Evaluation of the efficacy of prophylactic hoof health examination and trimming during midlactation in reducing the incidence of lameness during late lactation in dairy cows

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Objective—To assess the efficacy of prophylactic hoof health examination and trimming during midlactation at reducing the incidence of lameness during late lactation in dairy cows.

Design—Randomized field trial.

Animals—333 Holstein cows.

Procedures—Cows without apparent lameness were randomly allocated into 1 of 2 groups approximately 204 days after calving. Cows allocated to the treatment group (n = 161) were examined on a tilt table for diagnosis and underwent hoof-trimming procedures, if needed, for treatment of hoof disorders or lesions. Cows in the control group (n = 172) were not examined. Cows were assigned a locomotion score weekly for 28 weeks after allocation to a group. The number of cows classified as lame during late lactation (approx 205 to 400 days after calving) was compared between groups to assess the efficacy of prophylactic examination and trimming.

Results—Incidence of lameness during late lactation was 24% in cows in the control group and 18% in cows in the treatment group.

Conclusions and Clinical Relevance—The 25% decrease in number of new cases of lameness in cows undergoing prophylactic hoof health examination and trimming during midlactation may be relevant for the well-being of dairy cows and should not represent a major economic burden to producers. (*J Am Vet Med Assoc* 2007;230:89–93)

In the approximately 9 million dairy cows in the United States, lameness is one of the most important health problems that results in premature culling. In the 1996 National Animal Health Monitoring System report,[1] lameness was the reason for culling in 15% of dairy cows that were sent to slaughter. Ten percent of the cows in the report had been lame in the previous 12 months. The economic importance of lameness is attributable to decreased milk yield,[2–5] loss from culling,[6,7] impaired reproductive performance,[6–13] and costs of treatment and control.[14–21] Lameness in dairy cows is also an issue of animal welfare because of its prevalence and the associated pain and discomfort in affected cows.

In many commercial dairies, trimming procedures are performed in cows at the end of lactation to reduce the incidence of lameness (which is known to be highest during the early stages of lactation)[6,13,14] during the following lactation. Overgrowth of the hoof horn capsule can lead to incorrect weight bearing, with focal areas of increased pressure on the corium.[22] Such contusion causes an inflammatory process that can result in development of an ulcer in the sole.[23] The objectives of hoof trimming are to restore appropriate and balanced weight bearing in the 2 digits, correct hoof overgrowth, and prevent development of new hoof lesions. Although it is recognized that the overall incidence of lameness is highest during early lactation, hoof lesions are diagnosed in many lame cows during late lactation.[4,24] In a previous study conducted in Florida,[4] lameness associated with hoof lesions was diagnosed in 71 of 100 cows during the middle and late stages of lactation. In another study in Sweden,[23] increasing the frequency of cows' hoof health examinations from every 12 months to every 6 months and use of hoof-trimming procedures helped reduce the incidence of lameness in dairy cows. On the basis of clinical observations at commercial dairies in the United States, we have favored performing hoof health examinations and hoof trimming procedures both during midlactation and at the end of lactation (instead of at the end of lactation only) to reduce the frequency of lameness associated with hoof lesions that develop during late lactation.[24] However, the efficacy of that prophylactic measure has not been evaluated with objective research

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Supported in part by the National Research Initiative of the USDA Cooperative State Research, Education and Extension Service (grant No. 2002-35204-12308), the Florida Dairy Check-off Program, and the College of Veterinary Medicine, University of Florida.

The authors thank Shawn Ward, Marie-Joelle Thatcher, Megan Elliott, Manon Schuppers, Brooke Bloomberg, Emily Piercefield, and Maria vonChamier for technical assistance.

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methods. The purpose of the study reported here was to assess the efficacy of prophylactic hoof health examination and trimming procedures in Holstein cows during midlactation at reducing the incidence of lameness during late lactation.

Materials and Methods

Study herd—The study protocol was reviewed and approved by the University of Florida Institutional Animal Care and Use Committee (Protocol A765). Cows used in the study were from a high-producing dairy herd (rolling herd average milk production, approx 12,000 kg [26,400 lb]) of approximately 600 Holstein cows in Florida. The herd was selected for study because a surveillance system for early detection of lameness had been instituted,[5,12,13] the quality of veterinary records was high, and the owner was willing to participate in the study. Cows were milked and fed a total mixed ration 3 times/d. Cows were housed in lots equipped with sprinklers, fans, and shade cloths over the feed bunks to reduce heat stress. As part of the herd health management program, all lactating cows routinely underwent hoof trimming by a farm employee at the end of lactation.

