A Review of the Relationship Between Hoof Trimming and Dairy Cattle Welfare

Grant C. Stoddard, BS[a,*], Gerard Cramer, DVM, DVSc[b]

KEYWORDS

• Hoof trimming • Claw trimming • Dairy cattle • Welfare

KEY POINTS

- The evidence to support a specific hoof trimming (HT) technique is limited.
- The HT process creates a physiologic and behavioral response, but it is unclear if this is due to the removal of horn, the restraint, or change in a cow's time budget.
- More frequent HT seems to reduce lameness and hoof lesions in specific environmental conditions.
- There is a need for appropriately designed research on the appropriate technique, timing, and frequency of HT.
- Future HT studies should provide a clear description of the HT technique used.

INTRODUCTION

Lameness is an important concern for the dairy industry because of its high prevalence and the effect it has on the productivity and well-being of the animal. Worldwide estimates of lameness prevalence have varied from 20% to 55%.[1–3] Furthermore, the prevalence of hoof lesions at the time of HT has been shown to be even higher.[4–7] The effects of lameness results in a significant economic cost to producers and is estimated to range from $100 to $220 per cow.[8] These costs include decreases in milk production,[9–11] reproductive performance,[12–14] and increased culling.[14,15] Lameness also causes changes in behavior[16–18] as part of a pain response.[19,20]

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[a] Veterinary Population Medicine Department, University of Minnesota, 225 VMC, 1365 Gortner Avenue, St Paul, MN 55108, USA; [b] Dairy Production Medicine, Veterinary Population Medicine Department, University of Minnesota, 225 VMC, 1365 Gortner Avenue, St Paul, MN 55108, USA
* Corresponding author.
E-mail address: stodd038@umn.edu

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Despite all the negative effects lameness has on the animal and the dairy industry, there has been limited research on evaluating preventative practices in clinical trials.[21] A variety of risk factors have been identified in observational studies[1,4,5] as potential targets for interventions. One commonly recommended practice is HT.[22] HT is a common practice in the US dairy industry with approximately 85% of herds HT a percentage of their herd at least once a year.[23]

HT is thought to prevent lameness by restoring a more upright foot angle by shortening dorsal wall length and excessive thickness of the sole at the toe, thereby distributing weight more evenly within the weight-bearing surface of each claw and balancing weight bearing between the 2 claws.[24] Several different HT techniques have been described in the peer reviewed literature,[25–28] text books,[22,24,29,30] or at HT conferences.[31,32] HT techniques can be split into categories based on how the technique leaves the angle of the sole relative to the metatarsals. A majority of methods[22,24,26,30] advocate a flat sole whereby the abaxial and axial walls are trimmed to be level and perpendicular to the axis of the metatarsals. The differences that exist between the flat HT methods are mainly procedural. This method advocated originally by Raven[24] focuses on using specific measurement to achieve proper dorsal wall length and toe thickness. Other methods prefer to use hoof angle[26] or sole reading methods[30] to achieve appropriate length and thickness. The measurements for proper dorsal wall length and corresponding sole thickness have recently been called into question.[33,34] Adaptations to the flat trimming method have been advocated and have focused on increasing the amount of horn removed underneath the flexor tuberosity to reduce pressure on the sole ulcer location.[25,35]

Alternative trimming methods to the flat trimming method encourage a sloped sole whereby the abaxial wall is higher than the axial wall.[31,36] Proponents of this method consider this a more natural sole angle and the procedures to achieve this angle focus on reading the sole and stopping when dehydrated horn disappears. A majority of hoof trimmers use either these methods as a basis for their own personalized trimming techniques.[32] Data from the authors' research groups show that of 44 hoof trimmers attending a 2014 HT conference, 55% used functional trimming (the method described by Raven[24]), 17% used the white line method (a sole reading method described by Blowey[30]), 12% used the Kansas method (the method described by Siebert[31]), and 15% used a combination of methods.[37]

Unfortunately, few data exist about the efficacy of these various HT methods. Because HT is a commonly recommend practice to prevent lameness, there is a need to evaluate the efficacy, frequency, and the physiologic and behavioral response of an animal to these different techniques. One method recently used to review current knowledge is to identify knowledge gaps and set directions for future research through a systematic evaluation of the current literature.[38] The objective of this method is to critically evaluate the evidence that exists for HT techniques as it relates to efficacy, frequency, and associations with behavior and physiologic parameters.

