J. Dairy Sci. 98:1–10
http://dx.doi.org/10.3168/jds.2014-8930

Effect of rubber flooring on dairy cattle stepping behavior and muscle activity

Eranda Rajapaksha,* Christoph Winkler,† and Cassandra B. Tucker*[1]
*Department of Animal Science, University of California, 1 Shields Avenue, Davis 95616
†Department of Sustainable Agricultural Systems, Division of Livestock Sciences, BOKU—University of Natural Resources and Life Sciences, Gregor-Mendel-Strasse 33, 1180 Vienna, Austria

ABSTRACT

Use of compressible flooring, such as rubber, has increased on dairy farms. Rubber improves locomotion and is well used by cattle in preference experiments that combine walking and standing. Previous work has found that rubber is particularly beneficial for lame animals, perhaps because a softer material is particularly useful when a single hoof is compromised. The goal of this work was to evaluate the effect of flooring while standing, because cattle in freestall housing spend 40 to 50% of their time engaged in this behavior. In a 2 × 2 design, cows (n = 16) were evaluated on 4 standing surfaces that varied in terms of both floor type (concrete or rubber) and presentation [same floor under all 4 legs (all 4 legs on either concrete or rubber) or a rough surface under only one hind leg and the other 3 legs on concrete or rubber] in a crossover design. Surface electromyograms were used to evaluate muscle fatigue, total activity, and movement of muscle activity between legs during 1 h of standing. Muscle fatigue was evaluated in 2 contexts: (1) static contractions when cows continuously transferred weight to each hind leg, before and after 1 h of standing, and (2) dynamic contractions associated with steps during 1 h on treatment surfaces. In addition, stepping rate, time between each consecutive step, and the latency to lie down after testing were measured. No interaction between floor type and presentation was found. Presentation had a significant effect; when one hind leg was on a rough surface, cattle took 1.7 times more steps with this leg and the non-rough hind leg had 1.2 times more muscle activity, compared with when all 4 legs were on the same surface. These changes are consistent with movement away from concrete with protrusions. When standing on rubber, muscle-activity movements among legs remained stable (0.6–0.7 movements per min) over 1 h but increased on concrete (0.6–0.9 movements per min), indicating that, like humans, cattle may sway to counteract effects of standing. However, additional work, including measurements of blood flow in the leg, is needed to fully understand the biological implications of these changes. Overall, the rubber flooring tested had little effect on standing behavior.
Key words: behavior, electromyogram, muscle activity

INTRODUCTION

Cows spend 11 to 13 h/d standing in freestall housing systems (Ito et al., 2009). Concrete is the most common flooring material (USDA, 2009) and is a known risk factor for hoof and leg lesions (Vokey et al., 2001; Somers et al., 2003) and lameness in cattle (Cook, 2003; Vanegas et al., 2006). Use of alternatives to concrete, such as rubber, has increased during the last 2 decades (USDA, 2009) and is thought to improve cow comfort. Cows walk faster, take longer strides, and slip less (Telezhenko and Bergsten, 2005; Rushen and de Passillé, 2006) on rubber floors compared with concrete. These benefits of rubber, namely in walking speed, are more marked in lame cows compared with sound ones (Flower et al., 2007). Cows also prefer rubber over concrete when walking and standing (Telezhenko et al., 2007) and while spending time near the feed bunk (Tucker et al., 2006).

Although cattle show a clear preference for rubber, research evaluating stepping rate during forced standing on rubber (Chapinal and Tucker, 2012) or rubber surfaces that differ in compressibility (Krebs et al., 2011) has not found any differences among treatments. Other methods, such as measures of muscle function, may provide more insight into how cattle respond to standing surfaces. For example, reduced fatigue and total activity in back muscles has been used to compare compressible standing surfaces in humans (Kim et al., 1994; Madeleine et al., 1998). In addition to lacking measures of muscle function, previous comparisons of standing surfaces for cattle have involved the cows standing on all 4 legs on the same surface and used total steps taken as the dependent variable. However, stepping behavior seems to be a more promising assessment indicator in lame cows or when a disruptive surface is

Received October 2, 2014.
Accepted December 5, 2014.
[1]Corresponding author: cbtucker@ucdavis.edu

under a single hind leg (Neveux et al., 2006; Rushen et al., 2007; Rajapaksha and Tucker, 2015). Thus a protocol evaluating the effects of a rough surface under only one hind leg could provide additional insights into cattle response to standing surfaces such as rubber.

