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The Effects of One-Time Hoof Trimming on Blood Biochemical Composition, Milk Yield, and Milk Composition in Dairy Cows

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ABSTRACT. Although not scientifically proven, hoof trimming has been empirically shown to increase milk yields in healthy dairy cows. In this study, we examined the effect of one-time hoof trimming on blood biochemical composition, milk yield, and milk composition in healthy dairy cows. Eleven cows in the mid to late lactation period that were clinically fit and without hoof disease were subjected to hoof trimming, and metabolic profile tests and dairy herd improving tests were performed before and three weeks after the hoof trimming. The metabolic profiles showed changes in albumin, blood urea nitrogen, ammonia, glucose, and β-hydroxybutyric acid as a result of the hoof trimming. This was indicated by the fact that the cows began to intake more roughage after hoof trimming than prior to hoof trimming, and rumen fermentation became stable. There was no change in milk yield after trimming. However, the milk fat and milk protein compositions were significantly increased after trimming.

KEY WORDS: dairy cow, hoof trimming, metabolic profile test.

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The majority of dairy cows raised under today's demanding milk production management suffer from hoof disorders. Various factors, such as the housing environment, demands for higher productivity, high herd densities, and an individual's susceptibility predispose cows to these disorders [18]. Next to mastitis and reproductive disorders, lameness is the third leading cause of disease-associated economical losses for dairy farmers [1, 10]. According to the report by Esslemont, the annual average loss from foot and leg disorders exceeds 45 dollars per cow in the United Kingdom [2]. Uribe *et al.* examined 3-year health data obtained through a herd monitoring program in Ontario, Canada, and found that 3.5% of all cows were culled because of foot and leg problems [17]. In addition to economical losses, foot and leg disorders also affect the cow's welfare [10]. Therefore, there is an increasing awareness of the importance of hoof trimming.

Hoof trimming is performed to prevent hoof lesions and to improve gait by correction and maintenance of the hoof symmetry and shape, which ensures correct weight bearing [9]. Lameness caused by hoof disorders can be treated by correct hoof trimming. The correct hoof shape helps restore the weight-bearing balance and promotes recovery from hoof disorders [14]. The effect of trimming of healthy hooves, however, has not been reported. Our study aimed to examine the effect of hoof trimming in healthy cows with no hoof problems. We performed metabolic profiling tests (MPT) before and after hoof trimming and compared the blood chemical composition, milk yield, and milk composition.

MATERIALS AND METHODS

Animals: Thirty-four Holstein dairy cows in Iwate Prefecture, Japan, were examined. They were housed in tie-stall barns for separate feeding all day long and therefore had no exercise. Their hooves had not been trimmed for several years. The hooves were trimmed by professional trimmers certified by the Japan Farriers Association. All of the cows were trimmed on the same day and checked for hoof disease. The hoof angles of the left forelimb and hindlimb were also measured before and after trimming. Eleven cows that had healthy hooves and that were in the mid to late lactation period were selected for the study. During this lactation period, the blood chemical composition is stable [5], and therefore any changes seen may be considered to be a direct effect of hoof trimming. The mean days in milk for the group was 204.6 (range: 122–288 days) and the mean number of calvings was 2.7 times (range: 1–6 times) before trimming. Live body weight, one of the components of the dairy herd improving test, was estimated using a weight estimating tape before and after trimming.

Feeding: Cows were fed the same diet throughout the study. Concentrate (mainly corn, 10.5 kg) and roughage (3.5 kg beet pulp, 1 kg haycube, and 3 kg grass hay) were given separately once a day, and grass silage was fed *ad libitum*. Energy requirements were calculated from the average weight and milk weight according to the National Research Council (NRC) [6] requirements. The average feed composition is listed in Table 1.

Blood sampling, MPT compositions, and analytical methods: The MPT was performed a few days before and 3 weeks after hoof trimming. Blood samples were collected

Table 1. The average dietary intake of specific nutrients in cows (%)

Dry matter	101
Total digestible nutrient	104
Crude protein	105
Calcium	143
Neutral detergent fiber	107
Starch/dry matter	18
Roughage-to-concentrate ration	57

from the jugular vein in to K_2 ethylenediaminetetraacetic acid (EDTA) vacuum tubes, sodium fluoride (NaF) vacuum tubes, and serum separate vacuum tubes (SST) (Nippon Becton Dickinson Co., Ltd., Tokyo, Japan). Immediately after blood collection, the EDTA and NaF vacuum tubes were centrifuged to separate the plasma at 2,207 g for 5 min. The SST were incubated in a 37°C water bath for 15 min and centrifuged to separate the serum at 2,207 g for 15 min. EDTA-treated plasma, NaF-treated plasma, and SST-treated serum were used to measure ammonia, lactic acid, and for other chemical compositions, by respectively, automatic biochemical analyzer (7060, HITACHI Co., Ltd., Tokyo, Japan).

