Risk Factors for Reduced Locomotion in Dairy Cattle on Nineteen Farms in The Netherlands

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ABSTRACT

A 3-point locomotion scoring system was used that incorporated the position of the back of cows while standing and when walking to investigate risk factors for elevated locomotion scores of 1,450 dairy cows on 19 farms in The Netherlands. Each of the farms was visited twice in an 18-mo period from February 2003 to July 2004. At each visit, all milking and dry cows were scored for locomotion by a single observer. Two multivariable regression models were constructed to identify factors associated with elevated mean locomotion score (increased abnormality) and the percentage of cows with the highest score (score 3). Risk factors for increased locomotion score were having a hoof-trimming stall with foot-lifting apparatus compared with not having such apparatus (increase in locomotion score = 0.15), presence of a footbath at the parlor exit or other site compared with not having a footbath on the farm (increase in locomotion score = 0.17 and 0.19, respectively), not providing supplemental vitamins and minerals to lactating cows compared with supplementing animals (increase in locomotion score = 0.17) and feeding corn silage to heifers compared with not doing so (increase in locomotion score = 0.10). The results provide a framework for hypotheses for future investigations of risk factors for high locomotion scores.

Key words: dairy cow, lameness, locomotion score, The Netherlands

INTRODUCTION

Lameness is a painful condition (Whay et al., 1997) and affects dairy cow well-being by reducing mobility and preventing normal behavior (Farm Animal Welfare Council, 1997). It reduces milk production (Green et al., 2002), fertility (Garbarino et al., 2004), voluntary visits to a robotic milking machine (Klaas et al., 2003),

and increases replacement rates (Sprecher et al., 1997; Booth et al., 2004). It is also of great economic cost (Green et al., 2002). Economic incentives for milk quality and research have led to improvements in the management of mastitis and SCC in dairy cattle. This is partly due to financial inducement directly assigned to farmers and due to the development of generic recommendations for mastitis control and prevention, such as the 5-point plan (Blowey and Edmondson, 2000). However, there have been few improvements in management of lameness in dairy cattle. Unlike mastitis, there are no direct financial incentives to reduce lameness. Management plans to minimize lameness in dairy cattle have not yet been developed because the research evidence is not robust enough to provide such a plan.

It is clear that there is a high prevalence of lameness and this is the evidence that recommendations are needed, both general and targeted, to reduce lameness. The prevalence of lameness in Europe has been estimated at 1.2% in 34 zero-grazing herds in The Netherlands (Smits et al., 1992), 5% on 101 farms in Sweden (Manske et al., 2002), and 22% on 53 farms in England (Whay et al., 2002). It is possible that the wide variation, both regionally and nationally, in estimates of prevalence of lameness occurs because of the scoring system used and because of different observers.

Observing lameness in cattle and scoring abnormalities in locomotion is subjective. To improve the objectivity of lameness, recording a number of lameness or locomotion scoring systems have been developed (Whay, 2002). However, some of these systems include subjective definitions of their specific scores, for example “...obvious lameness, some difficulty turning...” (Manson and Leaver, 1988); “...slightly lame...markedly lame...” (Tranter and Morris, 1991); and “abnormal locomotion/tender footed...lame...” (Whay et al., 1997). The system developed by Sprecher et al. (1997) uses the position of the back as well as placement of the feet and action in moving, and has clear objective descriptions of posture and gait for scoring, including subdivisions between sound and clinically lame. The system has 5 categories of increasing severity. The first describes a normal locomotion and only considers the back

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position (flat while standing and walking), the next describes a mild abnormality only visible when the animal walks when the back is arched and gait is abnormal. The top 3 scores classify a bovine as lame and observations are arching of the back while standing and walking, and increasingly poor placement of feet.

Despite the limitations of assessment of lameness, there are studies that report associations between management and lameness. Some have focused on the presence of foot lesions and others on actual abnormal locomotion as an indicator of lameness. In the former, solid concrete floors were associated with an increased prevalence of hoof lesions when compared with straw yards around first calving (Webster, 2002), straw yards for milking cows (Somers et al., 2003), slatted-concrete floors (Frankena et al., 1992), and rubber slats (Hultgren and Bergsten, 2001). Increased hoof lesions were associated with reduced lying times (Leonard et al., 1996), discomfort when lying, and the presence of high steps and slopes in housing (Philipot et al., 1994). However, in a recent study, although 2% of nearly 5,000 cows from 101 farms had hoof lesions, only 5% were clinically lame (Manske et al., 2002), suggesting that studies of lesions may not be specific to prevent lameness.

