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Relationship between close-up cows body weight, production performance, and β hydroxybutyrate levels during early lactation.

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ABSTRACT

Reduction in feed intake, loss of body condition, and reduced milk production has been seen in dairy cows affected by clinical ketosis. Subclinical ketosis occurs in early lactation are related with increased severity of mastitis, and lower milk production during early lactation. The objectives of the study were to determine whether close-up cows body weight, body condition score and changes in body condition score during the transition periods were related to β-hydroxybutyrate concentrations, milk yield, and composition and to determine whether changes in milk yield and composition of cows were related to postpartum β-hydroxybutyrate concentrations in early lactation. Twenty 3rd lactation Holstein dairy cows were randomly selected and grouped into group 1 (G1) or group 2 (G2) based on their live body weight at d -21 relative to calving. Body condition score at d -21 before calving was negatively correlated with milk yield ($P = 0.009$), protein, fat ($P < 0.01$), and lactose yields ($P = 0.05$) at d 7 after calving. Fat and protein yields were negatively correlated with β-hydroxybutyrate level ($P = 0.003$) in cows with high body weight at d14 after calving. The result revealed that cows that had lost body condition scores from d 21 prior to calving until d 21 after calving had higher circulating β-hydroxybutyrate concentrations after calving.

Keywords: concentration, milk urea nitrogen; somatic cell count

INTRODUCTION

Reduction of dietary energy intake and the high level of energy expenditure in high producing dairy cow leads to mobilization of body reserves and results in negative energy balance during early lactation. During negative energy balance both body condition scores (BCS) and body weights decline (Veerkamp and Brotherstone, 1997; Berry et al., 2007). The ratio of adipose tissue to non-fat components in the body of live animals is defined as body condition (Murray, 1955). However, BCS changes and body weight respond differentially (Veerkamp and Brotherstone, 1997; Berry et al., 2007). During maximum negative energy balance a relationship between BCS, relative change in body weight, and reduced reproductive performance (**Van Straten et al., 2009**).

Cows that lost a greater amount of body weight during early lactation have a lower conception rate than do cows that lost less body weight (Westwood et al., 2002). The postpartum BCS decrease can profoundly affect metabolic status and milk production of dairy cows (Roche et al., 2009). Reduction of feed intake, rapid loss of body condition, and reduced milk production is also linked to cows affected by clinical ketosis (Youssef et al, 2010). Cows affected by subclinical ketosis are characterized by increased concentrations of circulating plasma ketone bodies yet do not show clinical signs of ketosis (Duffield, 2000). Subclinical ketosis that occurs during early lactation is also related to the increased incidences of mastitis and reduced milk production during early lactation (Duffield, 2000; Folnožić et al., 2015).

Milk protein and lactose content, BCS, and body weight changes are important tools to identify cows at risk of poor reproduction (Buckley et al., 2003). There is a positive correlation between live body weight, cow breed, and MUN concentrations (Kauffman and St-Pierre, 2001). Body weight influences the level of urea in various body fluids of animals (Kohn et al., 2002), and Due to superior nitrogen utilization efficiency MUN concentrations are lower in heavy cows than in lighter cows (Doska et al., 2012). Dairy cows with higher body weights and have superior nitrogen utilization efficiency had lower MUN concentrations than cows with lower body weights (Doska et al., 2012). Therefore, bigger cows consume more crude protein and have higher production of ammonia (Kauffman and St-Pierre, 2001).

Relationships between milk yield and body condition score during early lactation can be used as important tools to identify cows at risk of poor reproductive performance (Buckley et al., 2003). The relationship between body adipose reserves and body weight can be impacted by different factors such as parity, stage of lactation, frame size, gestation, and breed; therefore, body weight alone is not a good indicator of body reserves (Berry et al., 2006). Because there is a large individual variation in body condition score and body weight traits within parity groups, this study was designed to investigate the relationship between BW, BCS, and changes in BCS with cow's milk production performances and β-hydroxybutrate concentrations during early lactation.