METHODS

To achieve our stated objective in the previous paragraph a narrative integrative review was carried out in June 2016 and bias was attempted to be reduced by incorporating aspects of a systematic review, as described by Sargeant and O'Connor[38] Databases searched included PubMed, AGRICOLA, Google Scholar, and Web of Science. The search terms used for all databases were "cattle HT" and "cattle claw trimming". All languages were included in the searches. A total of 613 articles were retrieved from the results of the 4 databases and stored in RefWorks software.[39] Of the 613 articles, 348 duplicates were removed, leaving 265 for further review. The abstracts of these 265 articles were retrieved and evaluated by the primary author (GCS) according to the inclusion criteria.

Inclusion criteria

1. Study animals were living adult dairy cows.
2. One group of cows underwent an HT procedure.
3. Study used either a before-and-after comparison or a separate control group.
4. Results were published in a peer reviewed journal and written in English.

A total of 16 articles met the inclusion criteria and were grouped into 4 categories, with one article fitting into 2 categories: behavior (4), physiology (7), efficacy (4), and frequency and timing (2).

ASSOCIATIONS WITH BEHAVIOR

Background

Behavior is used as a surrogate to indicate the effect a procedure has on an animal.[40] Common behavioral indicators used to evaluate lameness include locomotion scoring (LS), lying time, activity, and walking speed. LS is a subjective measure[41,42] that defines lameness based on an alteration in gait that develops due to pain. LS is commonly used to evaluate a herd's welfare status.[42,43] Unfortunately, a recent review[44] found 25 different manual LS systems and 15 different automatic LS systems described. This variation and the subjectivity of LS create difficulty when comparing studies that use LS as the outcome. Other behaviors that have been associated with lameness are lying time, activity, and walking speed. Changes to these parameters are hypothesized to be an indicator of a pain response.[42,45,46]

Review of the Literature

Chapinal and colleagues[18] evaluated the general effect of routine HT on LS, walking speed, lying time, and the distribution of weight between the rear legs while standing. This study consisted of 48 lame and nonlame lactating Holsteins with daily data collection 1 week prior to HT and for 5 weeks after. Results from this study showed that LS was impacted only in the 2 immediate days after HT with no long-term impact. Additionally, walking speed was decreased and lying time increased after HT and these change persisted for the entire study period. Finally, only lame cows showed a change in rear leg weight distribution after trimming. Unfortunately, this study failed to describe the HT methods or treatments used and housed cows in groups of 12, limiting its generalizability.

A follow-up study by Chapinal and colleagues[47] used a similar methodology and focused on the effect of using a nonsteroidal anti-inflammatory drug (NSAID), flunixin-meglumine (flunixinmeglumine [FLUMEG], Schering-Plough Animal Health, Union, NJ), before and 24 hours after HT. The study used 66 lactating Holstein cows allocated to 3 treatment groups. Group 1 (n = 10) underwent a sham HT. Group 2 (n = 28) cows were hoof trimmed and received Flumeg. Group 3 (n = 28) cows were hoof trimmed and received saline. Gait scores and weight distribution were monitored before HT, 2 hours after HT, and the day after HT. Lying time and frequency of steps were monitored in 3 time periods — 2 days before HT, 2 days after HT, and 3 days after HT. For both the Flumeg and saline groups, there was a tendency ($P<.10$) for an over 2-hour increase in lying time in the first 2 days post-HT. This increased lying time only persisted past 2 days in the saline group. The sham trimmed group did not show this increase in lying time. No biologically significant changes were found for the other outcomes measured in this study. Due to the inclusion of a sham trimming group, this study provides evidence that the HT process affects behavior. Unfortunately, the distribution of lame cows was not equal between groups because lame cows were not enrolled in the sham group. This makes it unclear if the relationships found in this study are due to the HT process, lameness, or treatment of the lameness. Similar to the first study, this study did not adequately describe the HT technique.

A small study by Tanida and colleagues[28] evaluated the gait components of 17 cows post-HT. The study measured vertical, lateral, and forward acceleration 1 month before HT and once monthly for the 2 months post-HT. Acceleration and direction were measured using a motion sensor on the final thoracic vertebrae of the cow and by analyzing video recordings of cow movements. Results suggested that the cows gait was smoother in the month post-HT because the variances of the lateral and vertical acceleration were lower than the baseline values. The utility of this study is limited due to a small sample size and a limited number of unclearly described measurement times. In addition, the lesion status of these cows was not described. Similar to the previous studies, HT method was not described clearly.

