Lameness is considered one of the leading welfare concerns in the dairy industry (von Keyserlingk et al., 2009). It is a costly ($100-$220/cow; Cha et al., 2010; Liang et al., 2017), painful (Whay et al., 1998), and highly prevalent, with prevalence estimated between 20 and 55% in North America (Espejo et al., 2006; von Keyserlingk et al., 2012; Solano et al., 2015) and 7.3–60.6% in the UK (Randall et al., 2019). The high cost of lameness is due to multiple factors, including milk production loss (Warnick et al., 2001; Green et al., 2002; Hernandez et al., 2005), decreased reproductive performance (Bicalho et al., 2007; Peake et al., 2011; Hudson et al., 2014), increased culling (Booth et al., 2004; Bicalho et al., 2007), and veterinary treatment and labor costs (Liang et al., 2017). Moreover, lameness can alter a cow’s natural behavioral expression, caused in part by a pain response (Whay et al., 1998; Tadich et al., 2013; Bustamante et al., 2015). Lameness causes a reduction in activity and walking speed along with an increase in resting time and in locomotion score (Chapinal et al., 2009; Gomez and Cook, 2010; Navarro et al., 2013). These behavioral changes indicate a reduced state of animal welfare (Dawkins, 2003) and further highlight the need for the implementation of preventative practices.

A recommended preventative practice for lameness is hoof trimming (HT) (Shearer and van Amstel, 2001). It is estimated that 85% of US herds have cows trimmed at least once a year (NAHMS, 2007). In the UK it is estimated that 82% of farms do preventative trimming (Pedersen et al., 2022). Despite how commonplace HT is on commercial dairies, few scientific research studies have investigated the relationship between HT and dairy cattle welfare (Stoddard and Cramer, 2017). Physiological data has shown that HT causes an acute stress response (Rizk et al., 2012; Korkmaz et al., 2014), indicated by a rise in respiratory and heart rates, as well as increases in plasma cortisol, lactate, and glucose concentrations. It is possible that this acute stress response induces changes in the behavior of the cow following HT. Previous behavioral studies have shown increases in resting time, decreases in activity, and increases in locomotion score (Chapinal et al., 2010a; b; Van Hertem et al., 2014) following HT, as compared with before HT. This would suggest that the HT process could be stressful and painful and has a negative effect on the well-being of the animal, and the cow is showing compensatory behaviors following HT. However, these previous studies included lame animals which likely influenced the observed changes, and it is unclear if the same behavioral changes would occur after HT in non-lame animals. For HT to be appropriate as a preventive practice for a non-lame cow, the behaviors associated with lameness should not be present immediately following the procedure, thus investigation into the impact of HT on behaviors of non-lame cows is warranted.

Observational study evaluating the association of hoof trimming with dairy cattle behavior and milk yield in Canada and the United Kingdom

G. Stoddard12 and G. Cramer1*
The objective of this study was to describe the associations between preventative HT of cows with no lesions and some behavioral- and production-related outcome measures, including activity, resting behaviors and milk yield in commercial dairy herds.

The procedures in this observational study were approved by the University of Minnesota Institutional Animal Care and Use Committee (1411–32094A). The study used a convenience sample of 4 Holstein herds using the AFI-PLUS or AFI-ACT2 pedometer system (Afimilk, Afikim, Israel) located in the United Kingdom (n = 2) and Ontario, Canada (n = 2). The pedometer system used allowed for the collection of activity and resting time data (Borchers et al., 2016). Participating herds were required to have a regular HT schedule, with herds routinely trimming cows either at dry off and as needed (n = 2) or at mid-lactation and dry off (n = 2) during lactation. Two of the farms used a mattress surface bedded with sawdust, one used deep bedded sand bedding and one used a combination of sand and sawdust bedding on a mattress surface. The herd sizes ranged from 104 to 1,150 cows. The average 305-d milk production for the herds ranged from 11,137 kg to 13,691 kg.

Cows were hoof trimmed according to the farm’s regular schedule and technique with no intervention from the research team. Hoof trimming techniques on all farms were variations of the functional hoof trimming technique (Toussaint-Raven, 1989).

All the farm’s HT data, describing the presence or absence of lesions, were collected from April 2015 to July 2016. Only the first non-lesion HT of a cow (i.e., a routine or as-needed trim during the lactation or a trim a dry off) was included in the analysis. Additional HT events or data from HT that had lesions were not included in the analysis. Other cow-level data such as days in milk (DIM), breed, and parity was obtained from the farm’s recording herd management software (DairyComp 305; Valley Ag. Software, Tulare. CA). Activity (steps/day), resting time (minutes/day) and resting bouts (bouts/day) were recorded daily by either AFI-ACT pedometer PLUS tags or AFI-ACTII tags (Afimilk, S.A.E. AFIKIM, Kibbutz Afikim, Israel). In addition, milk yield (kg/day) data was collected at each milking using automatic milk meters (AFIFarm, Afimilk, S. A. E. AFIKIM, Kibbutz, Afikim, Israel) and the total daily milk yield (kd/d) was calculated. All data was captured automatically every time the animal entered the parlor for milking. This behavioral and milk production data was transferred daily from the AFI herd management software to a text text-based file.