We hypothesized that dairy cows with high close-up body condition score, and high body weight at d -21 before calving would lead to lower β-hydroxybutyrate levels with superior nitrogen utilization efficiency to reduce milk urea nitrogen concentration and increased in milk yield and composition in early lactation. The objective of this study was to: (1) determine whether body weight and body condition score changes in close up cows across pre- and post-partum periods were related to milk yield, milk composition, and BHBA concentrations in early lactation; (2) determine whether changes in milk yield and composition of cows in early lactation were related to postpartum BHBA concentrations in early lactation.

MATERIALS AND METHODS

Experimental animals and dietary ration

In brief, the study was conducted by randomly selected 20 third lactation close-up Holstein-Friesian dairy cows at d -21 ± 5 relative to calving from large close-up dairy cows in the dairy farm. All the selected cows were grouped into group 1(G1) or group 2 (G2) based on their live body weight at d -21 relative to calving. Cows with body weights < 868kg were grouped into G1 whereas cows with body weight > 868kg were grouped into G2. Cows in G1 and G2 had BW of 785.6 ± 23.58 kg and 902.6 ± 13.09 kg, respectively at d -21 relative to calving (P < 0.01). BCS and BHBA levels were continually scored and measured at -14, -7, 0, 7, 14, and 21 relative to calving. All cows in G1 and G2 were fed the same close-up diet (1.37 NEL Mcal/kg DM, 15% CP) from d -21 to calving date, and fresh cow lactation diet (1.695 NEL Mcal/kg DM, 18% CP) from calving to d 21 after calving during the study period. It should be noted that the dietary energy level that was provided to cows in G1 and G2 during the close-up period (from d-21 to calving date) was relatively low relative to NRC [28] recommendations. Prior to switching to a close-up low energy diet on d -21 relative to calving, the body weight, BCS, and BHBA levels of experimental cows were measured and scored. During the far-off, close-up, and fresh cow periods all experimental cows were fed TMR ad libitum. Fresh water was constantly available for all cows.

Blood, milk samples collection and BCS

Blood samples from individual cows were collected at 0700h daily on -21, -14, -7, 0, -3, 7, 14, and 21 relatives to calving via the coccygeal vein. The concentrations of blood β-hydroxybutyrate was immediately determined (< 30 min) in each sample using a ketometer and blood ketone test strips according to the manufacturer's instructions (Nanjing Jiancheng, Bioengineering Institute Nanjing Jiancheng technology Co.Ltd. China).

Duplicate milk samples from individual cows were collected at three consecutive milking and mixed based on the average milk production at each milking (morning, afternoon, and night; volume ratio: 4:3:3) on d 7, 14 and 21. One aliquot of milk was preserved with bronopol-B2 preservative (D&F Control System Inc., Dublin, ON, Canada) at 4°C and subsequently analyzed for fat, protein, lactose, SCC, and MUN using a mid-infrared machine (Foss MilkoScan, Foss Food Technology Corp., Eden Prairie, MN).

Body condition scoring of cows in both groups were scored at d -21, -14, -7, 0, 7, 14 and 21 relative to calving using a standard 5 point scale (1 = emaciated, to 5 = obese). Body condition scores were performed by the same trained operative by palpating and visualizing individual body parts of the spinal column (chine, loin, and rump), the cranial coccygeal vertebrae (tail head), the tuber ischia (pin bones), the tuber sacral (hip or hook bones), and the thigh region as described by Edmonson et al. (1989).

Statistical analysis

Data were analyzed as a complete randomized design with repeated measures using PROC MIXED of SAS (version 9.2 SAS Institute Inc.,Cary, NC). The MIXED statistical model used for analysis of the data was: $y_{ijkl} = \mu + G_i + T_j + G_iT_j + A_{ij} + \varepsilon_{ij}$, where y_{ij} was the dependent, continuous variable, μ was the overall mean; G_i was the fixed effect of groups (G1 = low BW or G2 = high BW); T_j was the fixed effect of time (days); G_iT_j was interaction effect of group and time; A_{ij} was the random effect of the k'th cow in the ij'th combination of group and time, and ε_{ij} was the residual error. To assess the main effect of group, times (in days) and their interaction effect on blood BHBA levels, BCS, milk yield, and composition were used to analysis the data at various time point that were not equally spaced, hence the covariance structure for the repeated measurements was modeled using the spatial power option. The Kenward-Roger option was used for the computing the denominator degrees of freedom for testing hypotheses. Pearson correlation coefficients were calculated to describe relationships of BCS, body weight with milk yield, fat, protein, lactose, yield, and SCC, BHBA levels, and milk urea nitrogen. In the analyses of BHBA levels, milk yield and composition, with-animal factors and group as the between-animal factor were included in the model to test for differences between the 2 groups of animals with respect to changes of parameters from d-21 to the first 21 d postpartum. Tukey test was used for the determination of differences between BW groups and statistical differences were declared significant at P ≤ 0.05 and tendencies were determined at P ≤ 0.10.