A more recent study by Van Hertem and colleagues[27] evaluated the relationships between HT and rumination, neck activity, and LS in a 1100 cow dairy. Cows in this study were evaluated at 19 different times for LS and had daily electronic rumination and activity data recorded. LSs were analyzed in several different manners, including long term (up to 70 days post-HT) and short term (1 week pre-HT and 1 week post-HT). Results from 152 cows with LS data from 6 different time periods ranging from 34 days before HT to 70 days post-HT showed that lameness prevalence doubled significantly, from 16% to 32% in the 2 weeks post-trimming, but returned to immediate pre-HT levels by 70 days. An analysis of 288 cows that had complete data on LS, rumination, activity, and milk yield for the week before and the week after HT was also completed. This analysis showed that LS increased in the week after HT, whereas neck activity decreased only on the first day post-HT. The effect of HT on rumination was dependent on parity. Due to the larger sample size, the investigators were able to explore potential confounders, such as lesion status, parity, and days in milk (DIM). This study provided adequate details about the HT equipment and technique used.

Summary

All 4 of the studies have several common experimental design issues that limit the conclusions that can be drawn about the association between HT and behavior. None of the studies fully describe the HT process, making it difficult to judge differences in techniques and limiting the external validity of each study. In addition, all 4 studies included lame cows, making it difficult to determine if the effect was due to the HT process or the lesion treatment process. Only 1 study had a large enough sample size to attempt to control for this confounding.[27] Based on these 4 studies, the HT process is associated with a change in animal behaviors, such as resting time and LS. The increase in LS from several studies[18,27] indicates this is a negative change in the welfare status of the animal[42,43] and supports the hypothesis that the increase in lying time is a compensatory response.[17,42,43,46] To truly evaluate the impact of preventative HT on animal behavior, however, there is a need for HT studies on cows without lesions.

ASSOCIATIONS WITH PHYSIOLOGIC CHANGES

Background

To assess the welfare impact of a procedure, it is important to evaluate the impact it has on the animal physiologically.[40,48] Exposure to stressors challenges the homeostasis of an animal, leading to the activation of the hypothalamic pituitary adrenal axis and the sympathetic nervous system. This subsequently leads to an increase in stress hormones in the blood stream[49] and can have an impact ton physiologic functions, such as heart and respiratory rate, milk production, and reproductive functions. The HT process has the potential to expose the animal to various stressors, including restraint, handling, isolation, and pain due to treatment.

Review of the Literature

Nishimori and colleagues[50] investigated the effect of HT on blood parameters, in addition to milk composition and production, using 11 Japanese Holstein cows. Samples were taken before and after HT at time points that were not clearly specified. This study showed that after HT, milk fat percentage, protein percentage, and some blood parameters changed. Due to limited sample size and sampling times, however, this study has limited value.

Pesenhofer and colleagues[51] compared the effect of different chute designs on fecal cortisol metabolites and milk yield before and after HT. This study consisted of 207 lame and nonlame animals randomly assigned to the different chute designs that underwent HT according to the functional HT method.[24] Milk yield was recorded 7 days before HT and until 13 days after HT. Fecal cortisol metabolites were sampled 12 hours before HT and until 7 days after HT. This study showed a significant decrease of 0.6 L in milk production on the day of HT and the day after. Fecal cortisol metabolites were significantly higher for up to 24 hours after HT for both chute designs. This study showed that HT caused a stress response and affected the productivity of the animal. The inclusion of lame animals, however, does not allow for evaluating if the physiologic changes are due to HT or lesion treatment.

A smaller study by Rizk and colleagues[52] evaluated the stress response to HT in lateral recumbency. This study used a paired 3-way crossover design with 6 Holstein cows. Treatment groups consisted of cows receiving either a saline or xylazine injection prior to HT. Sampling times started 15 minutes before HT and continued until 3.25 hours after HT. Changes in the cardiorespiratory system, stress hormones, and metabolism were measured and compared with status pre-HT. Results from this study showed that HT causes changes in blood diastolic blood pressure, mean arterial blood pressure, oxygen saturation, respiratory rate, cortisol, and lactate. Xylazine mitigated these effects but showed a depressive effect on respiratory parameters. Observed changes in this study indicate that the HT process resulted in a stress response in the animal. Caution must be used, however, when interpreting these results because the length of restraint in the HT chute was long (30 minutes).

