Back arch posture in dairy cows: An indicator of early signs of lameness?

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ABSTRACT

Visual observation of an arched back in dairy cattle while they are standing and walking is one criterion for assessing lameness through locomotion scoring. However, the assessment of back arch while cows are in stanchions is only variably associated with lameness. In this study, the degree of back arch was measured for lame and non-lame lactating Holstein cows on one farm. Locomotion scores were collected for all lactating cows and those that scored 2 or greater were used for this study. Eighteen cows received a locomotion score of ≥ 3 and 55 cows received a locomotion score of ≤ 2. Digital photographs of these cows while in stanchions and videos as they exited the milking parlor were taken. The images were analyzed for the degree of back arch, "deviation from flat" where a flat back was considered 180 °. It was determined that back angles extracted from still photographs of cows during lockup had no correlation to lameness. However, there was a trend for cows who were determined to have a locomotion score of ≥ 3 to have back angles that deviated further from 180 °.

INTRODUCTION

The cost of dairy cow lameness is estimated to be $120 to over $200 per case depending upon the cause (Cha et al., 2010). The costs incurred are due to lower milk production and poorer conception rates (Bicalho et al., 2007; Green et al., 2002; Hernandez et al., 2001; Hernandez et al., 2005; Juarez et al., 2003). Because more than 90% of the common causes of lameness are treatable (Cha et al., 2010), finding cases early should help reduce the impacts and improve overall animal welfare. Lameness prevalence within herds are often evaluated on an annual basis, with the information being abstracted from records of individual lameness treatments. It is not uncommon for farm records to be limited to lameness cases that required therapeutic trimming or antibiotic use. (A. Poursaberi et al, 2010)

The current "gold standard" for assessing early signs of lameness in dairy cows is locomotion scoring, which requires that the observer watch a cow's posture both standing and walking. The scoring system used most in the United States consists of a five-point scale where a score of 1 is a cow with a flat back while both walking and standing (Sprecher et al., 1997). A score of 2 is described as a cow with a flat back position while standing but "arched" when the cow walks, considered a minor gait abnormality. A cow is considered to be lame if she scores a 3, 4 or 5. A score of 3 is given when a cow is observed to have an arched back while both standing and walking. A score 4 is a cow favoring limb and a 5 is given to a cow that will not put weight on the limb. This locomotion scoring system has been tested for both intraobserver and interobserver agreement (Winckler and Willen, 2001).

Although such a standard exists, few veterinarians or dairy advisors engage in locomotion scoring cows, particularly in large herds, on a regular basis because of the requirement to watch cows both standing and walking to assign a score. A simpler means of detecting lameness in dairy cows by looking at the position of the back (arched or not) while cows were standing was evaluated by Thomsen (2009) and repeated by WSU investigators who observed over 2000 cows on large dairies while in headlocks (Hoffman et al., 2012). Although appearing to be a straightforward observation, neither Thomsen nor Hoffman found a greater than 66% Sensitivity of this "test" when compared to locomotion scoring (cows scoring > 2). However, some recent evidence collected in a pilot study using digital images indicated that the curvature of the spine of the cow becomes more convex with a higher locomotion score (Leroy, et al., 2008). If the visual observation of back arch could be better defined, the sensitivity of this method might be improved. It was the purpose of this study to evaluate the degree of back arch that would differentiate lame from non-lame cows while in stanchions and assess if the back arch posture in the lock-up is a predictable observation for lameness.

MATERIALS AND METHODS

Locomotion scoring

At one research Holstein dairy farm, all lactating cows were observed and given a locomotion score as they exited the milking parlor. Scores were assigned by one trained observer using a 5-point scoring system based on the system reported by Sprecher et al. (1997). A cow was given a score of a 1 if she was observed with a flat back while standing and while walking. The only deviation from this system was that a cow who scored a 3 was one that had an arched back while standing walking, and was observed to be short striding. Information on stage of lactation and parity from the herd's computerized records.

Training for observers was provided by a Washington State University College of Veterinary Medicine Veterinary Medicine Extension online training module for locomotion scoring dairy cows (http://vetextension.wsu.edu).