All behavioral, milk yield, cow-level and HT data management and analyses were performed using STATA 14.1 (Stata Corp., College Station, TX). Daily behavioral and milk yield data were merged with HT and cow-level data. A general linear mixed model was built to compare the outcome for 7 d after HT to the baseline for each of the following outcomes: activity (steps/day), resting bouts (bouts/day), resting time (mins/day), and milk yield (kg/day).

The baseline represents a 5-d average of the outcome of interest taken from the 5 d before trim event. This 5-d average baseline was included for all outcome models to reduce the impact of the natural variation that occurs in resting time and activity over a lactation (Maselyne et al., 2017). A 7-d follow up period was used for this study to focus on the acute effects that HT has on the outcomes. The decision to use a 7-d follow-up period was based on graphically evaluating the predictive margins of the null models. On d 7, most behaviors returned to the 5-d baseline or formed a plateau.

For each outcome variable, a generalized mixed model was created that included the following covariates: baseline value of the outcome of interest, lactation number (1, 2+), season (spring (March–May), summer (June–August), fall (September–November) and winter (December–February)), farm ID (1, 2, 3, 4), and DIM. ‘Days from HT’ was forced into all final models. All models included a time by farm interaction. All models included an exchangeable correlation structure to account for the repeated measures on cow, chosen based on the high correlations between different time points. Other correlation structures were evaluated and compared using model AIC (Dohoo et al., 2010). After models were run, contrasts of predicted margins were evaluated and graphed by farm to assess the farm by time interaction.

During the 15-mo time period, a total of 7,980 HT events, both lame and trim, were recorded. Of these records, 2,652 (33.2%) first HT events for a cow (routine and lame trim events). Of the total cows with a first HT events, 1,573 cows did not have a lesion present and had full follow up observations for outcomes of interest and thus were included in the analysis. Behavioral and milk yield data for 88 cows following HT were unavailable as the HT occurred on the day of dry-off and no post HT milk yield or behavior data were recorded. The cows included in the analysis were, on average, at 171 (95%CI: 166–176) DIM and a lactation of 1.5 (95%CI: 1.4–1.5). Descriptive statistics for the baseline behavioral outcomes (activity, resting time, and resting bouts) and baseline milk yield are presented in Table 1. Lying bouts frequency was evaluated, but little variation across the different time points in the study were found and excluded from further presentation in the paper.

The mean difference in resting time from baseline to the end of the 7-d follow-up period was dependent on farm (Figure 1). On the day of HT, farm 1 cows had the largest decrease in resting time compared with baseline (−51.8 min/d, 95%CI: −59, −44.1) followed by farm 3 (−44 min/d, 95%CI: −82.7, −6.1) and farm 4 (−28 min/d, 95%CI: −62.6, 5.9). Farm 2 did not see a reduction in resting time. Following HT, resting time increased for cows on most of the farms ranging from 1 to 25 min above baseline.

Activity had a inverse relationship to resting time, with an increase in step activity on the day of HT compared with baseline. For all farms, activity increased on the day of HT, ranging from +9 steps/d (95%CI: −7.4, 25.2) in farm 2 to +84 steps/d (95%CI: 41.4–126.3) in farm 4. All farms returned to levels that were similar to or lower than baseline with the exception of farm 3 which remained above baseline for the 7 d following HT. The average change in activity across the 7 d following HT was dependent on farm and ranged from −25 to 35 steps relative to baseline levels.

The impact of HT on milk yield was dependent on farm. Figure 2 shows the difference in estimated adjusted mean milk yields from the baseline period by farm. On the day of HT cows showed a change in milk production, but it varied in magnitude and direction among the 4 farms. Farms 1 and Farm 4 had a decrease in milk yield on the day of HT of −1.03 kg (95%CI: −1.33, −0.73) and −2.05 kg (95%CI: −3.11, −0.73), respectively. Farm 2, by contrast, had a 0.49 kg (95%CI: −0.02, 0.99) increase in milk yield on the day of HT. Farm 3 had no evidence of a change on the day of HT, but had the largest average reduction across the 7 d following HT. The average milk yield across the 7 d following HT was lower on Farm 4.

Our results indicate that changes in the cows’ lying time and activity behavior were associated with preventative HT, but the magnitude and direction of these associations was dependent on
the farm. These results indicate that on certain farms, HT may have a negative impact on the welfare of the animal.

On the day of HT, an increase in activity and a corresponding decrease in resting time on all farms was the only consistent association with HT in our study. This is an expected observation due to the change in a cow’s daily routine that HT creates. This increase in activity on the day HT has also been shown in previous research (Chapinal et al., 2010b; Van Hertem et al., 2014). The farm level variation is likely due to differences in how long cows are away from their regular pens.

