Effects of short-term repeated exposure to different flooring surfaces on the behavior and physiology of dairy cattle

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ABSTRACT

Dairy cattle managed in some pasture-based systems such as in New Zealand are predominantly kept outdoors all year around, but are often taken off pasture for periods of time in wet weather to avoid soil damage. It is common to keep cattle on concrete surfaces during such “stand-off” practices and we investigated whether the addition of rubber matting onto concrete areas improves the welfare of dairy cattle. Sixteen groups of 5 cows (4 groups/treatment, 5 cows/group) were allocated to 1 of 4 treatments (concrete, 12-mm-thick rubber mat, 24-mm-thick rubber mat, or deep-bedded wood chips) and kept on these surfaces for 18 h/24 h for 4 consecutive days (6 h on pasture/24 h). Each 4-d stand-off period was repeated 4 times (with 7 d of recovery between periods) to study the accumulated effects of repeated stand-off. Lying behavior was recorded continuously during the experiment. Gait score, stride length, hygiene score, live weight, and blood samples for cortisol analysis were recorded immediately before and after each stand-off period. Cows on wood chips spent the most time lying, and cows on concrete spent the least time lying compared with those on other surfaces [wood chips: 10.8 h, 24-mm rubber mat: 7.3 h, 12-mm rubber mat: 6.0 h, and concrete: 2.8 h/18 h, standard error of the difference (SED): 0.71 h]. Cows on concrete spent more time lying during the 6 h on pasture, likely compensating for the reduced lying during the stand-off period. Similarly, cows on concrete spent more time lying on pasture between stand-off periods (concrete: 12.1 h, 12-mm rubber mat: 11.1 h, 24-mm rubber mat: 11.2 h, and wood chips: 10.7 h/24 h, SED: 0.28 h). Cows on concrete had higher gait score and shorter stride length after the 4-d stand-off period compared with cows on the other surface types, suggesting a change in gait pattern caused by discomfort. Cows on rubber mats were almost 3 times dirtier than cows on concrete or wood chips. Cortisol and live weight decreased for all treatment groups during the stand-off period. We observed no major effect of the repeated stand-off exposure. In summary, adding rubber matting onto concrete surfaces for stand-off purposes is beneficial for animal welfare. A well-managed wood chip surface offered the best welfare for dairy cows removed from pasture, and the findings of this study confirm that a concrete surface decreases the welfare of cows removed from pasture.

Key words: behavior, concrete, dairy cattle, rubber mat, wood chips

INTRODUCTION

Dairy cattle spend a large proportion of their daily time resting (Singh et al., 1993; Fregonesi and Leaver, 2001; Jensen et al., 2005), and the provision of a comfortable surface to rest on is essential to maintain the health of cattle (Singh et al., 1993; Leonard et al., 1996). Cattle with reduced lying times show elevated indicators of physiological stress (Fisher et al., 2002; Tucker et al., 2007) as well as behavioral signs of frustration (Munksgaard and Simonsen, 1996; Munksgaard et al., 1999).

Lying behavior has been used as a measure of cow comfort in numerous studies investigating different surface types (Fregonesi and Leaver, 2001; Haley et al., 2000, 2001) and there is overwhelming evidence that dairy cattle prefer and spend more time lying on soft, well-bedded (Haley et al., 2000, 2001; Tucker et al., 2003, 2009; Cook et al., 2004a; Tucker and Weary, 2004; Drissler et al., 2005), and dry (Fregonesi et al., 2007; Reich et al., 2010) surfaces.

The type of lying surface strongly influences leg health (Rutherford et al., 2008; Lombard et al., 2010; Potterton et al., 2011). For example, hock health was better on deep-bedded stalls than on foam mattresses (van Gastelen et al., 2011). Indeed, leg health and lameness may be improved by the amount of bedding (Colam-Ainsworth et al., 1989) and by use of rubber mats as flooring surface instead of concrete (Leonard et al., 1994; Vanegas et al., 2006; Rushen et al., 2007).

