

# A pilot study to determine the production and health benefits of milking visibly lame cows twice daily compared with three times daily

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## Abstract

A randomized clinical trial was conducted on lame cows to study the effect of milking frequency on milk production, lameness prevalence, and body condition score (BCS). At the beginning of the study, the entire herd of lactating Holstein dairy cows was visual locomotion scored (VLS) by 2 trained veterinarians. Lame cows (VLS > 2) were eligible for the study. The initial study population consisted of 270 cows randomly allocated to the three-times-daily milking frequency group (MFG) and 230 cows randomly allocated to the twice-daily MFG. Milking frequencies did not significantly affect average milk production. Cows in the twice-daily MFG had a significant increase in BCS, however, compared with cows in the three-times-daily MFG ( $P$ -value < 0.001). In addition, the probability of lameness in cows in the three-times-daily MFG was 36% higher than for cows in the twice-daily milking routine ( $P$ -value = 0.006).

## Résumé

Un essai clinique randomisé a été effectué sur des vaches qui boitent afin d'étudier les effets de la fréquence de traite sur la production laitière, la prévalence de boiterie et le pointage de la condition corporelle (BCS). Au début de l'étude, 2 vétérinaires entraînés ont attribué une note après examen visuel de la locomotion (VLS) du troupeau entier de vaches Holstein en lactation. Les vaches qui boitent (VLS > 2) étaient éligibles à cette étude. La population initiale à l'étude était constituée de 270 vaches réparties de manière aléatoire au groupe avec une fréquence de traite (MFG) de 3 fois par jour et 230 vaches réparties de manière aléatoire au groupe avec une MFG de 2 fois par jour. La production moyenne de lait n'était pas affectée par les fréquences de traite. Une augmentation significative du BCS était noté chez les vaches dans le groupe avec une MFG de 2 fois par jour comparativement à celle du groupe avec une MFG de 3 fois par jour ( $P < 0,001$ ). De plus, la probabilité de boiterie chez les vaches avec une MFG de 3 fois par jour était 36 % plus élevé que celle des vaches avec une MFG de 2 fois par jour ( $P = 0,006$ ).

(Traduit par Docteur Serge Messier)

## Introduction

Lameness is a crucial issue in the welfare of cows in modern dairy production (1,2). Lame cows suffer discomfort and long-lasting pain (3). The observation of lameness has been classified as the most representative animal-based indicator of welfare in dairy cattle (4). Lameness is of concern to the welfare of cows due to its debilitating effects and high prevalence in herds throughout the world (5,6). Preventing lameness is the most important step in reducing its implications for cows as well as the associated economic losses to dairy farmers (7).

As shown in our previous research, lameness is significantly associated with poor body condition score (BCS), which is highly associated with the thickness of the digital cushion (8). The digital cushion is primarily composed of adipose tissue located underneath the distal phalanx; its biomechanical importance is in alleviating compression under the tuberculum flexorum of the distal phalanx and protecting the living epidermis beneath the cushion. Animals with thinner digital cushions are 3.4 times more likely to have claw

horn lesions, which are a major cause of lameness in cattle (8). The importance of protecting the dermis from compression by the third phalanx is highlighted in several observational studies that associated lameness with production systems and management strategies. For example, dairy cows housed in zero-grazing, free-stall production systems appear to have the highest prevalence of lameness, probably because they stand on a hard concrete floor between lying bouts (9). Espejo and Endres (1) reported that the amount of time spent away from the pen for milking purposes each day was significantly associated with lameness prevalence. Several previous studies of cows have shown that increased comfort and resting time are associated with healthier feet (1,9,10).

## Materials and methods

Although cows have traditionally been milked twice daily, the practice of milking three times daily is becoming popular as it has been demonstrated to increase milk production by 6% to 28% (11). Increased milking frequency is likely to increase the amount of time

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that a cow spends away from the herd, which decreases the cow's resting time and ultimately affects foot health. Therefore, the objective of this study was to evaluate the effect of milking lame cows [visual location score (VLS) > 2] twice daily versus three times daily on lameness prevalence, BCS, and milk production. Our hypothesis was that lame cows would benefit from twice-daily versus three-times-daily milking as a result of the increased resting time.

