Relationship of Plasma Nonesterified Fatty Acids and Walking Activity in Postpartum Dairy Cows

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ABSTRACT

To survive and produce milk, postpartum dairy cows use their reserves through lipolysis. If the negative energy balance is severe, nonesterified fatty acids (NEFA) are formed that can impair several physiological processes. A pilot study suggested that increased walking activity after calving may be related to a reduced serum concentration of NEFA. The objective of this study was to determine the relationship between plasma concentrations of NEFA and walking activity in dairy cattle during the postpartum period. Data were collected from 33 multiparous Holstein-Friesian dairy cows. Walking activities were quantified using pedometry, and blood samples were collected for determination of NEFA. Results of this study indicated that a negative relationship existed between walking activity and plasma NEFA concentrations in postpartum dairy cows.

Key words: postpartum, walking activity, energy balance, lipolysis

INTRODUCTION

The energy status of dairy cows, which is variable during the periparturient period, is often evaluated based on the balance of energy intake and energy requirements (Rukkwamsuk et al., 1999). To compensate for the increased energy demands resulting from fetal growth and lactogenesis, NEFA are released from adipose tissue even before copious milk secretion (Grummer, 1995). A more severe negative energy balance (NEB) results in a greater serum concentration of NEFA (Rukkwamsuk et al., 1999; Block et al., 2001).

Although elevated concentrations of NEFA in the circulation are toxic (Jorritsma et al., 2004; Vanholder et al., 2005), they can also be used directly for energy, especially by the peripheral tissues such as muscles (Drackley, 1999; Chilliard et al., 2000). An increased concentration of serum NEFA and their increased up-

take by the liver may be accompanied by hepatic lipodosis, metabolic and digestive disorders such as ketosis, retained placenta, milk fever, displaced abomasum indigestion, reduced feed intake, traumatic gastritis, acidosis, and bloat (Grummer, 1995; Cameron et al., 1998; Rukkwamsuk et al., 1999).

In a pilot study, a negative correlation was found between the walking activity of dairy cows and postpartum concentrations of NEFA (Adewuyi et al., 2005). The objective of the present study was to determine the relationship between serum concentrations of NEFA and walking activity in postpartum dairy cattle.

MATERIALS AND METHODS

Thirty-three multiparous Holstein cows were selected based on their expected calving dates between March and December 2004. Cows were housed in a free-stall barn with 2 rows of free stalls and a solid concrete floor with manure scraper. Cows were fed according to the recommendations of the Dutch Central Feedstuff Institute (Centraal Veevoeder Bureau, 1999).

The walking activity of a cow was quantified using a pedometer (Kiddy, 1977). The pedometer (NEDAP, the Netherlands) recorded the number of steps per 2-h period during 21 d postpartum. The maximum, minimum, and mean number of steps per 2 h (designated maximum, minimum, and mean activity) were determined during 5 periods of 4 d from 2 to 21 d postpartum (first period = 2 to 5 d, second period = 6 to 9 d, third period = 10 to 13 d, fourth period = 14 to 17 d, and fifth period = 18 to 21 d).

Blood samples were collected from the coccygeal vessels every 4 d, beginning on the day after calving (to exclude the stress of calving) to 21 d postpartum. Blood samples were centrifuged immediately after collection and stored at -20°C until analyses of plasma NEFA. Plasma concentrations of NEFA were measured enzymatically with a commercially available kit (kit number FA115-038054-46-2C; Randox Laboratories Ltd., Ardmore, UK). Cows were regarded as having severe NEB when plasma NEFA concentrations were ≥ 0.7 mM,

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Figure 1. Scatter plot of maximum activity and plasma NEFA concentration of 33 cows during period 3 (10 to 13 d postpartum). Bivariate correlation coefficient (r) = -0.57 ($P < 0.01$).

Figure 2. Scatter plot of mean activity and plasma concentrations of NEFA of 33 cows during period 3 (10 to 13 d postpartum). Bivariate correlation coefficient (r) = -0.42 ($P < 0.05$).

whereas those having concentrations >0.2 mM but <0.7 mM were considered to be mild cases of NEB.

For statistical analysis, SPSS was used (SPSS Inc., Chicago, IL). Using Spearman's rank correlations, the relationship was determined between plasma concentrations of NEFA and the mean, maximum, and minimum pedometry activity ($P < 0.05$; 2-tailed). Activities were found to be normally distributed by a test of normality within and between periods, although the standard deviation was large at each period because of the high maximum and very low minimum activities of individual dairy cows.