Study cows—Five hundred cows that calved from June 1, 2003, through May 31, 2004, and that reached 200 days in lactation were initially considered for inclusion. An attending veterinarian scored cows weekly for lameness during the first 200 postpartum days by use of a 6-point locomotion scoring system (scale, 0 to 5; **Appendix**).[5,12,13] One hundred sixty-two (32%) cows were classified as lame (locomotion score, 4 or 5) during the first 200 days after calving and were excluded. This group of lame cows was excluded because this trial was prophylactic and to make experimental groups comparable. Five additional cows classified as nonlame (scores ≤ 3) were misidentified (ie, were inadvertently scored twice on a weekly farm visit) and were also excluded, leaving 333 cows that reached 200 days in lactation and had weekly locomotion scores ≤ 3 that were sequentially enrolled in the study.

Allocation of cows into experimental groups—From computerized herd records, a list of cows close to 200 days in lactation was generated each week. Cows on the list were randomly allocated into 1 of 2 groups by flipping a coin and were sequentially enrolled in the trial at approximately 204 days in lactation.

Experimental groups—On the day of allocation, cows in the treatment group were examined on a tilt table by the attending veterinarian for diagnosis and, if indicated, treatment of hoof disorders or lesions by means of functional or corrective trimming procedures, respectively.[22] Cows in the control group were not examined.

Outcomes—The main outcome of interest was lameness (cows with a locomotion score of 4 or 5) during late lactation (approx 205 to 400 days after calving). Other outcomes evaluated were duration of lameness (in weeks), number of cows culled during late lactation, and number of cows with hoof disease or hoof lesions at the end of the follow-up period.

Sample size—A sample size of 161 cows in the treatment group and 172 cows in the control group was sufficient to deem incidences of lameness of 20% in the control group and 10% in the treatment group (ie, 50% efficacy) as significantly different with 95% confidence and 80% power. A goal of 50% efficacy was established on the basis of clinical observations by one of the authors (JKS) at commercial dairies where trimming procedures were conducted both during midlactation and at the end of lactation and where hoof lesions were the chief cause of lameness during late lactation.

Follow-up period and data collection—The follow-up period for each cow was 28 weeks after allocation to a group and corresponded to 205 to 400 days after calving. Cows were observed and scored for lameness weekly during the follow-up period by a professional hoof trimmer (who was unaware of group allocations) as they walked out of the washing pen to the holding area before milking; cows classified as lame were examined on a tilt table and treated as indicated by hoof examination findings. The hoof trimmer had 4 years of professional experience and had participated in previous studies[5,12,13] conducted in this herd. Cows in which lameness was detected by farm personnel between those visits were also examined on a tilt table; in those instances, treatment was initiated by farm personnel. In both groups, each cow was examined at the end of the follow-up period on a tilt table for diagnosis and treatment of lameness, if indicated, by the hoof trimmer. During all examinations, hoof disorders or lesions were observed and dates of occurrence were recorded.

Hoof disorders were defined as hoof overgrowth, excessive sole thickness, unbalanced hooves, or excessive toe length; cows with these disorders were treated with functional trimming procedures.[24] Hoof lesions were defined as sole ulcers, white line disease, or heel horn erosion; cows with these lesions were treated with corrective procedures.[24] Lame cows with interdigital phlegmon had an interdigital lesion, swelling of the entire foot above the dewclaws, and separation of the digits and were treated with parenterally administered antimicrobials.[4] Lame cows with digital dermatitis had inflammation confined to the epidermis and, in some instances, hyperkeratosis, which creates a roughened appearance to the interdigital skin. This condition was frequently accompanied by cracks in the heel and heel horn erosions with underrunning of the heel horn.[25] Cows with heel horn erosion had loss of heel horn and a smaller hoof weight-bearing surface; this condition was repaired with corrective trimming (ie, removal of hard edges and undermined heel horn and preservation of as much weight-bearing surface as possible).[26]