Korkmaz and colleagues[53] completed a randomized clinical trial using 14 cows that evaluated the impact of dexketoprofen on cows that were trimmed in a squeeze chute. Outcomes evaluated included cortisol, nitric oxide, malondialdehyde, total antioxidant activity, and heart and respiratory rates. Data were collected 30 minutes before HT and again at 15 minutes and 30 minutes after HT. Results of the study showed an increase from baseline to 15 minutes post-HT for heart, respiratory rate, and cortisol. None of the other parameters were different compared with baseline. Similar to the previous studies, this study is limited by sample size and a short follow-up period; it supports the view that the HT process affects physiologic measures.

The study by Van Hertem and colleagues,[27] described previously, also investigated milk production in the week before and the week after HT. Unlike some of the behavioral parameters, no association with HT was found for milk production.

Using a randomized controlled trial, Maxwell and colleagues[54] evaluated the effect of an early lactation functional HT[24] compared with no trimming in 281 primiparous

Holstein cows. Outcomes in this study were 305-day adjusted milk yield and conception rate at 100 DIM. No significant difference between the HT and no HT group was found for either outcome. An interaction with LS existed, however, wherein HT lame animals resulted in higher milk production post-HT compared with untrimmed nonlame animals. Results of this study with limited sample size suggested that trimming all heifers would not provide an economic return. This is one of the few studies to provide a clear description of their HT method.

The most recent physiologic study investigated the claw temperature changes that occur at the coronary band after HT.[55] Skin temperature can be increased due to inflammation[56,57] or other metabolic activity.[58] This study consisted of 81 nonlame and lame cows that had infrared temperature readings at the coronary band taken pre-HT and 21 days post-HT. HT technique was not described. At 21 days after HT, the mean change in hind feet temperature was 0.25°C (P = .08) cooler. This temperature change was different, however, between medial and lateral claws and not present in the front feet. Although this study showed a trend for a change in coronary band temperature, the biological significance of this change after 21 days is unclear.

Summary

These studies provide evidence that the HT process changes physiologic parameters. Caution must be used when interpreting and comparing these studies because sample size was limited and HT technique was not adequately described in most of the studies. The design of the studies also makes it difficult to determine if it is the restraint or the actual removal of horn that is causing the change in physiologic measures. Even though effects on physiologic parameters can be found, there is still a knowledge gap on the exact cause and the biological significance of these changes.

EFFICACY OF HOOF TRIMMING

Background

In addition to knowing how HT affects an animal from behavioral and physiologic perspectives, it is important to know if HT is efficacious at preventing lameness and lesions. The goal of HT is to prevent lameness by restoring proper foot angle, removing excess horn growth, and redistributing the weight of an animal over the 2 claws.[24] As discussed previously, there are various HT methods and it is important to evaluate the efficacy of these methods in preventing lameness.

Review of the Literature

van der Tol and colleagues[59] evaluated the standing weight distribution and surface area between hind claws in 5 Holstein cows before and 2 weeks after functional HT[24] using force plates. Results from this study showed that the average pressure on the hind limbs decreased by 30% and improved the distribution of weight between the lateral and medial claws. The improvement in the weight distribution did not equalize weight bearing between the 2 claws. Additionally, HT did not show a significant change in the maximum pressure on the claws. Although this study showed an improvement in certain weight distribution parameters due to HT, the extent of the difference was much smaller than expected and left the investigators to speculate changes in HT techniques are necessary. This study had a small sample size and only used 1 follow-up sampling time period. This makes it possible that cow-level confounders could have influenced the result or that the follow-up period was inappropriate.

Using force plates in a different manner, Carvalho and colleagues[60] evaluated the weight distribution and pressure points on the sole between trimmed cows (14) and untrimmed cows (17). In this study, the untrimmed group had significantly more total pressure applied to heel of the lateral claw of the hind limb than trimmed cows. At the claw level, numeric differences were found for increased pressure on several other claw regions. Due to small sample size and the lack of descriptive data about the cows and HT technique, it is difficult to determine if these differences are due to confounding or HT.