Studies in which clinical lameness has been used as the outcome of interest (usually defined by need to give treatment) have associated a high prevalence of lameness with slippery walking areas and uncomfortable stalls (Faull et al., 1996), free stalls compared with tie stalls (Cook, 2003), concrete compared with a sand stall base (Cook, 2003), and the lack of biotin supplementation for milking cows (Hedges et al., 2001). These studies provided associations and are independently insufficient evidence to form the basis of a management program; consequently, it is not yet possible to provide a best-practice management for reducing lameness in dairy cattle from scientific literature. Exposure to different husbandry practices means that risk factors for lameness are likely to vary between farms, management systems, and countries; therefore, a generic and targeted plan is required.

The aim of Lamecow (an European Union framework 5 funded project number OLRT-2001-00969) is to use a multidisciplinary approach to reduce lameness in dairy cows through development of "best practice" in dairy enterprises in member states of the European Union and to understand the biological mechanisms by which lameness is caused and may be minimized. The first stage was to elucidate specific risks. The purpose is to report risk factors identified from an epidemiological study that were associated with increased mean and maximum locomotion scores on 19 farms in The Netherlands.

MATERIALS AND METHODS

Nineteen farms in The Netherlands (1,450 cows) were enrolled into a study of risk factors associated with high locomotion score in dairy cattle in February 2003. These farms were selected from approximately 500 farms employing 1 of 5 professional hoof trimmers at the convenience of the researchers. Each hoof trimmer worked in one area of the Netherlands, specifically the north, northeast, northwest, east, and south.

The 5 hoof trimmers each visited 4 farms and trimmed all the cattle. Each farm was also visited twice by a researcher (PK), one visit during winter housing and once when the cattle were at pasture, with the exception of one herd that was visited during the housed period only. At each visit, all cows were locomotion-scored by PK in confinement or at pasture, using an adaptation of the method of Sprecher et al. (1997), in which scores 3 to 5 were classed as score 3 (Table 1), enabling all scoring to be done using only the position of the cow's back while walking and standing. Farmers completed a questionnaire with questions on management practices that have been hypothesized as risks for lameness (Manske, 2002) including aspects of housing, nutrition, and health for heifers, lactating cows, and dry cows (Table 2). In addition, there were observations made directly on the housing environment including cubicle dimensions, bedding and floor types, and external observations of tracks and gateways. Farmers were asked to complete the questionnaire themselves; answers that were unclear were clarified at the subsequent visit by PK.

Data Management and Analysis

All data were entered into a Microsoft Access database and were examined for errors and missing values that were checked against paper records and, where possible, followed up by contacting the farmer.

The impact of management on locomotion score was assessed in 2 separate models. The individual farm mean locomotion score was calculated by summing the individual cow scores from all visits and dividing by the number of cow observations per farm. The percentage of cows with locomotion score 3 was estimated by summing the number of locomotion score 3 observations from all visits and dividing by the total number of observations. Any differences between the housing and pasture visit locomotion scores was assessed using ANOVA of the farm mean scores.

All independent variables with at least 3 farms in each category were tested first in bivariate linear regression models with mean locomotion score and then with percent locomotion score 3 as the outcome variable. Independent variables with a significance probability

Table 1. The study locomotion scoring system compared with criteria of Sprecher et al. (1997)

Study locomotion scoring system			Sprecher et al. (1997)	
Locomotion score	Back position at standing	Back position while walking	Score and clinical description	Assessment criteria
1	Flat	Flat	1 (normal)	The cow stands and walks with a level-back posture. Her gait is normal.
2	Flat	Arched	2 (mildly lame)	The cow stands with a level-back posture but develops an arched-back posture while walking. Her gait remains normal.
			3 (moderately lame)	An arched-back posture is evident both while standing and walking. Her gait is affected and is best described as short-striding with one or more limbs.
3	Arched	Arched	4 (lame)	An arched-back posture is always evident and gait is best described as one deliberate step at a time. The cow favors one or more limbs/feet.
			5 (severely lame)	The cow additionally demonstrates an inability or extreme reluctance to bear weight on one or more of her limbs/feet.