The majority of research investigating the effects of surface types has been undertaken in systems where cats-
tle are permanently or mostly housed indoors. In some pasture-based dairy systems, such as in New Zealand, cows are predominantly kept outdoors all year round; however, in wet weather they are sometimes removed from the pasture to a separate area to reduce soil damage. Common surfaces for these “stand-off” practices include specially constructed wood-chip pads, concrete yards, small “sacrifice” paddocks, and gravel laneways. Cows can sometimes be kept on these surfaces for up to 22 h/d for several consecutive days, depending on the weather conditions. This winter management practice could influence the health and welfare of animals. For example, Fisher et al. (2003) demonstrated that cows spent less time lying and had a greater physiological stress response when they were temporarily housed on hard surfaces and on surfaces with poor drainage compared with a well-drained wood chip surface.

In New Zealand, an increasing number of farmers are interested in adding rubber mats onto concrete yards for stand-off purposes to improve animal welfare. Although it is known that long-term exposure to hard surfaces for standing and lying causes lameness and other physical injuries (Haskell et al., 2006; Potterton et al., 2011), less is known of the effects of short-term exposure to different surface types on the behavior and physiology of cattle, and in particular any potential benefits of rubber mat surfaces compared with concrete. Therefore, the aim of this study was to investigate the behavioral and physiological effects of different types of surfaces when used in a simulated weather-induced, stand-off situation during winter in a pasture-based dairy system.

**MATERIALS AND METHODS**

**Animals and Treatments**

All procedures involving animals were approved by the Ruakura Animal Ethics Committee under the New Zealand Animal Welfare Act of 1999. Eighty pregnant, nonlactating Holstein Friesian dairy cows at the AgResearch Tokanui research farm near Hamilton, New Zealand (37°47′S, 175°19′E) were used in the study. The cows had an average BW of 488 ± 52.2 kg and BCS of 4.8 ± 0.28 at the start of the experiment and were, on average, 4.5 ± 1.70 yr of age (mean ± SD for all preceding values).

Cows were divided into 2 groups of 40 and allocated to 1 of 4 treatments (16 groups in total, n = 4 groups per treatment, 5 cows per group) consisting of 4 different surface types: (1) concrete; (2) 12-mm-thick rubber mat (Agrimat Uni, 1,190 × 850 × 12 mm interlocking mat, Numat Ltd., Auckland, New Zealand); (3) 24-mm-thick rubber mat (Agrimat Kura, 1,190 × 850 × 24 mm interlocking mat, Numat Ltd.); and (4) wood chips (approximately 0.5 m deep). Cows were habituated to their group of 40 for 5 d before the start of the experiment. The cows had no previous experience of lying down on the rubber mats (the farm was using deep-bedded wood chips as a stand-off surface). Treatment groups were balanced for BW. Eight groups of 4 cows (2 of each treatment) were tested simultaneously in 8 uncovered experimental pens (6.4 × 3.8 m, stocking density of 4.9 m²/cow) with surface types randomly allocated to pens. The stand-off period consisted of 18 h in the treatment pens and 6 h on pasture (0900 to 1500h) per 24 h for 4 consecutive days to simulate a weather-induced stand-off period. The chosen duration of stand-off period exposure is common on New Zealand farms during winter. Following normal farm practice, no feed was available in the pens; however, water was freely available at all times from a rectangular, plastic trough (80-L capacity). The concrete and rubber surfaces were cleaned every 2 d and the wood chip surfaces refreshed (new material added) after each stand-off period. The 4-d stand-off period was followed by 7 d on pasture (recovery). These 2 periods were repeated 4 times to explore any potential accumulated effects of repeated exposure to the different surfaces, thus resulting in 44 d of data collection during June and July 2012 (Southern Hemisphere winter). A fresh sward of pasture (approximately 8 kg of DM/cow) and supplements (approximately 4 kg of DM/cow of maize, palm kernel expeller, molasses, and straw) were made available on each day at 0900 h. Behavioral and physiological measures were recorded immediately before and after each 4-d stand-off period, and weather variables were recorded continuously throughout the trial. Air temperature (°C), relative humidity (%), and rainfall (mm) were recorded at 10-min intervals using a portable weather station (Wireless Vantage Pro2 Plus, Davis Instruments, Harvard, CA) located outdoors within 5 m of the test pens. The air temperature was 8.0°C ± 2.99°C, relative humidity was 89.3% ± 7.09%, and rainfall was 6.2 mm ± 0.10 mm during the experimental period (24-h mean ± SD for all preceding values).