Observations while stanchioned

The day after locomotion scoring, cows scoring ≥ 2 on the five point scale were observed in the stanchions by the same trained observer before milking. A visual assessment of back arch and body condition score and the time spent in the stanchion were recorded. Back arch was assessed only when the cow's head was up and she was not eating, defecating or urinating, as per Thomsen (2009). Cows were then marked with an orange paint stick on their withers and at the base of their tail head as landmarks for image analysis. Lateral view, digital images were collected for each cow as she stood in lockup using a Cannon *PowerShot* A560.

Video recording of gait

After milking, video recordings were taken of each marked cow as they walked using a SONY Handycam digital video camera recorder (model number DCR-SR42) and tripod. The video camera was positioned approximately 30 feet away from the alleyway where the cows exited from the milking parlor to return to their pens. Each video segment was locomotion scored individually by 3 trained observers. Each cow's locomotion score reflects the agreement between 2 or more observers. If discrepancies were found between the in-person and video assessments of the locomotion scores the scores from the recorded video were used.

Image processing and analysis

The still images of cows in lock up as well as still images from the video footage were used to evaluate the degree of back arch. From each video segment, 4 stills were chosen, that represented the four-beat gait of the walk. Microsoft Moviemaker was used to capture video stills. Microsoft Powerpoint was used to place a circle through the withers and the base of the tail head as well as for recording a midpoint half way between the withers and the base of the tail on the still images. Each of the still images was analyzed and back angle was collected using a software program "VistaMetrix" (http://www.skillcrest.com), to connect a line based at the midway point to the withers and to the base of the tail head. This program facilitated the collection of the angle of the back for each of the images. A back arch was calculated for the video footage by taking the average of each of the 4 video stills.

To account for the 4 video stills representing each cow, back arch was averaged for each cow, such that each cow had an average back arch from the videos. Data points recorded for back arch that were $\leq 5^{o}$ from the other data points were discarded so that the average was not pulled towards the outlying data point. A "deviation from flat back" was calculated from each image where a flat back was considered a cow with a measurement of 180°. The number of degrees of spine curvature was assessed for both still and video images. Differences in the average curvature were compared for cows that are observed to be lame (locomotion score>2) and those that are not lame. The sample size deemed necessary to see a difference of 0.001 degree per cm of curvature with a SD of 0.001, 80% power and alpha=0.05 calculated to be 15 cows per group, where Group 1 was lame cows (locomotion score>2) and Group 2 was non-lame cows, based on previous research (Leroy et al., 2007).

Lockup time study

Time spent in lockup was studied to determine its influence on the presence or absence of a back arch. 52 Cows were observed in lock-up over a time span of 60 minutes before their first milking of the day. One trained observer visually assessed whether each cow had a back arch as he walked down a line of cows in lock-up. To make the observation cows could not be eating, urinating or defecating at the time when the visual assessment of back arch was made. The trained observer completed 5 visual assessments during the 60-minute time period, each observation period lasted approximately 5-6 minutes long and the cows only remained locked up for as long as it took the barn crew to clean their pen and perform pregnancy examinations.

Statistical analysis

The data were managed and summarized in a computerized spreadsheet (Microsoft Office Excel, Microsoft Corp., 2011). Epi Info Analysis Version 3.4 was used for data analysis. The ANOVA method was used to analyze back angle differences by locomotion score. Logistic regression was used to assess the relationship between potential risk factors and lameness.

RESULTS

Descriptive statistics

Locomotion scores were collected for all lactating cows and those that scored 2 or greater were used for this study. Eighteen cows received a locomotion score of ≥ 3 and 55 cows received a locomotion score of ≤ 2. Thirty-five of the 70 cows with locomotion scores >1 were observed with an arched back while stanchioned.

Do lame cows exhibit arched backs in lockup?

There was a tendency for lameness, based on locomotion score >2, and the observer's ability to identify a cow with an arched back while the cows were stanchioned (P = 0.11). As a test to predict lameness, observation of a back arch had a sensitivity and specificity of 0.65 and 0.56, respectively, with 95% confidence intervals ranging from 0.39-0.85 for sensitivity and 0.41-0.69 for specificity.

Is there any correlation between back angle of cows in lock up and locomotion score?

The average degree angle measured from still images for lame cows was 176 (SD=5.0). The average degree angle for non-lame cows was 177 (N=52; SD=4.9) degrees. No statistical significance between back angle in lockup and locomotion score was found (Table 1; $P = 0.15$).