of less than 0.25 were then tested in the general linear multivariate regression models. The multivariate models were developed using manual forward stepwise and backward elimination. The significance probability was set at $P < 0.10$. If, after a nonsignificant term was removed, a coefficient changed by $>50\%$, then that term was retained as a confounder in the model. No interaction terms were tested. After each model was built, all the variables not in the final model were retested individually. Those with a significance $P < 0.10$ were then included in the model. All statistical analysis was carried out using S-PLUS for Windows (version 6.2; Insightful Corp., Seattle, WA).

RESULTS

The mean and standard errors for locomotion score and percent locomotion score 3 was 1.6 ± 0.03 (range: 1.2 to 1.9) and 16.5 ± 1.29 (range: 3.8 to 30.8), respectively (Table 3). There was no apparent change in locomotion score by visit (approximately 6 mo between visits). The mean herd size was 76.1 (range: 33 to 113) cows with an average yield of $8,439 \pm 145.8$ kg. All of the farms used stall-housing systems, all were bedded with saw-

dust apart from one using straw, and all had slatted concrete floors. Eleven farms indicated that they fed some form of supplemental vitamins and minerals to the milking cows (specific mineral and vitamin details were recorded for copper, vitamin E, and biotin only), but no farms fed supplemental biotin in the diet. Further details of these farms are presented in Table 3.

In a univariate analysis, 10 variables were associated with mean locomotion score ($P < 0.25$). The presence of a hoof-trimming stall with foot-lifting equipment, a footbath, copper sulfate in a footbath, keeping sick animals in a separate house, cows not standing after milking before reentering their housing, heifers not given vitamin supplements, milking cows not given vitamin supplements, managing grazing using any method other than set stocking density, and increased average milk yield were associated with elevated locomotion scores (Table 4). Four variables remained in the final model for mean locomotion score (Table 5). These were having a hoof-trimming stall with a foot-lifting apparatus compared with not having such apparatus (mean locomotion score increase of 0.15), presence of a footbath at the parlor exit or another site compared with not having a footbath (mean locomotion score in-

Table 2. Areas of risk factors related to locomotion scores of dairy cows on farms from The Netherlands

Farm data recorded	
Farmer questionnaire	By direct observation
Buildings and building management	Floor types
Fields and field management	Bedding type and quantity
Lame cow management	Cubicle type and dimensions
Use of footbaths	Passageway dimensions
Replacement policy	Collecting yard and parlor details
Heifer rearing	Tracks and gateways
Dry cow management	
Transition to milking herd	
Milking cow management	
Parlor management and milk recording	

Table 3. Mean ($\pm$ SE) values for mean locomotion score and percentage of cows with locomotion score = 3 and main farm variables for 19 dairy herds in The Netherlands

Farm average locomotion score	1.6 $\pm$ 0.03
Proportion of cattle with locomotion score 3	16.5 $\pm$ 1.29
Stall types, %	
Dutch Supercomfort ('mushroom')	16
Newton Rigg	42
Cantilever	37
Other	5
Wall dimensions, m	
Length	2.30 $\pm$ 0.03
Width	1.11 $\pm$ 0.004
Center dimensions, m	
Length	2.18 $\pm$ 0.02
Width	1.11 $\pm$ 0.005
Stalls per cow	1.03 $\pm$ 0.04
Bedding, %	
Straw	5
Sawdust	95
Lying floor base, %	
Concrete	68
Mat	26
Mattress	5
Floor cleaning, %	
Automatic scrapers	32
No scrapers	68
Herd size (study distribution), %	
26 to 50	15
51 to 75	30
76 to 100	45
101+	10
Milk yield, kg	8,439 $\pm$ 145.8

crease of 0.17 and 0.19, respectively), not providing supplemental vitamins and minerals to lactating cows (mean locomotion score increase 0.17), and the inclusion of corn silage in the diet of heifers compared with not doing so (mean locomotion score increase of 0.10). The final model for the percentage of locomotion score 3 retained the same variables with the same effect as the mean locomotion score model (data not presented). The residual plot for both models indicated a random distribution of the residuals around the mean.