RESULTS AND DISCUSSION

The effect of close-up cows body weight, time, and their interactions on milk, fat, protein, and lactose yields, SCC, and MUN levels are presented in Table 1.

Item	G1	G2	SE	P-Value		
					Time	Group x time
Milk yield (kg/d)	44.6	48.3	2.0	0.19	0.01	0.23
Milk compo						

sition(kg/d)						
Fat	2.1	2.2	0.44	0.92	0.26	0.76
Protein	2.1	1.9	0.21	0.53	0.00	0.82
Lactose	2.2	2.5	0.18	0.29	0.00	0.58
MUN	15.2	13.6	1.0	0.28	0.88	0.66
SCC	2.0	1.6	0.22	0.20	0.78	0.35
BHBA	0.92	1.1	0.12	0.43	0.00	0.77

Table 1: Effect of close-up cows body weight at d -21 relative to calving on milk yield, milk composition and β-hydroxybutrate levels during early lactation.

G1 = low body weight, and G2 = high body weight at d -21 relative to calving, BCS = body condition score, BHBA = β-hydroxybutyrate, MUN = milk urea nitrogen, and SCC = somatic cell count.

No significant difference was observed in BCS between G1 and G2 across pre and postpartum periods. Cows with higher BCS at d -21 relative to calving continued to have higher BCS up to d 21 after calving than did cows with low BCS. No significant differences were observed in milk yield, milk composition and BHBA levels between G1 and G2 cows. Similarly, Aeberhard et al. (2001) did not record any milk yield differences between high and low BCS. Our data indicated that cows in G2 numerically had higher milk yield, higher fat yield and lower MUN at d 21 after calving compared to cows in G1 (Table 1). There was no significant difference in milk lactose yield in the first 3 weeks of lactation between G1 and G2 cows. However, milk lactose yields numerically, higher in G2 cows as compared to cows in G1 (Figure 1a).

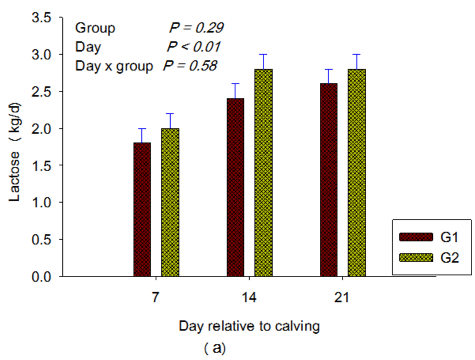

Figure 1: Effect of close-up body weight on milk lactose yield during early lactation (a) milk lactose yield in early lactation (day 7 to 21). Error bars represents the standard error of the mean (± SEM). G1= low body weight, G2 = high body weight at d -21 days relative to calving.

Relationship of close-up cows BCS with milk yield and composition during early lactation

Pre-calving higher BCS cows in G2 cows at d -21 relative to calving negatively correlated with fat yield (P = 0.02), lactose yield (P = 0.04) and tended to negatively correlated with milk protein yield (P = 0.05) at d 7 after calving Table 2.

Variables	Day 7 G1		Day 7 G2		Day 14 G1		Day 14 G2		Day 21 G1		Day 21 G2	
	r	P	r	P	r	P	r	P	r	P	r	P
Milk yield	-37	NA	-0.04	NA	-0.56	NA	-0.47	NA	0.23	NA	-0.29	NA
Fat	-16	NA	-0.74	0.02	0.06	NA	-0.77	0.04	0.13	NA	0.12	NA
Protein	-43	NA	-0.83	0.05	0.24	NA	-0.43			NA	-0.34	NA
Lactose	-12	NA	-0.67	0.04	0.16	NA	-0.58	NA	0.25	NA	-0.33	NA
SCC	-431	NA	-0.67	NA	0.08	NA	0.31	NA	0.09	NA	0.20	NA
MUN	-53	NA	-0.36	NA	0.69	0.08	0.50	NA	0.54	NA	0.69	0.05
BHBA	0.39	NA	0.27	NA	0.44	NA	-0.74	0.02	0.42	NA	0.56	NA

Table 2: Relationship of BCS at d -21 before calving with BHBA levels, milk yield and composition of dairy cows during early lactation (at d 7, 14 and d21).

