Prevalence of Lameness in High-Producing Holstein Cows Housed in Freestall Barns in Minnesota

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ABSTRACT

A cross-sectional study was conducted to estimate the prevalence of clinical lameness in high-producing Holstein cows housed in 50 freestall barns in Minnesota during summer. Locomotion and body condition scoring were performed on a total of 5,626 cows in 53 high-production groups. Cow records were collected from the nearest Dairy Herd Improvement Association test date, and herd characteristics were collected at the time of the visit. The mean prevalence of clinical lameness (proportion of cows with locomotion score ≥ 3 on a 1-to-5 scale, where 1 = normal and 5 = severely lame), and its association with lactation number, month of lactation, body condition score, and type of stall surface were evaluated. The mean prevalence of clinical lameness was 24.6%, which was 3.1 times greater, on average, than the prevalence estimated by the herd managers on each farm. The prevalence of lameness in first-lactation cows was 12.8% and prevalence increased on average at a rate of 8 percentage units per lactation. There was no association between the mean prevalence of clinical lameness and month of lactation (for months 1 to 10). Underconditioned cows had a higher prevalence of clinical lameness than normal or overconditioned cows. The prevalence of lameness was lower in freestall herds with sand stalls (17.1%) than in freestall herds with mattress stall surfaces (27.9%). Data indicate that the best 10th percentile of dairy farms had a mean prevalence of lameness of 5.4% with only 1.47% of cows with locomotion score = 4 and no cows with locomotion score = 5.

Key words: lameness prevalence, freestall, locomotion score

INTRODUCTION

Lameness has been classified as the most important welfare problem in dairy cows and its observation is

the most representative animal-based indicator of welfare in dairy cattle (Whay et al., 2003). Additionally, lameness is one of the most important diseases that cause economic loss on dairy farms (Weaver, 2000).

Few studies have been performed on the prevalence of lameness in the population of dairy cows, especially in high-producing Holstein cows. The last study of lameness prevalence in Minnesota dairy farms was published in 1993 and it included primarily tie-stall herds (Wells et al., 1993). The current trend in the dairy industry is for housing cows in freestall systems with concrete flooring. Research has indicated that exposure to concrete flooring can increase the proportion of cows with claw disorders compared with other systems (Somers et al., 2003).

In addition, there are limited or no data available in the literature on the distribution of locomotion scores of high-producing dairy cows housed in freestall barns. Locomotion scoring of dairy cattle evaluates certain walking behaviors and postures that are thought to be indicative of lameness (Wells et al., 1993; Clarkson et al., 1996; Sprecher et al., 1997). Use of locomotion scoring should help identify cows at earlier stages of lameness, and result in faster recovery and reduced treatment costs. Some research indicates that producers tend to underestimate the prevalence of lameness in their herds (Wells et al., 1993; Whay et al., 2002).

Body condition and parity have been associated with prevalence of lameness. Wells et al. (1993) reported an increased risk of lameness with increased parity; and they also found a strong correlation between poor body condition and clinical lameness. However, the authors explained that loss of body weight might be the result of lameness, and not a causative factor for lameness.

Factors related to the cow's environment have been associated with lameness. Among all housing systems, freestall barns have been shown to be more detrimental to hoof health compared with tie-stall barns or straw yards (Cook, 2003; Sogstad et al., 2005). Stall base is another factor associated with lameness. Studies in Wisconsin have shown that cows in sand-based stalls have a lower prevalence of lameness than cows in mattress-based stalls (Cook, 2003; Cook et al., 2004).

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A study of 17 nonrandomly selected herds housed mainly in tie stalls in Minnesota and Wisconsin, estimated the prevalence of clinical lameness to be 13.7% in summer and 16.7% in spring (Wells et al., 1993). In another study performed in 30 nonrandomly selected dairy herds in Wisconsin with Holstein as a predominant breed, Cook (2003) found a prevalence of clinical lameness of 21.1% in summer and 23.9% in winter.