This study investigated the effect of compressibility of the standing floor on cows during 1 h of restricted standing, a period of time chosen because it represents the length of an average feeding bout (DeVries et al., 2003). The objective was to assess how rubber flooring affects cow stepping behavior and muscle activity when presented under all 4 legs and when a rough surface was under a single hind leg. The predictions were that cows would take fewer steps and have less muscle fatigue when standing on rubber compared with concrete, and that these benefits of rubber would be more marked when one hind leg was placed on a rough surface.

MATERIALS AND METHODS

General Information

This experiment was conducted at the University of California, Davis, dairy facility between April and May of 2012. All procedures were approved by the Institutional Animal Care and Use Committee.

Animals and Housing

A total of 16 lactating Holstein-Friesian dairy cows were tested in groups of 4. All were clinically sound, with gait score $\leq$2 (Flower and Weary, 2006). Cows had an average ($\pm$SD) BW of 656 $\pm$ 65 kg, BCS of 2.8 $\pm$ 0.2 (Edmonson et al., 1989), DIM of 107 $\pm$ 49, and daily milk production of 39 $\pm$ 1 kg. They were in either their first (n = 13) or second lactation (n = 3). Cows were housed in a pen with 24 head-to-head freestalls (1.2 m $\times$ 2.4 m; one cow per freestall) deep bedded with sand and had a neck rail 106 $\pm$ 2 cm above the stall surface. All surfaces outside the freestalls (alleyways, crossovers, walkways) were concrete. The cows were milked twice daily at 0600 and 1700 h, had ad libitum access to water, and were fed a total mixed ration consisting of 37% alfalfa hay, 36% grain mix, 10% whole cottonseed, 12% almond hulls, 2% soybean meal, and 3% mineral mix on a DM basis. They were fed 3 times a day at 0400, 1100, and 1600 h.

Experimental Procedures

During the experiment, animals were moved to a test area located 20 m away from the freestall pen. The testing area contained 4 standing stalls that were 2.4 m long and 1.2 m wide and separated by steel panels (Powder River Inc., Provo, UT; Figure 1). Each stall had 1 of 4 treatments: either concrete or rubber under all 4 legs (**ALL4**, either all 4 legs on concrete or all 4 legs on rubber) or these same surfaces but with one hind leg instead on a rough concrete grid (**3–1ROUGH**, either 3 legs on rubber and 1 on the rough surface, or 3 legs on concrete and 1 on the rough surface). The rough grid had 49 equally distributed 4-sided trapezoidal, prism-shaped (5.08 $\times$ 5.08 cm at the base and 2 $\times$ 2 cm at the top half pyramid) protrusions from the top of each slab, created with a concrete mold. Unless specified otherwise, the concrete surfaces were poured material without any grooving and the rubber was 2 layers of revulcanized mats (38 mm thick, 4 times as compressible as concrete; Animat, Animat Inc., Saint-Élie d'Orford, Quebec, Canada). The compressibility of the rubber was tested by Anamet Inc. (Hayward, CA) using a modified ASTM D575 standard engineering technique (ASTM International, 2007), and the full results of these tests are presented by Krebs et al. (2011). All treatment surfaces were level. Location of the floors within the testing area and the disrupted area of the rough treatment were alternated and balanced among groups of 4 cows and across the experiment.

Cows were moved to treatment surfaces at approximately 0830, 1000, 1115, and 1230 h and restrained for 1 h for behavior observations and surface electromyogram (**SEMG**) recordings. While standing in these treatment stalls, 2 horizontal metal bars kept the cow confined. They were able to move their head, look sideways, and take a few steps forward or backward, but each leg remained within its designated quadrant. Each cow was tested on a single treatment per day and had at least 22 h between each day of testing. The order of exposure to the 4 treatments was balanced across cows and time.

Measures

Behavioral Observations: Stepping Behavior. Five trained live observers using Etholog version 2.2 software (Ottoni, 2000) continuously recorded all steps during the 1-h tests. Observers had r $\geq$92% intra- and interobserver reliability, with the latter measured by correlation with an experienced observer (E. Rajapaksha) as a gold standard. A step was defined as lifting any part of the hoof off the ground. Steps were recorded separately for all 4 legs. Although live observation was used as the primary method to collect stepping information, for one cow on 1 d, video recordings were used because of malfunction of the Etholog software. The video recordings were collected with 4 CVC627B color CCTV video cameras (Speco Technologies, Amityville, NY) connected to a digital video recorder with a GV-