**Lying Times, Gait Score, Stride Length, and Hygiene Score**

Lying and standing times were recorded continuously using Onset Pendant G data loggers (64k, Onset Computer Corp., Bourne, MA) set to record the y- and z-axes at 30-s intervals. The data loggers were placed in a durable fabric pouch and attached on the lateral side of the hind leg above the metatarsophalangeal joint. The pouch was held in position by using Velcro patches, one sewn to the pouch and the other glued...
(Kamar Adhesive, Kamar Products Inc., Zionsville, IN) to the leg of the cow. The pouch was further held in place by a strap around the leg of the cow. The data were downloaded using HOBOware Pro software (Onset Computer Corp., Pocasset, MA) and converted to daily summaries of lying behavior using SAS software (SAS Institute Inc., Cary, NC) code designed for this purpose (N. Chapinal, University of Guelph, ON, Canada, personal communication) and based on the work of Ledgerwood et al. (2010) correcting for single standing and lying events.

Locomotion score was recorded on a 5-point scale (Thomsen et al., 2008) when the cows were walking on a flat concrete surface (cows were forced to walk in a single lane by narrowing the width of the surface to approximately 1.5 to 2 m) on their way to or from the treatment pens (within 100 m of the treatment pens) using a video camera (Sony Handycam Camcorder, DCR-SX65, Sony, Tokyo, Japan).

Stride length (Telezhenko and Bergsten, 2005) for all cows was calculated from the number of steps taken by the hind legs over a 10-m distance on a flat concrete surface, using the same video recording as for locomotion scoring. Each cow was also given a hygiene score ranging from clean to very dirty (on a 5-point scale; Table 1).

Multiple observers were used to collect the behavioral information. Inter-observer reliability for hygiene score, as measured by percentage agreement, was 72%. One person recorded the gait score, and the intra-reliability for that person, as measured by percentage agreement, was 98%. One person recorded stride length off video recordings, and the intra-observer reliability for that person, as measured by correlation, was >0.99.

**Cortisol Measurement and BW**

Blood samples were taken before and after each stand-off period. Blood samples were obtained by coccygeal venipuncture into 1 evacuated tube that contained lithium heparin (Vacutainer, Becton Dickinson, Franklin Lakes, NJ) for analysis of concentrations of cortisol. Samples were held in ice following collection and centrifuged at 1,200 × g for 10 min at 4°C; then, the plasma was aspirated and aliquots stored at −20°C until assayed. Serum samples were analyzed for cortisol concentrations using a commercial RIA kit (Siemens Cortisol-A-Count kit, Cruinn Diagnostics Ltd., Dublin, Ireland).

Body weight was recorded in the morning (around 0900 h) before and after each stand-off period.

**Statistical Analysis**

All data for each group were averaged per animal per 4 d of stand-off period (repeated 4 times per group, n = 4 groups/treatment). The change in each variable from the start to the end of each stand-off period was analyzed for all variables except for lying times, where the daily averages were analyzed. In addition, lying times during the 7 d on pasture between stand-off periods were averaged per animal (repeated 4 times). All data were analyzed in a repeated-measures model using REML, with groups and cows as random effects, and treatments, repetitions (1 to 4), and their interaction as fixed effects. Specific comparisons between the 4 treatments were tested using the Tukey test. For cortisol, we analyzed changes in log values and back-transformed these values to give proportional changes in cortisol levels.