The objectives of this study were to estimate the prevalence of clinical lameness and determine locomotion score distribution in high-producing Holstein cows housed in freestalls in a randomly selected dairy farm population in Minnesota, and to evaluate the association of lameness prevalence with lactation number, month of lactation, BCS, and type of stall surface.

MATERIALS AND METHODS

This study was a cross-sectional evaluation of 5,626 Holstein dairy cows housed in 50 freestall dairy farms in Minnesota. A list of all dairy farms in the state was provided by the Minnesota Department of Agriculture. The geographic analysis of herd location within the state determined that most of the dairy farms (85.7%) and dairy cows (84.7%) were located in an area from the central to the southeast region of the state (Figure 1). From the population of herds with 150 cows or greater in this geographical area (262 farms), a list of 70 farms was randomly selected using Microsoft Excel software. From this list, dairy producers were contacted and asked about their willingness to participate in the study until 50 farms were enrolled. The sampling methodology was a simple random sampling, in which all the dairy farms with more than 150 cows in the selected geographical area had the same opportunity to participate in the study, and without any previous knowledge about the prevalence of lameness on these farms. The sample size was calculated with the hypothesis that the prevalence of clinical lameness in these herds would average 20% with a 95% confidence interval from 10 to 30%.

Dairy farms were visited once between June and October 2004. Data were collected using direct observation of the cows and their environment, and examination of DHIA records when available. In each farm, data were collected from what producers called the high-production group on the farm. The selection of cows within the farms corresponded to a clustered sampling in which only cows in the high-production group participated in the study. Characteristics of the farms and their high-production groups are given in Table 1. In 3 farms, we studied 2 high-production groups instead of 1, because the farmers considered both groups as high-production groups and there were differences in stall

Figure 1. Location of all (●) and selected (▲) dairy farms in Minnesota; shaded area represents geographical area used in the selection procedure.

design or flooring type between the 2 groups. Therefore, we studied a total of 53 high-production groups on 50 farms. There were 16 high-production groups out of the total of 53 groups in the study that did not include first-lactation cows. High-production group cows (as defined by the herd manager) housed in the hospital pen at the day of the visit were also included in the study. All non-Holstein cows in the groups were excluded from the study. On average, 97.2% of the cows housed in the high-production groups were used in this study.

Cows were evaluated for their lameness status using a 5-point locomotion score (LS; Sprecher et al., 1997) with additional observations as suggested by O'Callaghan et al. (2003), in which 1 = normal locomotion, 2 = imperfect locomotion, 3 = lame, 4 = moderately to severely lame, and 5 = severely lame. Additional observations included tracking (hind feet on fore feet position), head bob (extent of movement and level of bobbing), and abduction/adduction (rotation of feet from the direction of travel). For each locomotion score (1 to 5) the mean percentage, the minimum, the maximum, and the 25th and 75th quartiles were calculated. In addition, the best and the worst 10th percentiles were calculated. Locomotion scoring was performed by the same experienced observer at the exit of the parlor after

Table 1. Characteristics of 50 randomly selected freestall dairy farms and their 53 high-production groups of Holstein cows in Minnesota

Variable	Farms		High-production group	
	Mean	SD	Mean	SD
Cows, ¹ n	470 ^a	330	117 ^b	51
3.5% FCM yield, kg/cow per day ^{1,2}	32.9 ^a	5.41	37.6 ^b	6.9
Lactation number ¹	2.23 ^a	0.2	2.64 ^b	0.43
DIM ¹	207.7 ^a	13.5	169.7 ^b	50.8

^{a,b}Different superscripts within rows indicate significant differences ($P < 0.01$).

¹From DHIA when available (48 farms) and from on-farm records when DHIA records were not available (2 farms).