What influences the appearance of a back arch in addition to lameness?

Three trained observers who were individually asked to note whether they saw a back arch or not based on still images of the cows were not different from each other in their observations ($P =$ 0.77). The observers individually identified 26 cows as having a back arch, 6 of these cows had a locomotion score of ≥ 3 but only 23.1 %- percent of time did the observer correctly identified a lame cow by back arch observation of digital images. This test showed a sensitivity of 0.73 and a specificity of 0.24.

The time a cow spent in the stanchion before she was evaluated for a back arch was recorded. Cows observed with a back arch while in lockup and those who did not averaged 51 and 52 minutes, respectively, which was not significantly different ($P = 0.56$).

To better evaluate the time spent in the lock-up and the consistency of observing a back arch, one pen of cows was observed consecutively several times over one hour. Of the 52 cows observed five successive times in the stanchions, 26 were identified as having a back arch at least one time point; however, only 17 of these cows were consistently recorded as having a back arch, with 3 or more of the visual assessments. The proportion of time cows displayed an arched back ranged from 0-100% of the time. The average proportion of observations that cows exhibited a back arch was 26%. The proportion of time cows displayed an arched back was significantly greater for lame cows vs. non lame cows (60% vs. 20%, respectively $P = 0.001$). spent in lockup did not appear to influence the presence or absence of a back arch.

Factors affecting lameness and back arch

Body condition scores for non-lame cows ranged from 2.5-3.5. Body condition scores for lame cows ranged from 2.5-4. The days into their lactation (DIM) when observations were made ranged from 5-513 in all cows. The average DIM for lame cows was 217 days and for non-lame cows was 203 days. There were 35.1% of cows in lactation group 1, 20.6% of cows in lactation group 2 and 44.3% of cows in lactation group 3. Lameness was significantly higher in cows in their third lactation or higher (P= 0.008). Using a logistic regression model, the odds of being identified as lame increased with decreasing BCS (Table 2; P = 0.01). There was a tendency that the odds of being called lame increased for each increase in DIM (P = 0.09). As lactation group increased, the odds of being called lame increased (P = 0.03). However, there was no significance difference between the presence of an arched back and body condition score or lactation group ($P > 0.05$). The cows' DIM had no effect on the observer's ability to observe a back arch ($P > 0.05$).

DISCUSSION

Our study indicates that the back angle, as we measured it, was not associated with either locomotion score or the observation of an arched back while the cows were stanchioned. There was a tendency for a greater average deviation from flat back (<180 degrees) with increasing locomotion score. One potential confounding factor were the observations of a few cows with convex backs (angle measuring >180 degrees in our angle measurement system) and a couple of these cows had locomotion scores 3 or 4. These angles could have influenced the average angle in each locomotion score group. Future analyses should perhaps reduce all the convex angles to 180 degrees since there is no reported reason for these angles other than conformation.

One important findings from this study was that the average proportion of time cows displayed an arched back was significantly higher for lame cows when back arch was observed at multiple time points within one hour. This information tells us that there is increased sensitivity to observing back arch on truly lame cows with increased observations. The more often you observe the cows, the more likely you are to detect a problem. An application of this finding could be used by veterinarians during regular herd checks to better detect lameness within herds as they make their way down the line of cows in lockup.

As back arch pertains to locomotion scores, that is “are these observation methods for detecting back arch sensitive to calling a back arch on only truly lame cows” both in person observation and analyzing still photographs to assess the presence of a back arch showed no statistical significance in relation to locomotion score ($P > 0.05$). However, our findings for the accuracy of calling an arched back on a truly lame cow in person does showed an increased sensitivity compared to the sensitivity for detecting a back arch from still images at later dates.

The low sensitivity between accurately being able to detect an arched back on truly lame cow at one time point while she remains in lockup brings to attention that this method still requires some finessing. It is possible that some cows are simply better at hiding their lameness than others while standing still which would explain why some cows who had locomotion scores of ≥ 3 exhibited no back arch or that the methods we used to be able to calculate back arch from cows in lockup needs improvement.