G1 = low body weight, G2 = high body weight, r = correlation coefficient, p = p-values, NA = non-significant, MUN= milk urea nitrogen, SCC = somatic cell count and BCS = body condition score, d 7, d 14 and d 21 indicated milk yield, composition and BHBA levels of cows at week1, week2 and week 3 after calving respectively.

However, lower BCS in G1 cows at d -21 before calving did not (P > 0.05) correlate with milk yield, fat, protein, lactose yield, MUN concentrations, or SCC at d 14 after calving but MUN tended to positively corrected with BCS in G1 (P = 0.08, Table 2). Body condition is an important factor which affected milk production (Petrovska & Jonkus, 2014). In our study, pre-partum body condition score numerically, negatively correlated with milk yield both in G1 and G2 in the first 2 weeks after calving. Previous study showed that the highest milk performance was observed in cows with the lowest BCS before calving, BCS < 4 (Jílek et al., 2008). In our study, we did not observe any significant difference between two groups. But other authors reported that milk yield was the greatest by cows with average

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BCS value 2.5 points (Kadarmideen, 2004, Petrovska & Jonkus, 2014) and mobilization of body fat reserves and milk production is closely related (Pryce et al., 2002).

Relationship of BCS across early lactation with, BHBA, milk yield and compositions

BCS change can affect metabolism process of cows because of body condition is connected with lipids metabolism. Metabolism of lipid affected cow's milk productivity (Bernabucci et al., 2005). Milk yield and milk composition of cows in G1 and G2 at different time points during the first 3 weeks after calving are presented in Table 1. BCS at d 21 after calving negatively correlated with milk yield (P = 0.009), fat yield (P < 0.01), milk protein yield (P < 0.01), tended to negatively correlate with milk lactose yield (P = 0.05) in G2 cows Table 3.

Variables	Day 7 G1		Day 7 G2		Day 14 G1		Day 14 G2		Day 21 G1		Day 21 G2	
	r	P	r	P	r	P	r	P	r	P	r	P
Milk yield	0.6	0.06	0.02	NA	-0.54	NA	-0.26	NA	-0.03	NA	-0.8	0
Fat	-0.22	NA	-0.43	NA	-0.14	NA	0.78	0	0.06	NA	-0.8	0.01
Protein	0.31	NA	-0.56	NA	-0.38	NA	-0.1	NA	0.04	NA	-0.9	0
Lactose	0.33	NA	-0.25	NA	-0.41	NA	-0.29	NA	-0.12	NA	-0.7	0.05
SCC	0.48	NA	0.27	NA	-0.48	NA	0.22	NA	0.08	NA	-0.4	NA
MUN	0.4	NA	-0.25	NA	0.19	NA	0.62	NA	-0.33	NA	-0.3	NA
BHBA	-0.37	NA	-0.86	0	0.38	NA	-0.22	NA	0.13	NA	0.27	NA

Table 3: Relationship of changes in BCS in the first 3 weeks after calving with BHBA levels, milk yield and composition cows during early lactation.

G1 = low body weight, G2 = high body weight, r = correlation coefficient, p = p-values, NA = non-significant, MUN= milk urea nitrogen, SCC = somatic cell count and BCS = body condition score, d 7, d 14 and d 21 indicated milk yield, milk composition and BHBA levels of cows at week1, week2 and week 3 after calving respectively.

BCS at -21 before calving was numerically positively correlated with BHBA in the first week after calving whereas BCS at d 7 after calving highly negatively correlated with BHBA levels at this point (P = 0.003). This showed that BCS in the first week after calving is very crucial to manage the energy balance in dairy cows which may has great impact on BHBA levels in early lactation.