²Did not include 2 farms that were not members of the DHIA.

the afternoon milking with the exception of 3 dairy farms, where the assistance of a second trained observer was required to score cows. Agreement between observers was evaluated using kappa coefficient in 268 cows. The prevalence of lameness ($LS \geq 3$) and the LS distribution in the groups were calculated as a proportion of cows affected in each group at the day of the visit. The overall prevalence of lameness in this study was the average of the prevalence in the groups. At the time of the visit and before the evaluation of the locomotion score, herd managers were asked how many cows they considered to be lame, using their own definition of lameness, in the high-production group on that day.

Cows were scored for body condition by the same experienced observer on a scale of 1 to 5, where 1 = thin and 5 = obese (Ferguson et al., 1994). Lactation number and DIM were obtained from DHIA records nearest to the time of the visit, with the exception of 2 farms that were not associated with DHIA, in which case on-farm daily milk records were used. For the analysis of the results, the variable DIM was grouped as month of lactation, and BCS was grouped as underconditioned ($BCS \leq 2.5$), normal condition ($BCS \geq 2.75$ and ≤ 3.5), or overconditioned ($BCS \geq 3.75$). Information about the stall surface was collected at the time of herd visit.

Statistical Analysis

Differences between farm means and group means were analyzed using one sample Z-test with the MEANS procedure of SAS (SAS Institute, 2004). The individual association between lactation number, month of lactation, BCS, and type of stall surface with mean prevalence of lameness was evaluated using the MIXED procedure of SAS (SAS Institute, 2004) with a mixed model weighted by the number of cows, in which the prevalence of lameness in the groups of cows (experimental unit) was the response variable and the high-

production groups were used as random effect. The assumption of random distribution of the residual was visually evaluated on a residual chart. The Bonferroni t -test was used to compare the least squares means in categorically distributed variables.

RESULTS AND DISCUSSION

Dairy farms were randomly selected from the total population of herds with more than 150 cows located within a geographical area where most of the dairy farms in the state are located (Figure 1). No previous knowledge of herds' lameness status affected selection of the farms. These selected farms had, on average, 470 cows and milk production averaged 37.6 kg of FCM/cow per day. Therefore, the results from this study would represent the population of cows in the high-production group housed in freestall barns with a herd size equal to or greater than 150 cows.

The kappa coefficient analysis for locomotion scoring between observers was 0.77 with a 95% confidence interval between 0.70 and 0.84 ($P < 0.01$). The 2 observers agreed in the LS in 86.6% of the cases. In the remaining observations, the LS differed by one unit between observers. In contrast, Winckler and Willen (2001) found a percentage of agreement of 68% using a similar LS . In addition, in 30% of the cows, observers differed by one LS unit, and in 2% of the cows, differed by 2 units. The agreement evaluation in LS made by Winckler and Willen (2001) was performed using 3 independent observers, which likely increased the sources of variation compared with this study.

The prevalence of lameness ($LS \geq 3$) in the 53 high-production groups averaged 24.6% (SD = 11.68) with a range from 3.3 to 57.3%. This prevalence of lameness was greater than in a previous study conducted in Minnesota by Wells et al. (1993). Those authors estimated that the prevalence of lameness in 17 dairy farms in Minnesota and Wisconsin was 13.7% during summer and 16.7% during spring. The difference between these

Table 2. Locomotion score distribution for 53 high-producing groups of Holstein cows housed in free stall dairy farms in Minnesota

Variable	Locomotion score ¹				
	1	2	3	4	5
Minimum, %	0	19.85	3.28	0	0
25th Percentile, %	4.58	42.11	13.04	2.56	0
Mean, %	19.27	56.07	18.58	5.82	0.26
75th Percentile, %	32.04	68.32	22.47	8.33	0
Maximum, %	69.85	90.00	39.22	18.29	2.25
Cows per category, n	1,224	3,056	1,017	314	15

¹Sprecher et al. (1997) and O'Callaghan et al. (2003).