Four cows did not complete the duration of the treatment period because of health reasons that were unrelated to the treatments (2 on concrete, 1 on 12-mm rubber mat, 1 on wood chip). Another 2 cows (1 each from the wood chip and 12-mm rubber mat treatment) showed signs of early calving and were removed from the trial in the last repetition. In all cases, these ani-

<table>
<thead>
<tr>
<th>Hygiene score</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>The animal is generally clean. Front udder, escutcheon, and hind limbs below the hip are clean. Stains are only on the hock points and tail provided adherent particles are minimal; there is no major fecal accumulation on the tail.</td>
</tr>
<tr>
<td>2</td>
<td>The animal is mildly dirty. Front of udder (teats and udder) is generally clean. Hocks are contaminated with adherent material on the back of leg. Hind limbs below the hip are overall clean but may have a few adherent particles. The escutcheon may have a few adherent particles and there may be clumps of fecal matter on the tail.</td>
</tr>
<tr>
<td>3</td>
<td>The animal is moderately dirty. Some dirt on the front of the udder, including small clumps at rear of abdomen and some staining of lower abdomen. Hock points have small clumps of dirt and fecal matter adhering. The area on hind limb below the hip is dirty and may have some clumps of fecal matter. The escutcheon and tail have some adherent material and clumps of fecal matter and the tail is generally matted.</td>
</tr>
<tr>
<td>4</td>
<td>The animal is very dirty. The front of the udder and skin of abdomen are very dirty, with dirt extending about a third of the distance up the abdomen. Hock points have clumps of dirt and fecal matter adhered to the lower hind legs. Hind limbs below the hip are very dirty with material forming into clumps of fecal matter. Escutcheon has dirt and clumps of fecal matters adhering to backs of legs. Tail has much adherent material and clumps of fecal matter.</td>
</tr>
<tr>
<td>5</td>
<td>The animal is extremely dirty. As for 4 but with large clumps of fecal matter hanging off the underside of the stomach.</td>
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mals were replaced with spare cows of similar BW to maintain the stocking density; however, data for these cows were excluded from the analysis.

All statistical analyses were conducted using the statistical package GenStat, version 13.2 (VSN International, Hemel Hempstead, UK).

RESULTS

Lying Times, Gait Score, Stride Length, and Hygiene Score

We observed significant differences between surfaces in the lying times during the 18-h stand-off period (P < 0.001), with cows on wood chips lying the most (10.8 h/18 h), those on concrete the least (2.8 h), and those on rubber mats being intermediate (6.0 h for 12-mm rubber mat, 7.3 h for 24-mm rubber mat; SED for these means was 0.71 h). The surface differences changed significantly throughout the study (P < 0.001), with lying times increasing with repetition on the rubber mats but remaining fairly constant for the other surfaces (Figure 1).

During each 4-d stand-off period, the cows spent 6 h of the day on pasture to allow for their daily feed intake. Lying times were reversed during this time on the pasture (P < 0.001, Figure 1). Cows on the wood chips spent the least time lying (0.4 h/6 h), cows on concrete spent the most time lying (1.5 h), with lying time of those on rubber mats being intermediate (0.9 h for 12 mm and 0.8 h for 24 mm; SED for these means was 0.12 h). Although times changed significantly throughout the study (P < 0.001), the differences between the treatments did not change significantly with repetition (P = 0.22). Total lying times (including time on stand-off and on pasture) during the 4-d stand-off period were as follows: concrete: 4.4 h, 12-mm rubber mat: 6.9 h, 24-mm rubber mat: 8.1 h, and wood chips: 11.2 h/24 h.

A similar pattern was observed for lying times during the 7 d on pasture between stand-off periods (P < 0.001, Figure 1). Cows on the wood chips spent the least time lying (10.7 h/24 h), cows on concrete spent the most time lying (12.1 h), and those on rubber mats had intermediate lying times (11.1 h for 12 mm and 11.2 h for 24 mm; SED for these means was 0.28 h). Although lying times changed significantly throughout the study (P < 0.001), the differences between the treatments did not change significantly with repetition (P = 0.99). Daily lying times throughout the experiment are shown in Figure 2.