Numerically, protein yield, lactose yield, SCC, and MUN concentrations in G1 cows were positively correlated with BCS at the first week after calving but fat, protein, lactose and MUN in G2 cows were negatively correlated with BCS at d 7. Milk yield tended to be positively correlated with BCS in G1 cows at d 7 (P =0.06, Figure 2a), and positively correlated in G2 cows. Similarly, a positive association between calving BCS and milk production was previously reported (Veerkamp, 1998); Pryce et al., 2002). In general, different relationship exist between body condition score and milk yield at different point of time, this relationship may be depending on the degree of fat mobilization from body reserve to compensate negative energy balance in early lactation. The high genetic merit dairy cattle have a higher tendency for mobilization of body fat reserves to cover milk production demands (Veerkamp, 1998); Pryce et al., 2002). Similarly, our data showed that high producing cows had higher BHBA levels in G2 cows which indicate higher body fat mobilization during early lactation.

SCC and MUN levels did not differ (P > 0.05) between low BCS and high BCS cows over the first 21 d of lactation. Genetically, BCS is negatively correlated with mastitis. Previous study showed that decreased postpartum body condition score resulted in increased mastitis. This indicated that cows with low body condition score is easily susceptible to mastitis and metabolic diseases as compared to cows with high BCS (Loker et al., 2012). BCS does not affect somatic cell count. Similarly, we did not observe any significant difference in somatic cell count between high and low BCS in G1 and G2 cows in our study. Phenotypic correlation was low between somatic cell count and BCS. This showed that somatic cell count is affected by environment factors and udder form (Kadarmideen, 2004). Milk yield and milk urea nitrogen (MUN) of cows in G1 and G2 at different time points during the first 3 weeks after calving are presented in Figure 2a and 2b.

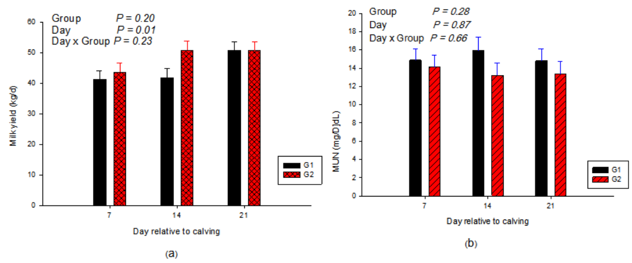

Figure 2: Effect of close-up body weight on milk yield and milk urea nitrogen levels during early lactation (a) milk yield in early lactation (day 7 to 21) (b) milk urea nitrogen in early lactation (day 7 to 21). Error bars represents the standard error of the mean (± SEM). G1= low body weight, G2 = high body weight at d -21 days relative to calving.

Relationship of BHBA with BCS, milk yield and composition during early lactation

Blood BHBA concentrations of cows in G1 and G2 were steadily increased over the first 21d of lactation but were not significantly different between low and high BCS in pre and postpartum cows during the transition period (P =0.43, Figure 3a and 3b).

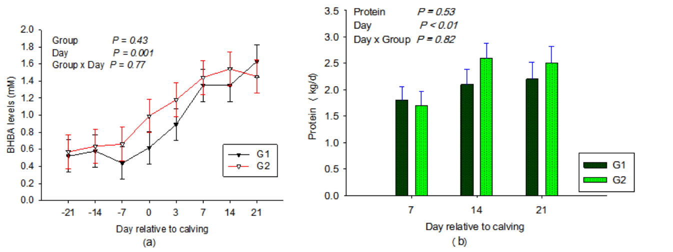

Figure 3: Effect of close-up body weight B-hydroxybutrate concentrations and milk protein yield during early lactation, (a) B-hydroxybutrate concentrations (day 7 to 21) (b) milk protein in early lactation (day 7 to 21). Error bars represents the standard error of the mean (± SEM). G1= low body weight, G2 = high body weight at d -21 relative to calving.