2 studies could be explained by the housing system. The results reported by Wells et al. (1993) involved mostly cows housed in tie-stall barns, whereas the current study focused exclusively on freestall barns. Cook (2003) found that the prevalence of clinical lameness in tie-stall barns was lower than in freestalls during the winter housing period. A study in the United Kingdom (Clarkson et al., 1996) estimated that the mean prevalence of lameness in 37 farms was 20.6% with a range of 2 to 53.9%. The mean prevalences during summer and winter were 18.6 and 25%, respectively. The mean prevalence in summer was lower than the mean prevalence in the current study. However, cows were on pasture during the summer and again, the housing system could account for the difference. The mean prevalence during the winter period when cows were housed in freestalls is similar to the mean prevalence estimated in the current study. Clarkson et al. (1996) scored cows for locomotion at regular visits during each season and concluded that prevalence measured at a single visit was significantly correlated with the mean prevalence for the respective season. Results of the current study agree with a more recent study in Wisconsin (Cook, 2003), in which the mean prevalence of lameness in 15 freestall dairy farms was 27.8% during winter and 22.8% during summer.

A summary of the distribution of LS in the 53 groups is given in Table 2. The mean percentage of cows in the 53 high-production groups without any gait abnormalities (LS = 1) was approximately 20%, which is less than half of the value (54.9%) reported by Cook (2003) in 30 dairy farms in Wisconsin during the summer. In addition, more than half of the cows were classified as having locomotion abnormalities (LS = 2), but not clinically lame. Many reasons could explain this imperfect locomotion such as the presence of mild or chronic lesions that are not painful enough to cause clinical lameness, abnormal conformation of legs or claws, pain in other body areas, or problems in the evaluation because of slippery or irregular floors. Approximately 6% of the cows had LS $\geq$ 4 (more severe lameness). This is

also higher than that observed by Cook (2003), in which the proportion of cows with severe lameness (LS = 4) was 3 to 3.2% depending on the season. Although the latter study used a 1-to-4 scale LS system, an LS = 4 would correspond to the combination of scores 4 and 5 in our study (more severely lame cows). Cows in the high-production group are exposed to the stress of high milk production, which could have a negative effect on hoof health. There are almost no data in the literature on the locomotion score distribution of high-producing dairy cows in loose housing systems with concrete flooring. It is very possible that the high scores observed in this study reflect the fact that many of these cows have hoof problems. Somers et al. (2003) in a study of Dutch herds reported that 80% of the cows exposed to concrete flooring had at least one claw disorder at the time of observation.

The best 10th percentile of farms in the current study had a mean prevalence of lameness of 5.4%, with only 1.47% of cows having an LS = 4 and no cows with LS = 5, whereas the worst 10th percentile of farms had a mean prevalence of lameness of 46.2%, with 11.8% of cows having an LS = 4, and 0.41 of cows with LS = 5. In addition, the best quartile of farms had approximately 15% of cows scored as clinically lame with only approximately 2.5% of cows scored as severely lame. Therefore, the presence of a relatively large percentage of severely lame cows (LS $\geq$ 4) could be an indication of a herd lameness problem. A goal of less than 15% clinically lame cows in a freestall herd should be achievable.

This study focused on Holstein cows housed in the high-production group in each dairy farm. As indicated earlier, there were 16 high-production groups out of the total of 53 groups in the study that did not include first-lactation cows. On average, the high-production groups had higher milk production, lower average DIM, and higher lactation number than the overall average for their farms (Table 1). Some of these characteristics could be associated with higher prevalence of lameness. An increase in the prevalence of lameness with lacta-

Table 3. Univariate regression analysis between mean prevalence of lameness and lactation number/month of lactation in 53 high-producing groups of Holstein cows housed in freestall dairy farms in Minnesota

Variable	Coefficient	SE	95% CI
Lactation number	7.93	0.69	6.57, 9.30
Month of lactation (from mo 1 to 10)	0.27	0.28	-0.29, 0.38

tion number was reported previously by Wells et al. (1993) and observed in the current study. High milk yield has been reported to increase the risk of lameness (Barkema et al., 1994; Green et al., 2002). These factors could contribute to the high prevalence of clinical lameness observed in this study. We caution that there could be a potential bias on the estimation of lameness prevalence in these herds because only high-production group cows were included in the study. However, these groups included cows with long DIM and approximately 70% of them were mixed groups of first-lactation and older cows, which might have helped reduce this bias.