The following data were collected from farm records for each cow: lactation number, calving date, and calving season (winter months, January through April and October through December; summer months, May through September). Other data collected included treatment group allocation at approximately 204 days postpartum (control vs treatment), number of days after calving at the time of allocation to a group, weekly locomotion scores during the follow-up period, lameness (yes vs no), duration of lameness (in weeks), hoof diseases diagnosed, hoof disorders or lesions in cows when first classified as lame during the follow-up period and at the

end of the follow-up period, date of the end of lactation, culling during follow-up period (yes vs no), and date of culling (if applicable). Culled cows were identified from computer herd records by an animal health technician who was unaware of treatment group identification.

Statistical analysis—The hypothesis that the incidence of lameness during late lactation would be lower in treatment cows than in control cows was tested by use of a χ^2 test. In addition, Cox proportional hazards regression analysis[27] was used to test the hypothesis that time (in number of weeks) to diagnosis of lameness was longer in cows in the treatment group, compared with that in cows in the control group; lactation number and calving season were included in the analysis to adjust for residual confounding effects that these 2 variables might have had on time to diagnosis of lameness.

Among cows classified as lame, duration of lameness (weeks; rank values) was compared between groups by use of the Mann-Whitney *U* test.[28] Number of culled cows during the follow-up period and number of cows with foot diseases or hoof lesions at the end of the follow-up period were compared by use of a χ^2 test. A 1-sided value of $P \leq 0.05$ was interpreted to indicate that new cases of lameness, time to diagnosis of lameness, duration of lameness, and number of culled cows in treatment cows were significantly different than in control cows. Baseline comparisons were performed to establish the comparability of experimental groups. Number of cows in the first, second, third, or later lactations and number of cows that calved during the summer or winter months were compared between groups with a χ^2 test. Number of days after calving when cows were assigned to a group and the sum of weekly locomotion scores during the first 28 postpartum weeks were compared by use of the Mann-Whitney *U* test. For such tests, a 2-sided value of $P \leq 0.05$ was considered significant. All analyses were performed with statistical software.[a]

Results

One-hundred seventy-two cows were assigned to the control group, and 161 cows were assigned to the treatment group. At approximately 204 days after calving, most cows in the treatment group (n = 129/161 [80%]) had no hoof lesions, but underwent functional trimming only (**Table 1**); 21 (13%) cows had no hoof lesions and did not require trimming. Eleven (7%) cows had hoof lesions; 7 and 4 of these cows underwent corrective and functional trimming, respectively.

Baseline comparisons—Proportions of cows in the first, second, third, or later lactations; cows that calved in summer months; median number of days after calving when cows were allocated into experimental groups; and median cumulative sum of weekly locomotion scores during the first 28 weeks after calving were not different between groups ($P = 0.24$; **Table 2**).

Outcome comparisons—The incidence of lameness during late lactation was 24% in control cows and 18% in treatment group cows, a change that indicated a 25% efficacy for treatment, although the difference was not significant ($P = 0.09$; Table 2).

After adjusting for lactation number and calving season, cows in the control group became lame sooner than cows in the treatment group, and cows in the control group were 1.25 times as likely to become lame as cows in the treatment group, but the differences were not significant ($P = 0.12$ for both comparisons; **Figure 1**).

At the end of the follow-up period, the percentage of cows examined for diagnosis of foot diseases or hoof lesions was not different between cows in the control group (79%) and cows in the treatment group (73%; $P = 0.21$; **Table 3**). Eighteen (10%) cows in the control group were removed from the herd without a diagnosis, and 18 (10%) cows missed detection by the hoof trimmer and did not receive a diagnosis. Fourteen (9%) cows in the treatment group were removed from the herd without a diagnosis, and 29 (18%) cows were missed for diagnosis. Fourteen of 136 (10%) cows examined for the purpose of establishing a diagnosis for lameness in the control group had hoof lesions, compared with 6 of 118 (5%) cows in the treatment group, but that difference was not significant ($P = 0.08$).

Table 1—Hoof conditions detected and procedures performed in the 161 cows in the treatment group that were examined approximately 204 days after calving for diagnosis of hoof lesions or disorders.