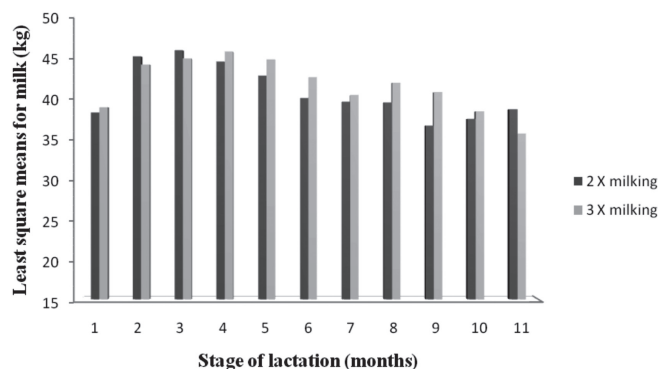
A randomized clinical trial was conducted to study the effect of milking frequency on lameness prevalence, BCS, and milk production in lame cows. The study was conducted on a dairy farm near Ithaca, New York from January 30 to May 8, 2009. This farm was selected because of a longstanding history of collaborative efforts with the Ambulatory and Production Medicine Clinic at Cornell University. The farm milked 2800 Holstein cows three times daily in a double-52 milking parlor. The cows were housed in free-stall barns with concrete stalls covered with mattresses and bedded with waste paper-pulp. Feed alleys were grooved-concrete flooring, which was cleaned by automatic scrapers.

Before the study began, all of the herd's 2800 lactating cows were visual locomotion scored by 2 trained veterinarians using a 5-point scoring scale (1 = normal and 5 = extremely lame) as described in a previous study (8). Cows were also body condition scored using the 5-point scale with a quarter-point system (1 = thin to 5 = obese) as described by Edmonson et al (12). The scores were recorded using a voice recording device and then entered into a computer database. Each cow received 2 scores, 1 from each observer, and the weighted average of the 2 scores was calculated. The cows were classified as lame and therefore eligible for the study when the weighted average of the visual locomotion scores (VLSs) was > 2.

While a total of 600 cows were classified as lame, 100 cows were excluded from the study because they were in the antibiotic pen or were due to be dried-off within the study period. Therefore, the initial study population consisted of 270 cows randomly allocated to the three-times-daily milking frequency group (MFG) and 230 cows randomly allocated to the twice-daily MFG. Due to the logistics of milking schedules and the physical availability of free-stall pens, all 230 cows from the twice-daily MFG were housed in a single pen containing 210 free-stall beds and the 270 cows from the three-times-daily MFG were equally allocated into 3 free-stall pens physically identical to those of the twice-daily MFG. The 4 study pens were kept at similar crowding rates throughout the study period. However, the cows in the three-times-daily MFG were co-mingled with healthy lactating cows to complete the stocking of the pens.

Two experienced veterinarians from the research team collected the visual locomotion scores (VLSs) and BCS on a monthly basis. Information on individual cows, such as parity number, stage of lactation, milk production, fresh date, and lameness cases, was extracted from Dairy Comp 305 (Valley Agricultural Software; Tulare, California, USA).

Descriptive statistics and univariate analysis were undertaken in SAS (SAS Institute, Cary, North Carolina, USA) using the FREQ and UNIVARIATE procedures. The effect of the milking frequency group (MFG) on BCS was analyzed by a general linear mixed model fitted to the data using the MIXED procedure of SAS. The dependent variable in this model was BCS and the independent variables were MFG, parity (1, 2, > 2), study month (1 to 3), and the interaction



**Figure 1. The effect of twice-daily and three-times-daily milking on milk production. A general linear mixed model was used to analyze the data. The dependent variable was test day milk (kg) and the independent variables were milking frequency, parity group, and stage of lactation. There was no significant difference in milk yield between the twice-daily and three-times-daily milking groups ( $P$ -value = 0.21).**

**Table I. Least square means of body condition scores and their respective confidence intervals. Data were analyzed using the MIXED procedure of SAS. A first-order autoregressive covariance structure was used to account for the within-cow correlation of the BCS observations**

Variable	LSM	95% CI	$P$ -value
Three-times-daily milking	2.93	2.91 to 2.95	< 0.001
Enrollment	2.93	2.90 to 2.96	
30 d	2.91	2.88 to 2.94	
60 d	2.93	2.90 to 2.96	
90 d	2.95	2.92 to 2.99	
Twice-daily milking	2.98	2.96 to 3.00	
Enrollment	2.93	2.90 to 2.96	
30 d	2.95	2.92 to 2.98	
60 d	3.01	2.98 to 3.05	
90 d	3.03	2.99 to 3.06	

LSM — least square means.

CI — confidence interval.

d — day.

of MFG and study month. A first-order autoregressive covariance structure was used to account for the within-cow correlation of the BCS observations.