Similar to previous research (Chapinal et al., 2010a; b; Van Hertem et al., 2014), cows on 3 farms had a decrease in activity on the days following HT. We hypothesize a decrease in activity on the day following HT is the cow compensating for an increase in activity on the day of HT. However, based on the association of a decrease in steps for at least 7 d on 3 of the 4 farms following HT, we hypothesize that events associated with the HT process caused this decrease; however, the exact reason as to why these cows would have this decrease in activity following HT is unclear. Possible reasons that HT is causing a change in behavior for a longer time period include the cow is acclimating to changed weight bearing between the hooves or HT creates pain or inflammatory response, or the decreased resting time on the day of hoof trimming. It is important to note, however, that it is unclear what the biological impact of a decrease (5–44 steps/d) or, in the case of the 4th farm, an increase (12–89 steps/d) in daily step activity has on the welfare of the cow. This change in activity appears to be farm dependent. Future work is warranted to determine what aspects of the HT process may be causing this behavior change to find ways to mitigate this change in behavior and potentially improve the welfare of the cow following HT.

On the day of HT, the association between milk yield and HT was variable in magnitude and direction, depending on the farm. On 2 farms an important decrease in milk production was observed. On 4th farm, an increase (12–89 steps/d) in daily step activity has on the day HT. However, based on the association of a decrease in steps for at least 7 d on 3 of the 4 farms following HT, we hypothesize that events associated with the HT process caused this decrease; however, the exact reason as to why these cows would have this decrease in activity following HT is unclear. Possible reasons that HT is causing a change in behavior for a longer time period include the cow is acclimating to changed weight bearing between the hooves or HT creates pain or inflammatory response, or the decreased resting time on the day of hoof trimming. It is important to note, however, that it is unclear what the biological impact of a decrease (5–44 steps/d) or, in the case of the 4th farm, an increase (12–89 steps/d) in daily step activity has on the welfare of the cow. This change in activity appears to be farm dependent. Future work is warranted to determine what aspects of the HT process may be causing this behavior change to find ways to mitigate this change in behavior and potentially improve the welfare of the cow following HT.

On the day of HT, the association between milk yield and HT was variable in magnitude and direction, depending on the farm. On 2 farms an important decrease in milk production was observed. These results differ from the study by (Van Hertem et al., 2014) where no evidence of a difference in milk yield was observed. We hypothesize this association was compensatory due to stress during these behavioral changes and milk production on the welfare status of the cow is not completely clear. To minimize the impact of HT on the cow, various HT techniques, and approaches to handling and restraint should be investigated to determine what effect they may have on behavior and milk production, and to determine what is most efficacious for the welfare of the cow.

This study showed that preventative HT of cows without lesions was associated with short-term changes in cows’ resting time and activity behavior and milk production, but the direction and magnitude of these changes were dependent on the farm. The impact of these behavioral changes and milk production on the welfare status of the cow is not completely clear. To minimize the impact of HT on the cow, various HT techniques, and approaches to handling and restraint should be investigated to determine what effect they may have on behavior and milk production, and to determine what is most efficacious for the welfare of the cow.

### References


### Table 1: Baseline descriptive statistics for the cows on 4 farms included in the study analyses.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. Observations</th>
<th>Mean</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIM*</td>
<td>1,573</td>
<td>171</td>
<td>166–176</td>
</tr>
<tr>
<td>Lactation</td>
<td>1,573</td>
<td>1.5</td>
<td>1.4–1.5</td>
</tr>
<tr>
<td>Daily Milk Yield (kg)</td>
<td>1,572</td>
<td>32.5</td>
<td>32.0–33.1</td>
</tr>
<tr>
<td>Total Activity (steps/day)</td>
<td>1,567</td>
<td>356</td>
<td>350–362</td>
</tr>
<tr>
<td>Total Resting Time (mins/day)</td>
<td>1,567</td>
<td>601</td>
<td>594–608</td>
</tr>
<tr>
<td>Total Resting Bouts (bouts/day)</td>
<td>1,567</td>
<td>11</td>
<td>10.8–11.2</td>
</tr>
<tr>
<td>305-d Mature Equivalent Milk yield (kg)</td>
<td>1,573</td>
<td>11,482</td>
<td>11,466–11,497</td>
</tr>
</tbody>
</table>

*DIM = Days in milk.
Following hoof trimming compared with baseline. Baseline values were calculated as the average resting time across a 5-d period before hoof trimming.

Figure 1. Predicted differences (estimate, 95% confidence interval) for total resting time (mins/day), by farm, for the day of hoof trimming (Day 0) and the 7 d following hoof trimming compared with baseline. Baseline values were calculated as the average resting time across a 5-d period before hoof trimming.


Figure 2. Figure 1: Predicted differences (estimate, 95% confidence interval) for milk yield (kg/day), by farm, for the day of hoof trimming (Day 0) and the 7 d following hoof trimming compared with baseline. Baseline values were calculated as the average milk yield across a 5-d period before hoof trimming.

Notes

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Authors’ Roles: GS led the data curation, project administration, and writing of the original draft. GS had an equal contribution to the formal analysis, investigations, methodology, and reviewing and editing of the manuscript. GC led the
visualization, supervision, funding acquisition, and resources for the study. GC had equal contributions to the formal analysis, investigation, methodology, and review and editing of the manuscript.