Surface type (P < 0.001) but not repetition (P = 0.53) influenced the change in gait score after 4 d of stand-off. The gait score deteriorated more for cows on concrete than for those on the other 3 surfaces (P
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≤ 0.01), whereas no significant differences were found between the other surface types (P > 0.05, Figure 3). However, the highest gait score recorded throughout the study was 3 (moderately lame) on a 5-point scale for 1 animal in the concrete treatment after the 4-d stand-off period. We detected an interaction between surface type and repetition (P < 0.001); during the last repetition of stand-off, cows on concrete had a major increase in gait score (1.0-unit difference).

Surface type influenced the stride length of cows during the stand-off period (P = 0.05). Stride length decreased more for cows on concrete compared with cows on wood chips (P < 0.05), whereas no significant differences were observed between the other 3 surface types (P > 0.05, Figure 4). We found no effect of repetition (P = 0.17) or interaction between surface type and repetition (P = 0.37).

Surface type (P < 0.001) and repetition (P = 0.005) also influenced the change in hygiene score during the stand-off period. Cows on rubber mats were almost 3 times dirtier than cows on concrete or wood chips after

Figure 2. Daily mean lying times of dairy cattle (n = 4 groups/treatment, 5 cows/group) exposed to a repeated (4 times) 4-d stand-off period (18-h stand-off and 6 h on pasture per 24 h) on a 12-mm rubber mat, 24-mm rubber mat, concrete, or wood chip surface. The cows were on pasture for 7 d between each stand-off period (recovery).

Figure 3. Gait score of dairy cattle (n = 4 groups/treatment, 5 cows/group) before and after a repeated (4 times) 4-d stand-off period (18-h stand-off and 6 h on pasture per 24 h with 7 d of recovery on pasture between surface exposures) on a 12-mm rubber mat, 24-mm rubber mat, concrete, or wood chip surface. Values are means ± standard error of differences (SED) between treatments for the change in values of before and after all 4-d stand-off periods.
the 4-d stand-off period \((P \leq 0.01, \text{Figure 5})\), whereas we detected no significant difference between the 2 types of rubber mats \((P > 0.05)\) or between wood chips and concrete \((P > 0.05)\). We also observed a trend for an interaction between surface type and repetition \((P = 0.055)\).

**Cortisol**

Surface type \((P = 0.05)\) and time \((P < 0.001, \text{Figure 6})\) influenced the change in cortisol concentrations during stand-off. Cortisol decreased for all treatment groups during the stand-off period (concrete: 27%, 12-mm rubber mat: 22%, 24-mm rubber mat: 45%, and wood chips: 34% decrease, SED: 9.0%). We observed no interaction between surface type and repetition \((P = 0.30)\).

**BW**

All cows lost BW during the 4-d stand-off period and this change differed between repetitions \((P < 0.001, \text{Figure 7})\); however, we detected no effect of surface type on the change in BW \((P = 0.16)\) or any interaction between surface type and repetition \((P = 0.65)\).

**DISCUSSION**

The flooring surface during a simulated weather-induced stand-off period influenced the behavior and physiology of dairy cattle. Cows kept temporarily on concrete spent less time lying and changed their gait pattern more than cows kept on the other surface types, whereas cows on wood chips spent more time lying and were cleaner than the cows on rubber matting. Cows kept on rubber matting had intermediate lying times compared with those on wood chips and concrete; cows on the 24-mm rubber mat had numerically longer lying times than cows on the 12-mm rubber mat. Cows kept on concrete partly compensated for the reduced lying times by spending more time lying on pasture between stand-off periods. All cows had lower BW and cortisol concentrations after the 4-d stand-off period.