The effect of milking frequency on milk production was also analyzed by a general linear mixed model fitted to the data using the MIXED procedure of SAS (SAS Institute). The outcome variable was test day milk (kg) and the independent variables were MFG, parity group, stage of lactation, and the interaction of MFG and stage of lactation. To account appropriately for within-cow correlation of the daily milk yield (DMY), the error term was modeled by imposing a first-order autoregressive covariance structure for all statistical models. To analyze the effect of MFG on the odds of lameness (VLS > 2), a mixed logistic regression model was fitted to the data using Stata (StataCorp, College Station, Texas, USA). The dependent variable in this model was the dichotomous variable lame (0 = VLS < 3 and 1 = VLS > 2) and the independent variables were MFG, parity group, study month, and the interaction of MFG and

**Table II. Mixed logistic regression model evaluating the effect of treatment group (twice-daily versus three-times-daily milking) on the probability of lameness (VLS > 2). The variable “cow id” was added to the model as a random effect**

Variables	<i>n</i>	Lame at enrollment	Lame at 30 days	Lame at 60 days	Lame at 90 days	Adjusted odds ratio	<i>P</i> -value
Three times daily	261	100%	64%	56%	47%	1.36	0.006
Twice daily	219	100%	63%	51%	38%	Ref.	
Parity = 1	30	100%	57%	40%	10%	Ref.	0.01
Parity = 2	205	100%	43%	38%	23%	0.94	
Parity > 2	245	100%	52%	44%	31%	1.32	

Ref. — value of lameness in the reference group.

study month. Additionally, the variable “cow id” was added to the model as a random effect.

## Results

The final general linear mixed model included the following independent variables: milking frequency, parity group, stage of lactation, and the interaction of milking frequency and stage of lactation. Milking frequency did not significantly affect average milk production: the three-times-daily group had a least square means (LSM) of 41.9 kg/d and the twice-daily group had an LSM of 41.0 kg/d (*P*-value = 0.21) (Figure 1). These results differ from most of the available scientific literature. Other authors reviewed the available literature and concluded that milking three times daily increases milk production by 20% compared with milking twice a day (13). These published studies included entire groups of cows regardless of locomotion status, whereas the present study included only clinically lame cows. Cows affected by lameness are significantly thinner than their herdmates (8) and are likely to be ranked low in the hierarchical organization within the group (14). Therefore, when lame cows were milked twice daily, more time was probably allocated for resting and eating, which would compensate for the less frequent milking routine.

Milking frequency significantly affected BCS. Animals milked three times daily had a mean BCS of 2.93 while the twice-daily group had a mean BCS of 2.98 (*P*-value > 0.001). It must be emphasized that BCS did not differ between the 2 MFGs at the beginning of the study and a gradually larger difference was observed throughout the study period (Table I). These results are in accordance with previous studies, which reported that cows milked less frequently improved body weight and BCS at dry-off when compared with the standard management used in the study (15). Additionally, when cows were milked three times daily, the plasma glucose was 6% lower and the plasma β-hydroxybutyrate (BOHB) was increased by 19% compared with cows in the twice-daily milking group. This indicates the negative energy balance experienced by the cows that were milked three times daily (16).

The probability of lameness for cows in the three-times-daily MFG was 36% higher than for cows in the twice-daily MFG (*P*-value = 0.006) (Table II). At enrollment, 100% of the cows from both groups were visually lame (VLS > 2) and lameness prevalence decreased gradually throughout the study period, although at a higher rate for the twice-daily MFG than the three-times-daily MFG. Recent

research evaluated the effect of milking frequency (once daily versus twice daily) on hoof health and the authors concluded that milking once a day resulted in improvements to hoof health and locomotion ability (17). When observing a group of cows throughout a milking period, it is noticeable that lame cows are typically the last ones to be milked. As a result, the lame cows are likely to be away from the pen longer than their herdmates. In addition, when lame cows return from the milking parlor, space at the feedbunk is probably occupied by the other cows, which affects the feed intake of the lame cows.

## Discussion

In the present study, lame cows in the twice-daily milking frequency group (MFG) were housed together in 1 group while lame cows in the three-times-daily group were housed with other non-lame cows. It is possible that the health benefits observed in this study were not only the result of less frequent milking, but also of lower competition in the twice-daily MFG as other healthy, dominant cows were not housed in that group.

This pilot study provided insight into the opportunity to accelerate the recovery of visibly lame cows. The authors, however, would like to acknowledge important limitations in the study design. Firstly, the study was only performed at 1 dairy farm. This limited our ability to generalize the results of the study with other dairy farms, since other characteristics, such as foot health management, flooring, bedding, and crowding rates, may influence the final result of this treatment at different farms. Secondly, it was originally planned that the animals would be sorted into the following 4 different groups: twice-daily milking with only lame cows in pen; twice-daily milking with mixed (lame or not lame) cows in pen; three-times-daily milking with only lame cows in pen; and three-times-daily milking with mixed cows in pen. This was not possible because the study was held at a commercial farm and the economic side of the business presented some limitations. Additionally, despite efforts to minimize pen effects (physically identical pens kept at similar crowding rates), this study is still exposed to some pen effect. Nevertheless, the results from this pilot study were biologically plausible and generally supported by previous peer-reviewed research.

In conclusion, when lame cows were milked twice daily, their BCS and visible lameness were significantly improved compared with cows in the three-times-daily milking group. Milk production was unaffected by milking frequency. Multi-farm research is needed in order to support the findings of the present study.

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