DISCUSSION

The locomotion scoring system suggested by Sprecher et al. (1997) was used because of the clear objective descriptions that differentiated each score. Scores 3 to 5 were merged because a large number of cattle could then be scored rapidly using only the position of the back of the cow at standing and walking and also because scores 4 and 5 in Sprecher et al. (1997) identify markedly lame cows; a minimal number of score 4 and 5 animals were expected. Not all cows that arch their back are apparently lame on their feet, but for our study these cattle are assumed to have poor locomotion. Any other condition causing arching of the back would be rare and lead to a slight error. Some cows that were lame did not arch their backs, but again these were a negligible proportion and were not scored as being lame

Table 4. Univariate models for mean locomotion score against individual risk factors for 19 farms from The Netherlands including all terms associated with $P < 0.25$, average yield, and herd size (CI = 95% confidence limit)¹

Risk factor	n	Coefficient	SE	P	Lower CI	Upper CI
No hoof trimming stall	7					
Hoof trimming stall with foot lift	12	0.13	0.07	0.06	0.00	0.26
No footbath	5					
Footbath at parlor exit	10	0.05	0.08	0.56	-0.10	0.19
Footbath at other site	4	0.20	0.09	0.05	0.01	0.38
Do not use copper sulfate	14					
Copper sulfate footbath solution.	5	0.10	0.08	0.19	-0.05	0.25
Sick and lame animals kept in same house	7					
Sick and lame animals in separate house	12	0.11	0.07	0.11	-0.02	0.24
Cows go straight into housing after milking	11					
Cows stand for >0 min after milking	5	-0.10	0.08	0.26	-0.26	0.06
Information not given	3	-0.02	0.10	0.81	-0.22	0.17
Heifers not given vitamin supplements	10					
Heifers given vitamin supplements	9	-0.12	0.06	0.09	-0.24	0.01
Milking cows not given vitamin supplements	8					
Milking cows given vitamin supplements	11	-0.11	0.07	0.1	-0.24	0.01
Milking cows set stocked	5					
Milking cows grazed in rotation	7	0.13	0.09	0.16	-0.04	0.30
Milking cows zero grazed	2	0.16	0.12	0.21	-0.08	0.40
Milking cows given other grazing regimen	5	0.02	0.09	0.83	-0.16	0.20
Increase in herd size per 100 cows	42 to 113	0.01	0.19	0.94	-0.35	0.38
Increase in yield per 1000 kg	7,000 to 9,200	-0.10	0.05	0.06	-0.19	0.00

¹Factors in bold are the reference category for each term.

Table 5. Final linear regression models for farm mean locomotion score for 19 dairy herds from The Netherlands (CI = 95% confidence limit)^{1,2}

Risk factor	n	Coefficient	SE	P	Lower CI	Upper CI
Intercept		1.39	0.06	<0.001	1.26	1.52
No hoof trimming stall	7					
Hoof trimming stall with foot lift	12	0.15	0.05	<0.05	0.05	0.25
No footbath	5					
Footbath at parlor exit	10	0.17	0.06	<0.05	0.04	0.29
Footbath at other site	4	0.19	0.07	<0.05	0.05	0.32
Milking cows not given vitamin supplements	8					
Milking cows given vitamin supplements	11	-.17	0.06	<0.05	-0.28	-0.06
Heifers not fed corn silage³	9					
Heifers fed corn silage	10	0.10	0.05	0.063	0.00	0.20

¹Factors in bold are the reference category for each term.

²Model significance: $P < 0.01$; null deviance: 0.40 on 18 df; residual deviance: 0.13 on 14 df; $R^2 = 0.67$.

³Term not initially screened at $P < 0.25$.

(P. Kloosterman, personal communication). Using a simple objective scoring system could improve assessment of lameness through its ease of use, and allow quick training of evaluators.

The study herds were larger than the national average (76.1 vs. 60.5 cows, respectively) and produced more milk [8,439 vs. 7,415 average kg/cow; Productschap Zuivel (2005)]. All farms used a stall-housing system with slatted concrete floors and most bedded using sawdust (one with unhopped straw). Although this is the predominant housing type for The Netherlands it does preclude extrapolation of data to other housing systems such as straw yards (Somers et al., 2003), tie stalls (Cook, 2003), and rubber flooring (Hultgren and Bergsten, 2001). However, the variation of locomotion scores in cows from these homogeneous housing types means that our data could be used in an analytical study to compare the effects of other aspects of management and environment on locomotion score and to generate further hypotheses for study.