Cows that were kept on the concrete surface spent 74% less time lying compared with cows kept on wood chips, and 62 and 53% less time lying compared with cows...
The results agree with numerous studies demonstrating that cows spend less time lying on hard surfaces and that cows prefer lying and increase lying times on soft and well-bedded surfaces. For example, cows exposed to a 4-d stand-off period on concrete surfaces spent 40% less time lying compared with when they were kept on wood chips (Fisher et al., 2003) and lying times increased by 12 min per added kilogram of straw in tie-stalls (Tucker et al., 2009). Furthermore, the addition of (geotextile) mattress onto concrete increases lying times by 7.5% compared with concrete (Haley et al., 2001); however, mattresses are less preferred by cows over softer surfaces, such as sand or sawdust (Tucker et al., 2003), likely due to the compressibility of the surface or because cows may be hesitant in getting down and up on some surfaces (Rushen et al., 2007). Cows kept on the rubber mats increased their lying times throughout the study, and this is likely due to habituation to the rubber mats as a lying surface. The cows had previous experience of rubber matting although not as a lying surface (they were used to wood chips as a stand-off surface), and it is possible that lying times on the rubber mats, especially during the first week of testing, were lower than they would have been if cows had been previously habituated to the mats. However, even after 4 repetitions, lying times on rubber mats were still intermediate between those on wood chips and concrete, indicating that adding rubber mats to concrete increases lying times but not to the same extent as a well-managed wood chip surface (this surface was refreshed with new wood chips after each stand-off period). Cows exposed to the wood chip surface during stand-off had the longest lying times, in agreement with the findings of Fisher et al. (2003), where cows were kept on wood chips, concrete, a farm laneway, or a small paddock.

In New Zealand, cows on pasture spend approximately 10 h lying per day (Fisher et al., 2008; Schütz et al., 2013), and minimum lying times of 8 h/d are often recommended to farmers by the New Zealand dairy industry. Cows that were on concrete spent approximately twice as much time lying as cows on the other surfaces during their daily 6-h period on pasture (25% of 6 h) in between the surface exposures. This suggests that lying times for cows kept on concrete were not sufficient to meet their daily requirements, as cows were lying down when they should have been ingesting their daily feed allowance. Although stand-off is a winter management practice, during which time cows are not lactating and therefore energy requirements are lower compared with the rest of the year, it is unclear whether 4.5 h of grazing per day is sufficient to meet daily energy requirements. It is possible that cows were experiencing a trade-off between grazing and resting during the 6 h on pasture; indeed, others have found that after a deprivation period of both eating and lying, cattle choose lying over eating (Metz, 1984–1985; Munksgaard et al., 2005). We encourage future studies investigating the trade-offs that cows have to make between different activities. The total lying times of the cows on the different surfaces reached 8 h/d on only 2 surface types: wood chips and the 24-mm rubber mat, thereby suggesting that the 12-mm rubber mat and concrete did not meet the recommended minimum lying requirements. We observed no accumulated effect of repeated stand-off periods, suggesting that the 7 d of recovery on pasture between surface exposures was sufficient for the cows to recover from the reduced lying times. However, cows kept on concrete, compared with the other 3 surfaces, spent more time lying when on pasture between stand-off repetitions, which further suggests that the cows were likely compensating for the reduced lying times during the 4-d surface exposure.

The importance of providing cattle with a suitable lying surface to maintain animal health (Singh et al., 1993; Leonard et al., 1996) is well known. Dairy cattle with reduced lying times have elevated cortisol concentrations and other indicators of physiological stress (Fisher et al., 2002; Tucker et al., 2007). Cows on concrete had higher concentrations of fecal glucocorticoid metabolites after a 4-d stand-off period compared with cows on wood chips and a small (muddy) paddock (Fisher et al., 2003). Those findings disagree with those in the current study and we speculate that the decrease in plasma cortisol after the 4-d stand-off period in all groups could be due to the timing of sample collection. Blood samples were taken immediately before and
after the 4-d stand-off period, and we speculate that conditions before blood sampling (pasture vs. stand-off, including factors such as activity levels) could have influenced the results.