The blood chemical composition and analytical methods used were as follows: albumin (Alb, BCG method); blood urea nitrogen (BUN, urease-UV method); ammonia (NH_3, enzymatic UV method); nonesterified fatty acids (NEFA, ACS-ACOD method); total cholesterol (Tcho, enzymatic UV method); phospholipids (PL, enzymatic UV method); β-hydroxybutyric acid (BHB, cyclic enzymatic method); glucose (Glu, hexokinase method); lactic acid (LA, enzymatic UV method); calcium (Ca, *o*-CPC method); aspartate aminotransferase (AST, MDH UV method); and γ-glutamyltransferase (GGT, Glu-3-CA-4-NA substrate method).

Milk yield and composition: Milk yield, milk fat yield, milk protein yield, milk fat composition, and milk protein composition were obtained from the results of the dairy herd improving test.

Statistical analysis: The Student's *t*-test was used to analyze all of the results before and after hoof trimming.

RESULTS

Before hoof trimming, the average toe angle of forelimbs was 32.7 ± 5.5° (mean ± S.D.), and that of hindlimbs was 35.2 ± 6.0°. After trimming they were 41.5 ± 2.7° and 40.6 ± 3.7°, respectively. These changes were statistically significant for both the forelimbs and hindlimbs ($P<0.01$).

Many of the blood chemical composition results showed significant changes after hoof trimming (Table 2). The values before trimming were as follows: Alb, 4.37 ± 0.23 g/d*l*; BUN, 20.1 ± 1.7 mg/d*l*; NH_3, 28.0 ± 3.8 μg/d*l*; Glu, 69.2 ± 6.7 mg/d*l*; and GGT, 30.4 ± 7.6 IU/*l*. However, these values significantly decreased after hoof trimming as follows: Alb, 4.05 ± 0.41 g/d*l* ($P<0.05$); BUN, 16.4 ± 1.8 mg/d*l* ($P<0.01$); NH_3, 23.6 ± 7.2 μg/d*l* ($P<0.05$); Glu, 64.3 ± 3.1 mg/d*l* ($P<0.05$); and GGT, 26.4 ± 6.1 IU/*l* ($P<0.01$). In contrast, the BHB level was low before hoof trimming (191.5 ± 33.0 μM), but was significantly increased after trimming (680.8 ± 149.2 μM).

There was no change in milk yield, milk fat yield, and milk protein yield after hoof trimming. However, the milk fat and milk protein compositions were significantly increased (Table 3).

Table 2. Blood chemical composition results before and after hoof trimming (mean ± S.D.)

	Before	After	Significance[b)]
Alb (g/d*l*)[a)]	4.37 ± 0.23	4.05 ± 0.41	*
BUN (mg/d*l*)	20.1 ± 1.7	16.4 ± 1.8	**
NH_3 (μg/d*l*)	28.0 ± 3.8	23.6 ± 7.2	*
NEFA (μEq/*l*)	136.7 ± 28.2	160.6 ± 70.7	NS
Tcho (mg/d*l*)	258.9 ± 62.1	225.8 ± 63.7	**
PL (mg/d*l*)	381.1 ± 79.5	331.1 ± 78.8	**
BHB (μM)	191.5 ± 33.0	680.8 ± 149.2	**
Glu (mg/d*l*)	69.2 ± 6.7	64.3 ± 3.1	*
LA (mg/d*l*)	15.4 ± 6.9	12.6 ± 5.6	NS
Ca (mg/d*l*)	9.8 ± 0.7	10.4 ± 0.3	*
AST (IU/*l*)	80.9 ± 15.2	75.9 ± 8.9	NS
GGT (IU/*l*)	30.4 ± 7.6	26.4 ± 6.1	**

a) Alb: albumin; BUN: blood urea nitrogen; NH_3: ammonia; NEFA: nonesterified fatty acids; Tcho: total cholesterol; PL: phospholipid; BHB: β-hydroxybutyric acid; Glu: glucose; LA: lactic acid; Ca: calcium; AST: aspartate aminotransferase; and GGT: γ-glutamyltransferase.
b) NS: Not significant or $P\geq0.05$; *: $P<005$; **: $P<0.01$.