Similarly, previous studies indicated that there was no significant difference in BHBA levels between optimal BCS (3.25 to 3.75) and obese (BCS > 4) cows during the transition period (Folnožić et al., 2015). Day significantly affected both BHBA levels and milk protein yield during early lactation (P < 0.01). Changes in BCS of cows are related to change in blood content (Mouffok et al., 2013). Post-partum decreased BCS accompanied by increase β-hydroxybutyrate (BHBA) concentrations. Increased demands for energy put dairy cow under negative energy balance and the cow starts mobilizing her lipid reserves, getting thinner and lose her body condition score (Aeberhard, Bruckmaier, Kuepfer, & Blum, 2001; Agenäs, Burstedt, & Holtenius, 2003; Coffey, Simm, & Brotherstone, 2002). Cows fatter at calving would tend to lose more body fat than thinner cows (Garnsworthy, 2006). Due to intense mobilization of body fat which leads to higher BHBA concentrations, fat cows usually faced metabolically challenge during early lactation. However, thin cows were associated with increased plasma indicators of body protein mobilization during the first weeks of lactation, and lower milk protein secretion (Pires et al., 2013). Because of body condition is connected with metabolism of lipids, the degree of BCS change can affect metabolism process of cows (Bernabucci et al., 2005). Previous study showed that BCS has been considered an effective tool in monitoring the energy intake of cows and herd. Hence, increased BCS above 3.5 points after calving leads to ketosis and fatty liver [38]. In support of these finding, we found that increased BCS leads to increased BHBA concentrations in early lactations in our study. Although the mean values did not significantly differ in our study, BHBA concentrations, BCS, and milk yield slightly increased in G2 cows compared to cows in G1. Similarly, concentrations of BHBA in cows with a BCS > 2.5 or < 2.5 did not significantly differ (Aktas et al., 2011). In the present study, the highest BHBA level was found in low BCS (3.45) cows at d 21 after calving, whereas in other studies the highest BHBA levels were observed on d 12 and 19 after parturition in optimal BCS (3.25 to 3.75) and obese cows (BCS > 4) respectively, and subsequently BHBA levels reduced (Folnožić et al., 2015). In the present study, cows in G2 which had higher BCS relatively had more adipose coverage than did G1 cows, and this low BCS an indicator of nutritional status, potential metabolic disorders and associated health problems, and it can indicate poor farm management (Whay et al., 2003). The BHBA level (0.52 mM) in G1 cows at d -21 before calving in this study was higher than BHBA levels (0.48 mM) at 60 d postpartum of non-pregnant cows (Whay et al., 2003). In other studies, there was no marked relationship observed between BCS and ketosis (Reist et al., 2002; Iwersen et al., 2009). Similarly, we did not observe any significant relationships between BCS and BHBA levels except BHBA levels in G2 cows at d 7 after calving significantly negatively correlated with postpartum BCS at this period in our study (P = 0.003, Table 4). The BCS at calving was lower than the BCS at d -21 before calving in both groups of cows. This suggested that the incidence of ketosis in G1 and G2 of cow was lower because a higher BCS at calving leads to higher mobilization of fat tissue and an increased incidence of ketosis (Gillund et al., 2001).

Variables	Day 7 G1		Day 7 G2		Day 14 G1		Day 14 G2		Day 21 G1		Day 21 G2	
	r	p	r	p	r	p	r	p	r	p	r	p
Milk yield	0.08	NA	0.21	NA	-0.6	NA	-0.6	NA	0.18	NA	-0.4	NA
Fat	0.03	NA	0.18	NA	0.42	NA	0.39	NA	0.55	NA	-0.4	NA
Protein	0.21	NA	0.34	NA	0.12	NA	-0.72	0	0.2	NA	-0.5	NA
Lactose	-0.12	NA	0.03	NA	0.1	NA	-0.75	0	0.13	NA	-0.3	NA
SCC	-0.07	NA	0.05	NA	0.14	NA	0.2	NA	0.34	NA	-0.4	NA
MUN	0.27	NA	0.17	NA	0.31	NA	-0.29	NA	0.35	NA	0.19	NA
BCS	-0.37	NA	-0.86	0	0.37	NA	-0.22	NA	0.13	NA	0.26	NA

Table 4: Relationship of BHBA with milk yield and composition during early lactation

G1 = low body weight, G2 = high body weight, r = correlation coefficient, p = p-values, NA = non-significant, MUN= milk urea nitrogen, SCC = somatic cell count and BCS = body condition score, d 7, d 14 and d 21 indicated milk yield, milk composition and BHBA levels of cows at week1, week2 and week 3 after calving respectively.

