for each measurement. A leg lift was calculated when the weight placed on a leg decreased to <20 kg and increased again over the same limit (Pastell et al., 2006).