For instance, despite the picture being taken directly after the trained visual observer recorded the cow’s presence or absence of an arched back it is possible the cow could have moved, shifted her weight ect. after the application of the orange paint stick on her withers and tail head leading to the appearance of a relatively flat back. It is also possible that some cows are simply better at hiding their lameness than others while standing still which would explain why some cows who had locomotion scores of ≥ 3 exhibited no back arch. It has been found in previous studies that the pain experienced by lame cattle is often masked by their instinctive stoicism, leading to delayed detection and treatment of lameness (Callaghan *et al* 2003) and this must also be a factor that is considered when looking at why the observation of an arched back in the still photographs differs from those of the in person observer.

Other reasons cows might be exhibiting an arched back, which would lower the specificity for back arch in lockup being an effective method for detecting lameness are hardware disease, abomasal ulcers and acute laminitis,anything that might cause anterior abdominal pain. These conditions could result in misclassification of back arch and decrease the back arch test specificity.)

The deviation from flat back exceeded 180 ° in 14 cows within the herd with data extracted from their back angles from pictures taken while in lockup. This observed in cows with relatively convex backs and these cows appeared in Group 2 as well as in Group 1. Data for how many of the 14 cows belonged to Group 1 and Group 2 are unavailable, as locomotion scores for some of the cows were not collected. Finding cows with convex backs in Group 1 was not expected and makes diagnosing an arched back in lockup for these cows especially difficult. The finding that some lame cows simply do not show an arched back during standing has been discussed in other papers (A. Poursaberi et al.), however, the shape of the back at a standstill was not described.

Further breakdown of back arch is needed to approach future back arch observations in a more objective manner. All back arches are not the same, despite the presence of differing degrees of back arch among Holsteins, the origination of the arch does vary from cow to cow.

More research into how to objectively assign a back arch is needed to make this observational method effective. Current methods for detecting whether a cow shows signs of an arched back or not are very subjective which could be a large factor in why some dairies are under-detecting lameness within their herds. As our results show, the in person observer was more sensitive to detecting arched backs on truly lame cows but no sensitive enough to show any statistical significance.

Towards the end of our study we began to recognize that the shape of the back arch varied among cows. We began to realize that the apex of the arch was not consistently in the same location among cows that exhibited a back arch. Some cows had back arches whose apex was located directly in the center of the back and some cows exhibited back arches whose apex originated further towards their tail head. It was also noted that some cows back arches appeared to be one sided, with an apex near the center of their back who had an arch emanating rostrally but otherwise appeared to have essentially a flat back from the apex caudally. Further observation is needed to assess this observation as a method of improving the sensitivity of this test and what influences the location of the apex of the back arch might play in the overall appearance and diagnosis of a back arch.

CONCLUSIONS

There are very few studies that have addressed the use of back arch as an effective indicator of lameness. Many lameness studies focus on automatic recordings using camera and computer systems, pressure-sensitive mats and ankle monitors, however these methods despite being useful are time consuming and expensive. Future studies addressing time spent in lockup and how this influences the degree of back arch observed as well as future studies on the origination of back arch, for instance where is the apex of the arch and if the arch present on both sides of the apex will be important in helping to determine if this back arch method can be used as an effect, easy and inexpensive method to detect lameness in dairy cows. Current methods of detecting back arch are too subjective and more objectivity is needed. Due to the fact that pain experienced by lame cattle is often masked by their instinctive stoicism, leading to delayed detection and treatment of lameness (O'Callaghan *et al.*, 2003) it is important that future studies are conducted which allow cattle to remain in their natural environment and in their everyday normal routine with least interruption as possible to be able to truly asses future parameters that will aid us in detecting lameness in the least invasive way possible.

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TABLES

Table 1. Average measured back angle* of lateral view digital images of cows standing in stanchions.

Locomotion Score	Observations	Mean Back Angle	Range	Mode	Standard Deviation
1	2	183.5	180-187	180	4.9
2	50	176.4	168-188	177	4.9
3	14	175.9	170- 182	172	4.1
4	3	179	173-186	173	6.5

*back angle measuring above 180 degrees was convex and back angle less than 180 degrees was concave in appearance.

Table 2. Logistic regression model for risk factors associated with lameness (locomotion score >2).

Risk Factor	**Odds Ratio**	**95% Confidence Interval**		**Coefficient**	**P-value**
BCS	0.04	0.003	0.56	-3.13	0.02
DIM	1.01	1.0	1.01	0.007	0.09
Lactation Group	3.04	1.1	8.4	2.14	0.03