Diagnosis	Treatment	No. of cows
No lesions	Functional trimming	129
No lesions	None	21
White line disease	Corrective trimming	4
Sole ulcers	Corrective trimming	3
Long toes	Functional trimming	2
Bruising	Functional trimming	2

Table 2—Number (%) of cows in various baseline and outcome variable groups among 333 Holstein cows allocated to a treatment (underwent prophylactic hoof examination and trimming, if needed; n = 161) or control (cows that did not undergo examination or treatment; n = 172) group.

Variable	Control group	Treatment group	*P*
Baseline comparisons			
Lactation			0.95
1	67 (39)	64 (40)	
2	56 (33)	50 (31)	
3+	49 (28)	47 (29)	
Calving season			0.32
Winter	132 (77)	116 (72)	
Summer	40 (23)	45 (28)	
Number of days after calving when cows were assigned into 1 of 2 experimental groups*	204 (198, 213)	204 (198, 227)	0.24
Sum of weekly locomotion scores during first 200 postpartum days*	63 (19, 84)	63 (6, 84)	0.92
Outcome comparisons			
Lame cows			0.09
No	130 (76)	132 (82)	
Yes	42 (24)	29 (18)	
Duration of lameness (weeks)*	3 (1, 24)	3 (1, 20)	0.34
Culled cows			0.29
No	154 (90)	147 (91)	
Yes	18 (10)	14 (9)	

*Data are reported as median (minimum, maximum).

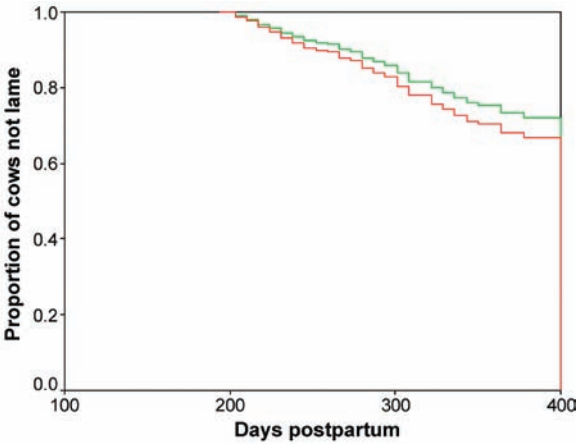

Figure 1—Proportions of cows that remained free of lameness from postpartum days 200 to 400. Cows underwent hoof examination and trimming (green line [n = 161]; treated) or were not examined (red line [172]; control).

Table 3—Number (%) of cows with various diagnoses for foot diseases and hoof lesions in the same cows as in Table 2 at the end of a 28-week follow-up period.

Variable	Control group	Treatment group	*P*
Cows examined at end of follow-up period for clinical diagnosis			0.21
No	36 (21)	43 (27)	
Yes	136 (79)	118 (73)	
Cows with injury of the proximal portion of the limb			ND
No	134 (99)	118 (100)	
Yes	2 (1)	0 (0)	
Cows with interdigital phlegmon			ND
No	135 (99)	118 (100)	
Yes	1 (1)	0 (0)	
Cows with digital dermatitis			ND
No	136 (100)	117 (99)	
Yes	0 (0)	1 (1)	
Cows with heel horn erosion			0.48
No	73 (54)	63 (53)	
Yes	63 (46)	55 (47)	
Cows with long toes			ND
No	136 (100)	117 (99)	
Yes	0 (0)	1 (1)	
Cows with hoof lesions			0.08
No	122 (90)	112 (95)	
Yes	14 (10)	6 (5)	
Hoof lesions			
Sole ulcer	7	3	
White line disease	7	1	
Abscess	0	1	
Sole hemorrhage	0	1	
Total	**14**	**6**	

ND = Not determined.

Discussion

This study was conducted to assess the efficacy of prophylactic hoof health examination and trimming procedures during midlactation for reducing the incidence of lameness in Holstein cows during late lactation. Results are only applicable to the study herd. The study population of 333 cows was sufficient to declare a reduction in the number of new cases of lameness of 50% or greater as significant. Results revealed that hoof health examination and trimming procedures conducted during midlactation failed to decrease the number of new cases of lameness by 50% during late lactation. The incidence of lameness was 24% in control cows, compared with 18% in cows in the treatment group. If the true efficacy of treatment was 25%, then the power of detecting this difference, given the sample sizes used, was 38% at the 5% level of significance. A field trial with a larger sample size that included cows from multiple herds would help determine whether the observed level of efficacy was real.