The prevalence reported by the herd managers had a mean estimate of 8.3% with a range from 0 to 30%. Therefore, the prevalence of lameness estimated by the investigators in this study was 3.1 times higher than the prevalence of lameness estimated by herd managers. Wells et al. (1993) estimated 2.5-times higher prevalence of lameness than the prevalence estimated by the herd managers. In another study, Whay et al. (2002) reported a lower estimation of the prevalence of lameness by dairy farmers (3.86 times) compared with the prevalence estimated by investigators. The perception of the prevalence of lameness can be affected by different criteria of classification, lack of observation of lame cows, or unwillingness to openly admit the problem of lameness in their herds (Wells et al., 1993; Whay et al., 2002).

Results of the association between prevalence of lameness in the high-production groups and lactation number are in Table 3 and Figure 2. The lowest prevalence of lameness was observed in first-lactation cows and prevalence increased with lactation number. The greatest prevalence of lameness was observed in the group of cows with 6 or more lactations in which half of the cows were clinically lame. Wells et al. (1993) also observed an increase in the prevalence of lameness with lactation number. In a study in 45 selected farms in Michigan, Groehn et al. (1992) estimated that the risk of becoming lame increased 1.4-fold per lactation. In the current study, the prevalence of clinical lameness increased, on average, by 8 percentage units per lactation or 1.3-fold per lactation.

In the herds visited in this study, cows were housed in the high-production pen mostly because of their pro-

Figure 2. Prevalence of clinical lameness by lactation number in 53 high-producing groups of Holstein cows housed in freestall dairy farms in Minnesota (mean and SE).

duction level and not necessarily their DIM. Approximately 49% of the cows included in the study had more than 150 DIM. There was no association between month of lactation and prevalence of lameness in the first 10 mo of lactation (Table 3, Figure 3). Similarly, Warnick et al. (1995) did not find an association between lameness and DIM in a study of 20 dairy herds in Virginia. Some studies investigating incidence of lameness have reported contrasting results. Rowlands et al. (1985), in a study with 48 veterinary practices in the United Kingdom, described that the average incidence of lameness per month in the first 4 mo of lactation was twice the number observed in the following 3 mo, and 3 times greater than the last 3 mo of the lactation. In another study in the United Kingdom, Collick et al. (1989) reported that 65% of the cases of lameness occurred in the first 100 d of lactation. Cook (N. B. Cook, Univ. Wisconsin, Madison; personal communication) suggests that in the United Kingdom, first-lactation cows transition poorly into the lactating herd and might become lame in early lactation. The poor transition also appears to result in a higher risk of lameness in first-lactation cows than has been observed in the United States. In addition, incidence of new cases of lameness may be higher in early lactation; however, the prevalence of lameness would tend to increase as lactation proceeds because lameness is a long-term event.

Body condition score was associated with the prevalence of lameness ($P < 0.01$). The least squares mean of prevalence of clinical lameness in the group of underconditioned cows ($BCS \leq 2.5$) was greater than the mean prevalence observed for normal ($BCS \geq 2.75$ and ≤ 3.5) and overconditioned cows ($BCS \geq 3.75$; $P < 0.01$). There

Table 4. Least squares means (LS means) of prevalence of lameness by BCS in 53 high-producing groups of Holstein cows (n = 5,107) housed in freestall dairy farms in Minnesota

BCS ¹	LS means, %	SE
≤2.5	42.57 ^a	2.53
≥2.75 and ≤3.5	22.05 ^b	1.47
≥3.75	19.69 ^b	4.37

^{a,b}Means with different superscripts within column indicate significant differences according to Bonferroni *t*-test ($P < 0.01$).