The 10 farms on which heifers were fed corn silage as part of their ration had higher locomotion scores than those on which corn was not fed. It has been reported in a study of 80 French dairy farms that the presence of laminitis and interdigital dermatitis was associated with an increased period of feeding corn silage (Faye and Lescourret, 1989) to milking cows. A possible hypothesis for this association is that corn silage causes metabolic disorders because of rapid fermentation in the rumen and a subsequent increase in acidity (Abel et al., 2001). These metabolic disruptions reduce the quality of hoof horn development (Mulling et al., 1999) and may predispose the cow to lameness because of lower resistance to wear. The current findings indicate that this may also be of concern in horn development in younger animals.

Supplementation with minerals and vitamins was associated with a reduction in locomotion score. Previous work has indicated that biotin is associated with a reduction in lameness, specifically white line disease (Hedges et al., 2001). Laboratory studies indicate that both biotin and zinc supplementation improve the quality of developing hoof horn, indicating the biological mechanism for these supplements (Mulling et al., 1999). This study provides further evidence that such supplements assist in reduction of lameness. Although no farms used a specific biotin supplement, these supplements may have balanced corn feeding. It is possible that the inclusion of supplements reflected superior management practice on these farms.

We hypothesize that farmers that recognized a high level of lameness in their herd might have purchased a hoof-trimming stall with lifting equipment as might those who treated their own lame cows. All farms used professional hoof trimmers routinely, but these brought their own hoof-trimming equipment. It is possible that hoof trimming by farmers was detrimental to the locomotion of the cows because of low quality of trimming (Kofler, 1999). Whatever the cause, having such equipment on the farm was associated with an increase, not a decrease, in lameness; the farmer's use of this equipment requires further study. The association between foot trimming by farmers and increased lameness was found in a parallel study in England and Wales (Z. E. Barker, J. R. Amory, J. L. Wright, R. W. Blowey, and L. E. Green, unpublished data). Similarly, the presence of a footbath may indicate a high level of infectious lameness (Sumner and Davies, 1984). Experimental studies indicate that the use of footbaths is beneficial in controlling digital dermatitis (Faye and Lescourret, 1989). A benefit from the use of footbaths was not detectable on commercial farms in this study. This is simi-

lar to the results of Wassink et al. (2003) in which there was no evidence that foot bathing was associated with a lower prevalence of foot rot (an infectious disease causing lameness in sheep). The lack of efficacy within this study may occur because the farmers did not use the footbath or because the baths were used incorrectly. The latter could include the footbath solution not being changed frequently and becoming contaminated or being too dilute or too concentrated. It might also be that the pit of the footbath became filled with feces and all cows then have to walk through this slurry as they leave to parlor possibly increasing the risk of spread of digital dermatitis.

A number of factors previously associated with increased lameness were not identified in our study. For example, Faull et al. (1996) reported an association between stall design and lameness, but no such association was found here because of the homogeneity in the farms. Epidemiological studies can be used to identify associations, but they cannot identify nonassociation just that there was no difference between an explanatory variable and the outcome.

In summary, aspects of diet, presence of a footbath, and presence of a hoof-trimming stall with foot-lifting gear were associated with poor locomotion. Reduction in lameness did not occur merely because farmers had good hoof-trimming equipment or a footbath. Absence of the role of specific types of housing occurred because of the lack of heterogeneity between farms. We hypothesize that improving diet management, ensuring that farmers can trim feet correctly (or use a trained expert), and using a footbath correctly may assist in lowering the prevalence of high locomotion scores. Elucidation of management practices and the specific lesions causing lameness and their association with locomotion score will assist in identification of targeted interventions.

CONCLUSIONS

Using linear multivariate models, risk factors for increased abnormality of locomotion were diet (including that of heifers), the presence of a footbath, and the presence of a hoof-trimming stall. Although foot bathing and correct foot trimming can certainly improve locomotion, the presence of such equipment on farm is not sufficient if not used or used improperly. Locomotion may be improved by addressing these areas and either using existing evidence to inform farmers of recommended management or through testing new management strategies to reduce lameness in intervention studies.

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