As a follow-up study to the van der Tol and colleagues[59] study, Ouweltjes and colleagues[25] investigated the efficacy of functional HT[24] to an adaptation that decreases the pressure in the typical sole ulcer region on both claws. Nonlame cows were randomized to either the functional method (33) or the adaptation (32) and observed for 3 months. Outcome measures included claw health, claw conformation, LS activity, and floor contact pressures. Results of the study did not show any significant differences between the 2 HT methods. There are several possible reasons for the lack of differences between treatments, including a short follow-up observation period and limited sample size. Additionally, both the lateral and medial claws trimmed with the adaptation could have masked an effect. A similarly designed unpublished study[35] did show a difference in lesion prevalence when only the lateral claw was trimmed with the adaptation. The Ouweltjes and colleagues[25] study had a clearly described trimming method section and should be considered a model for how to describe HT techniques in future publications.

A study from New Zealand evaluated the efficacy of HT in New Zealand by randomly allocating 2695 cows to functional HT[24] or no HT.[61] Outcomes evaluated included incidence and time to lameness as identified by trained farm staff. In this study, HT did not change the cumulative incidence of lameness but did increase the median time to lameness in the 70 days post-HT. This well-designed study had several strengths, including accounting for confounders and the use of multiple farms with 1 hoof trimmer. Using farm staff to identify lameness leads to an underestimated level of lameness[2] but this is a nonselective bias.

Summary

These 4 studies evaluated HT efficacy from 2 different perspectives and 3 studies showed a benefit by reducing pressures in the claw or increasing time to lameness. All the studies used the functional HT[24] method, but several other methods have been described[22,24–32] that also need to be evaluated. In addition, several studies were small in size[25,59,60] or their findings are likely environment specific.[61] Therefore, more studies evaluating the efficacy of HT are necessary.

FREQUENCY AND TIMING OF HOOF TRIMMING

Background

Hoof growth can vary with breed and genetics, but the net growth of dorsal wall horn is approximately 1 mm/mo to 2 mm/mo.[62,63] Functional HT attempts to deal with this growth by restoring an upright foot angle and balancing the weight bearing between the 2 claws.[24] Some observational studies have found associations with more frequent HT and lower lameness prevalence.[64,65]

Review of the Literature

Manske and colleagues[26] conducted a 2-year study on 3444 dairy cattle on multiple Swedish dairy farms that were block randomized to a second HT in the autumn. Regardless of allocation, all cows were LS and trimmed at the spring trimming. Results indicated that the additional trimming in the autumn led to lower odds of lameness and horn-type lesions. This study was well designed and included a long observation period with block randomization to control confounding and used multiple hoof trimmers and farms to increase generalizability to other farms in Sweden.

Hernandez and colleagues[66] evaluated the efficacy of a hoof health examination and an HT at midlactation compared with no evaluation at midlactation in 313 randomly allocated cows in 1 herd. This study showed that cows in the nontrimmed group had a 25% higher (P = .09) lameness incidence and a 1.25 (P = .12) higher risk of becoming lame compared with the trimmed group. Some problems in study design limit the interpretation of this study because the study was done in only 1 herd, the study did not evaluate control cows for lesions on entry into the study, and there was inadequate detail of the HT method.

Summary

These 2 studies showed that an additional HT can be beneficial in the herds studied. Only 1 of the studies,[26] however, described the HT technique used enough detail that it could be repeated. From these studies it is still unclear what is the most efficacious time to trim animals for a second time during lactation and if the additional HT is beneficial in all situations.

SUMMARY

This review of 16 articles of HT as it relates to the efficacy, frequency, and associations with behavior and physiologic parameters found several common study design issues that limit generalizability and conclusions. A majority of studies use a small sample size and lack a clear description of the HT technique. In the reviewed studies, HT seems to initiate a stress response, change behavior, improve components of weight bearing, and reduce lameness in specific environmental conditions.

There are still multiple knowledge gaps that need to be answered to create a more complete picture of the impact HT has on cows and lameness. Primarily, it is necessary to determine the most efficacious HT technique from physiologic, behavioral, and productivity perspectives. Furthermore, it is necessary to understand what the change in physiologic parameters means to the animal and what is causing it — the restraint or the actual removal of horn. Additionally, to encompass all aspects of welfare,[48] it is necessary to understand the effect HT has on the behavior of a nonlame animal. Lastly, additional information is needed on appropriate timing and frequency of HT.

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