¹Ferguson et al. (1994).

was no difference between normal and over-conditioned cows (Table 4). Wells et al. (1993) also found a strong correlation between poor body condition and clinical lameness. However, those authors explained that loss of BW might be a result of the lameness, and not a causative factor for lameness. Reduction in body condition could be a consequence of the disability in locomotion causing a reduction in feed intake. Hassall et al. (1993) and Juarez et al. (2003) suggested that lame cows not only reduce their feeding time, but also eat slowly because of the restriction of movement. Hassall et al. (1993) and Winckler and Brill (2004) found a reduction in feeding time in lame cows on pasture and cubicles, respectively. Bareille et al. (2000) estimated a reduction in feed intake of 24.2 kg due to foot lesions during the period from diagnosis to recovery (63 d). However, Singh et al. (1993) and Galindo and Broom (2000) did not find differences in the total time spent eating for cows housed in cubicles in behavioral studies with lame cows. Juarez et al. (2003) proposed that lame

cows tend to arrive later to the feed bunk, at which point the quantity and quality of feed is lower because of sorting by early-arriving cows. Consequently, they are not able to meet the nutritional requirements of high-producing cows, and eventually they lose condition.

Type of stall surface was associated with the prevalence of lameness ($P < 0.01$). Sixteen groups of cows were housed in stalls with a sand base and 37 groups were housed in stalls with a mattress base. The least squares mean of prevalence of lameness in cows using sand stalls was lower than the value observed for cows using mattress stalls (17.1 vs. 27.9%, respectively; $P < 0.01$). A lower prevalence of lameness in cows housed in sand stalls was observed in other studies (Cook, 2003; Cook et al., 2004). Cook (2003) reported that the prevalence of lameness in cows housed in freestalls with sand surfaces was significantly lower (21.2%) than in cows housed in freestalls with mattresses (33.7%) during winter, but this difference was not mentioned during summer. In another study, Cook et al. (2004) found a significant difference in the prevalence of clinical lameness in cows housed on sand (11.1%) compared with cows housed on mattress (24.4%). Those authors suggested that the difference in prevalence could be related to changes in the time budgets of the cows between stall surfaces. The time that cows spend standing in the stall could be a major factor explaining this difference. Lame cows behaved similarly to nonlame cows in terms of lying and standing time in sand stalls, whereas lame cows in mattress stalls spent more time standing (up to 4.31 h/d) in the stall than nonlame cows (Cook et al., 2004). Vokey et al. (2001) found that the severity of claw lesions increased with the use of mattress surfaces. Sand probably offers more traction and cushion than mattress surfaces with limited amounts of bedding.

Of the 53 groups of high-production cows, 23 were located in central Minnesota and 30 in southeast Minnesota. Sand and mattress stalls were not equally distributed in the central and in the southeast regions of the state. The analysis of the association between location and type of stall surface using χ^2 test revealed that a higher ($P < 0.01$) proportion of the groups of cows housed in stalls with sand bases were located in the southeast region of the state (87.5%). Because farms were randomly selected, it is also possible to establish that most of the farms located in the central region of the state used mattresses as a stall base.

Figure 3. Prevalence of lameness by month of lactation in 53 high-producing groups of Holstein cows housed in freestall dairy farms in Minnesota (mean and SE).

CONCLUSIONS

This study estimated that, on average, 24.6% of the cows housed in high-production group pens in randomly

selected farms in Minnesota with freestall barns were clinically lame. The prevalence of clinical lameness was greater than in a previous study in Minnesota, possibly because of the predominance of tie stalls in that study, a possible increase in lameness prevalence in recent years (as reported in more recent studies), and because of the risk factors associated with high-producing Holstein cows. This study confirmed results of previous research on the association of lameness with lactation number, BCS, and stall surface. However, there was no association between lameness and month of lactation.

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