RESULTS AND DISCUSSION

In the 5 periods during 3 wk postpartum, 33.3% of the cows had severe NEB in period 1; 24.2% in period 2; 21.2% in period 3; 15.2% in period 4, and 9.1% in period 5. The same cows had plasma NEFA concentrations of ≥ 0.7 mM during each period. Fluctuations occurred in the concentrations of plasma NEFA for individual cows. Concentrations of plasma NEFA for cows with severe NEB ranged from 0.7 to 1.45 mM and de-

clined during the 21-d study period, as did mean plasma NEFA concentrations in all 33 cows.

During period 3 (10 to 13 d postpartum), the maximum and mean activities were significantly correlated with the plasma NEFA concentrations, with correlation coefficients of -0.566 ($P < 0.01$) and -0.421 ($P < 0.05$), respectively. Results from this period are presented in Figures 1 and 2 as scatter plots. Maximum and mean activities during period 3 were found to be negatively correlated with the plasma NEFA concentrations in all periods of the 21-d postpartum study (Table 1). Concentrations of NEFA and activity in the other periods were also negatively correlated, but only 2 were statistically significant (Table 2).

Measurement of daily walking activity is used on farms primarily to detect estrus (Kiddy, 1977). According to Edwards and Tozer (2004), daily changes in walking activity, along with changes in daily milk yield, have proven to be useful for identifying potential disorders during the prebreeding stage of lactation. Furthermore, daily exercise has been suggested to improve the well being of dairy cows during the transition period (Barker et al., 1975; Grant and Albright, 1995). Al-

Table 1. Correlations between plasma concentrations of NEFA collected during the 5 periods and walking activities of the 33 cows at 10 to 13 d postpartum¹

	Period (days postpartum)									
	1 (2 to 5)		2 (6 to 9)		3 (10 to 13)		4 (14 to 17)		5 (18 to 21)	
	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>
Period 3 activity										
Maximum	0.017	-0.42	0.002	-0.51	0.001	-0.57	0.016	-0.44	0.001	-0.56
Minimum	0.061	0.33	0.599	0.10	0.708	0.07	0.078	0.33	0.314	0.18
Mean	0.515	-0.12	0.026	-0.39	0.016	-0.42	0.447	-0.15	0.011	-0.44

¹*P* = probability value; *r* = Spearman's rank correlation coefficient.

Table 2. Spearman's rank correlations between plasma concentrations of NEFA collected and walking activities of the 33 cows during 21 d postpartum¹

Activity	Period (days postpartum)									
	1 (2 to 5)		2 (6 to 9)		3 (10 to 13)		(14 to 17)		5 (18 to 21)	
	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>
Maximum	0.551	-0.11	0.498	-0.12	0.001	-0.57	0.461	-0.14	0.056	-0.34
Minimum	0.666	0.08	0.234	-0.21	0.708	0.07	0.021	0.43	0.404	-0.15
Mean	0.443	-0.14	0.091	-0.30	0.016	-0.42	0.396	0.16	0.183	-0.24

¹Values represent correlations of NEFA and activity from the same period. *P* = probability value; *r* = Spearman's rank correlation coefficient.

though no specific information is available on the role of exercise or walking activity in relation to serum NEFA during the periparturient period, NEFA are known to be used directly to fuel energy production in muscles and other peripheral tissues via mitochondrial oxidation of fatty acids or the Krebs cycle (Pethick and Dunshea, 1993; Chilliard et al., 2000). The use of NEFA during hypoglycemia or the sparing of glucose during periods of lactation or NEB is important to provide energy sources for cellular function and to maintain homeostasis. Excessive NEFA may be lost through this oxidative pathway during increased activity as muscular contraction or exercise. The relationship between plasma NEFA concentration and walking activity in our cows was significant at 10 to 13 d postpartum. This period is often near the nadir in NEB in high-yielding cows (Butler and Smith, 1989; Jorritsma, 2003).

Results of the present study show that cows having elevated concentrations of NEFA exhibit less activity than those with reduced NEFA. Perhaps the consequences of a severe NEB could be reduced by inducing forced activity in further study in which a treadmill is used, as for horses. However, this is not a practical solution for dairy farmers.

It is still premature to conclude that walking activity is a useful indicator of NEFA concentrations in individual cows. Undoubtedly, other factors can impair or enhance activity before and after parturition. The relationship between activity and NEFA could, for example, also be explained by the increased activity necessary for grazing in feral cattle. In daily dairy practice, however, it is impractical for dairy farmers to collect blood samples and have them assayed quickly. By measuring activity, a procedure that is already done as a means of identifying estrus, dairy producers might gain an impression of the NEFA status of individual cows. More research is warranted to understand and develop this as a possible means of monitoring the energy status of dairy cattle.

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