DISCUSSION

Hahn *et al.* reported that the average toe angle was 44.9° in the forelimbs and 42.9° in the hindlimbs at second lactation in Holstein cows [3]. But in this examination, the toe angle before trimming was more acute. This herd had not been trimmed for several years, they therefore had long hooves and acute toe angles. After trimming, the hoof shape was corrected, and the toe angle was closer to Hahn's value.

Cows with subclinical rumen acidosis develop dehydration due to increased salivation. Alb is an index of protein intake and dehydration, and hence rumen acidosis [4]. Glu indicates the intake of soluble carbohydrates [4]. When a cow takes in a lot of concentrate, propionic acid increases in the rumen leading to elevated levels of serum Glu. Accordingly, Glu is thought to be an index of concentrate intake. In this examination, Alb and Glu before hoof trimming were higher than after hoof trimming. This showed that the cows before hoof trimming took more concentrate or less roughage than after hoof trimming. The BUN and NH_3 levels were measured to evaluate protein intake and ruminal fermentation [4, 7]. Proteins contained in concentrate feeds degrade rapidly in the rumen and increase rumen NH_3 levels. The increase in ruminal NH_3 leads to elevation of BUN and blood NH_3. In this examination, BUN and blood NH_3 before hoof trimming was higher than after hoof trimming,

Table 3. Results for milk yield, yields of milk constituents, milk composition, and live body weight (mean ± S.D.)

	Before	After	Significance
Milk yield (kg/d)	24.4 ± 7.3	22.6 ± 5.1	NS
Yeilds of milk constituents (kg/d)			
Fat	1.05 ± 0.24	1.04 ± 0.22	NS
Protein	0.82 ± 0.20	0.81 ± 0.14	NS
Milk composition (%)			
Fat	4.4 ± 0.4	4.6 ± 0.5	*
Protein	3.4 ± 0.2	3.6 ± 0.3	**
Live body weight (kg)	594.5 ± 44.8	606.7 ± 35.5	NS

NS: Not significant or $P \geq 0.05$; *: $P<0.05$; **: $P<0.01$.

suggesting that the cows took in more concentrate before hoof trimming than after. It is known that a positive correlation exists between dry matter intake (DMI) and BHB [11]. Therefore, in this examination, as BHB before hoof trimming was lower than after hoof trimming, a similar trend is expected with DMI. The Alb, Glu, BUN, NH_3, and BHB values all showed that the cows took in little roughage before hoof trimming, but took in more roughage after hoof trimming. Because the grass silage was fed *ad libitum*, the cows took more roughage after hoof trimming, and rumen fermentation became stable. Phillips *et al.* have shown that hoof trimming corrects weight bearing and suggested a corresponding effect on posture [9]. Therefore there is a possibility that a change in weight bearing and posture may affect DMI. This assumption is supported by the fact that the cows in this study were able to take in more roughage after hoof trimming. GGT is thought to be an index of liver function [5]. In this experiment, GGT before hoof trimming was higher than after hoof trimming, and this was evidence that injury to the liver decreased after hoof trimming. Calcium ions are absorbed through the ruminal wall along with VFAs [11, 12]. An increase in ruminal VFAs after trimming was thought to have caused increases in both absorption and serum concentrations of Ca. Other authors have shown that PL and Tcho during the mid to late lactation period decrease with time [8]. There was a month's difference between the first MPT done before trimming and the second one carried out after trimming. For this reason, PL and Tcho were decreased after hoof trimming. It has been previously shown that a positive correlation exists between BHB and milk fat composition or milk protein composition [11]. In this examination, BHB after hoof trimming was higher than before hoof trimming. Subsequently, milk fat composition and milk protein composition were increased after hoof trimming.

Taguchi *et al.* has reported a similar experiment, but no changes in milk yield and composition were observed in their study [15]. They used cows whose hooves had not been trimmed for six to eight months, while the cows in our study had not been trimmed for one to two years. The impact of hoof trimming in this study was greater, and the milk composition reflected this. Tanaka *et al.* demonstrated that hoof trimming slows down the rate at which milk production declines in cows in late lactation [16]. Even though we did not examine this parameter, our findings concurred with Tanaka *et al.* in that no changes were observed in the milk yield following hoof trimming.

In conclusion, our study showed that hoof trimming during the mid to late lactation periods changed the blood chemical composition of the dairy cows. In our opinion this change could be attributed to stable rumen fermentation resulting from increased feed intake after trimming. In this study, we did not examine feed intake, and therefore would like to include this parameter in future studies. The milk yield did not change after trimming, but the milk fat and protein compositions were increased. Therefore, hoof trimming may be an invaluable asset in the improvement of milk productivity in dairy cows.

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