Study results are inconclusive. However, although the decrease in number of new cases did not reach 50%, we believe that a 25% reduction in number of new cases of lameness would justify institution of prophylactic hoof health examination and, if necessary, trimming because of the expected prevention of lameness and that this measure would not constitute an undue economic burden to the producer. For example, in a dairy herd with 500 cows in lactation, a 25% reduction in incidence of lameness (from 24% to 18%) would result in a reduction in new cases of lameness from 120 to 90 cows. Assuming an economic loss of $400/cow to lameness in this herd,[5,13] the cost of lameness without intervention during midlactation would be $48,000 (120 cows × $400/cow). With intervention, the estimated cost would be $41,000, assuming a $36,000 (90 cows × $400/cow) loss from lameness and $5,000 in costs for implementation of prophylactic procedures during midlactation; in Florida, the cost of prophylactic trimming is approximately $10/cow. The cited costs of lameness are made on the basis of lower milk yield ($200 cost) and the longer calving-to-conception interval ($200 cost) observed in the study herd. That estimated overall cost of $400 does not apply entirely to the late lactation period of interest in this study. If the cost of lameness was $100/cow (eg, resulting from lower milk yield in late lactation only), the cost of lameness without intervention would be $12,000 (120 cows × $100), whereas the cost with intervention would be $14,000 (90 cows × $100 = $9,000 + $5,000).

In the earlier study conducted in Sweden,[23] increasing the frequency of hoof health examinations and procedures from every 12 months to every 6 months helped decrease the incidence of lameness in dairy cows by 33%; that reduction was significant in part because of high statistical power (4,295 cows from 77 Swedish dairy herds were included in the study). Results of the studies from Florida[4] and Sweden[23] are difficult to compare directly because of differences in study design. The latter study involved cows at different stages of lactation, cows with and without a history of lameness in a given lactation prior to treatment, and a different locomotion scoring system for diagnosis of lameness. We are not aware of other published reports in which the efficacy of prophylactic hoof health examination and trimming during midlactation to reduce incidence of lameness during late lactation in US dairy herds was assessed.

In this study, 14 (10%) of the 136 control cows examined at the end of the follow-up period had hoof lesions, compared with 6 (5%) of 118 cows in the treatment group, but the difference was not significant. This outcome comparison is difficult to interpret because the frequency of cows with hoof lesions at baseline was not

known (cows in the control group were not examined at the time of treatment group allocation). However, random allocation of cows was used to reduce bias of treatment assignment, and we have no reason to believe that the frequency of hoof lesions at baseline was lower in treatment cows than in control cows. If the true difference between groups was 5% (10% vs 5%), the power of detecting this difference with the sample sizes used was 45%. A 50% decrease in the incidence of hoof lesions may not seem relevant because of the relatively low frequency of lame cows with hoof lesions during late lactation in this herd. However, because white line disease and sole ulcers can cause severe pain and lameness in cows, this result is important from both animal welfare and production-economy perspectives and would be even more important in commercial dairies with a high incidence of cows with hoof lesions and lameness during lactation. In the study[23] from Sweden, increasing the frequency of cows' hoof health examination and use of functional and corrective procedures helped decrease the incidence of hoof lesions in dairy cows by 28%.

a. Statistix, version 7, Analytical Software, Tallahassee, Fla.

Appendix

Locomotion scoring system used in 333 Holstein cows.

Locomotion score	Clinical description	Assessment criteria
0	Nonlame	Cow stands and walks with a level-back posture. Gait is normal.
1	Nonlame	Cow stands with a level-back posture but develops an arched-back posture while walking. Gait is normal.
2	Nonlame	An arched-back posture is evident when cow is standing or walking. Gait appears normal.
3	Moderately lame	An arched-back posture is evident when cow is standing or walking. Gait is altered and best described as short strides in 1 or more limbs.
4	Lame	An arched-back posture is always evident, and gait is best described as 1 deliberate step at a time. The cow favors 1 or more limbs or feet.
5	Severely lame	Cow is unable or extremely reluctant to bear weight on 1 or more limbs or feet.

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