Reduced lying times and increased standing on hard surfaces increase the risk of lameness (Singh et al., 1993; Leonard et al., 1996; Cook et al., 2004b) and leg injuries (Weary and Taszkun, 2000; Rushen et al., 2007). Soft flooring surfaces such as rubber are beneficial for hoof health (Vanegas et al., 2006) and improve stride length and locomotion (Telezhenko and Bergsten, 2005), likely due to the compressibility and coefficient of friction of the surface (Rushen and de Passillé, 2006). Cows that were exposed to the concrete surface had shorter stride length and higher gait score after the 4-d stand-off period, suggesting that even a short-term exposure to concrete surfaces influences the gait pattern of cows. The results agree with those of Fisher et al. (2003), where cows on concrete had shorter stride length compared with cows on a farm laneway or a small paddock after 4 d of exposure. We observed no difference in gait score or stride length between the 2 types of rubber mats or the wood chips treatment, suggesting that those surfaces are adequate for maintaining a normal gait pattern, at least under the conditions studied. Cows on concrete had a worse gait score after the last stand-off repetition; however, it is difficult to know whether this was due to the repeated stand-off periods or a general increase in the risk for lameness associated with concrete surfaces. No cows became severely lame during the present study and it is possible that the frequent access to pasture in combination with the short-term exposure to the surfaces may have reduced the risk of lameness associated with keeping cows on concrete, as pasture access has been suggested to reduce the risk of lameness compared with freestall systems (Hernandez-Mendo et al., 2007).

Cows lost BW on all 4 surfaces during the 4-d stand-off period and the reasons for this are unclear. Cows on concrete for 4 d in another study similarly lost BW during the stand-off period, whereas cows on wood chips or a paddock gained BW (Fisher et al., 2003). In the present study, BW was recorded immediately before cows went onto the stand-off pad and following the 4-d stand-off period, and we speculate that the loss in BW was due to gut fill. Although cows were weighed in the morning before being offered their daily feed allowance on pasture (exposure to the stand-off surfaces began at 1500 h), it is possible that they were able to ingest a certain amount of feed on pasture, compared with the last stand-off day when they had been standing or lying on the surface types for 18 h with no access to feed or pasture. Even though it has been demonstrated that restricting pasture access to 6 h in mid lactation does not significantly influence milk production (Kennedy et al., 2009), it is possible that the daily 6 h on pasture was not sufficient for the cows to meet their daily energy requirements. Indeed, a slower BW gain was found in nonlactating cows in winter that were given restricted pasture access and held on a concrete surface for 18 h/24 h during 7 d for 2 consecutive 14-d periods compared with cows with continuous access to pasture (Webster et al., 2007), indicating that the cows were unable to fully compensate for the reduced feeding time by increasing intake.

Finally, the surface type on which cows are kept influenced the level of hygiene of the animals. Cows on wood chips and concrete were cleaner than the cows on rubber mats and this agrees with Fisher et al. (2003), where cows on wood chips were cleaner than those kept on concrete, a farm laneway, or in a small paddock. It must be noted however that cows in New Zealand systems are normally not lactating in the winter period when stand-off practices are used, and rubber mats may not be suitable to house lactating cows on due to the risk of mastitis. Cows were cleaner when kept on concrete, but this was most likely due to the short lying times on this surface so that the animals had very little contact with the surface type. A concern exists among producers regarding the use of organic materials to house cows on because of a perceived risk of mastitis (Elbers et al., 1998), thus highlighting the importance of keeping all lying surfaces clean to maintain udder health.

CONCLUSIONS

Adding rubber matting onto concrete surfaces during short-term exposure is beneficial for animal welfare; cows on rubber mats had longer lying times and better gait pattern compared with those on concrete. The response to the 2 types of rubber mats was largely similar; however, total lying times for cows kept on the 24-mm rubber mat were numerically greater than those on the 12-mm rubber mat. Well-managed wood chips are the superior surface for stand-off in terms of animal welfare; cows on wood chips had the longest lying times and were cleaner compared with cows on rubber matting. The results for concrete confirm previous reports that this is not a suitable surface for cows; cows spend very little time lying and have altered gait patterns likely caused by discomfort. No major effects of repeated stand-off periods were found under the conditions studied.

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REFERENCES