In the present study, BHBA levels at d 14 negatively correlated with protein yield (P = 0.04) and lactose yield (P = 0.03) in G2 cows but not in G1 cows. The BCS of cows can be a rough estimate of energy balance, a positive energy balance is typically observed as an increasing BCS (Roche et al., 2004). In our study, lower BHBA levels (1.45mM) was found in high postpartum BCS at d 21 after calving which indicated relatively positive energy balance at this period compared to low BCS cows.

Relationship of close-up cow body weight with BCS, milk yield and compositions

Previous study showed that there was a favorable relationship between BCS and BW in dairy cows (Roche et al., 2007b). However, association among body weight, BCS, and cow health less consistent (Roche and Berry, 2006). In our study, we observed that cows with high BCS at calving had lost more BCS in weeks 1 and 2 after calving than cows that had lower BCS at calving. Cows with high BCS at calving had a greater tendency to lose more BCS after calving (Lacetera et al., 2005; Roche et al., 2007a). The average BW of cows at d -21 relative to calving significantly differed between G1 and G2 cows (P < 0.01) by design and was positively correlated with milk yield (P < 0.01), protein yield (P = 0.04), tended to positively correlate with milk lactose yield (P = 0.07) at d 21 after calving in low BCS cows. However, BW at -21 before calving negatively correlated with protein and lactose yields in G2 cows (P < 0.01, Table 5). Similarly, Berry et al., (2003) reported that milk yield and live weight positively correlated. Similarly, our data indicated that live body weight at -21 before calving significantly positively correlated with milk yield in both groups at d 21 after calving (P < 0.01). The relationship between body reserve and body weight can be affected by factors such as parity, stage of lactation, frame size, gestation, and breed; hence body weight alone is not a good indicator of body energy reserves (Berry et al., 2006). In our study, no significant correlation was found between body weight at d -21 before calving and BCS of cows in G1 and G2 during early lactation (Table 5) except BCS at d 7 which was negatively correlated (P = 0.04).

Variables	Day 7 G1		Day 7 G2		Day 14 G1		Day 14 G2		Day 21 G1		Day 21 G2	
	r	p	r	p	r	p	r	p	r	p	r	p
Milk yield	0.53	N	-28	NA	0.1	NA	-0.65	NA	0.66	0.03	0.93	0
Fat	-0.31	NA	-0.15	NA	0.59	NA	0.31	NA	0.55	NA	-0.3	NA
Protein	-0.15	NA	-0.24	NA	0.6	NA	-0.56	NA	0.67	0.04	-0.9	0
Lactose	0.05	NA	-0.13	NA	0.6	NA	-0.52	NA	0.62	0.07	-0.8	0
SCC	0.49	NA	-0.08	NA	0.64	NA	-0.25	NA	0.58	NA	-0.2	NA
MUN	-0.25	NA	-0.1	NA	0.36	NA	0.6	NA	0.45	NA	-0	NA
BHBA	-0.61	0.06	-0.45	NA	0.53	NA	-0.01	NA	0.49	NA	0.45	0.03
BCS	-0.06	NA	-0.65	0.04	-0.2	NA	-0.72	NA	0.41	NA	0.71	NA

Table 5: Relationship of body weight at d -21 relative calving with BHBA levels, milk yield and composition in early lactation

G1 = low body weight, G2 = high body weight, r = correlation coefficient, p = p-values, NA = non-significant, MUN= milk urea nitrogen, SCC = somatic cell count, BCS = body condition score and BHBA = β-hydroxybutrate, d 7, d 14 and d 21 indicated milk yield, milk composition and BHBA levels of cows at week1, week2 and week 3 after calving respectively.

Cows in G2 lost more BCS (2%) at d 21 after calving compared to cows in G1 which lost 1% BCS at this point in this study. Cows which had more average body weight and higher BCS at d -21 before calving had lost more weight (2%) at d 21 after calving than cows with less body weight and lower BCS. Cows that had the greatest BCS loss were heaviest at d 21 and subsequently had the greatest BCS loss before calving and continued to lose BCS during the first 21 d after calving (Barletta et al., 2017). Studies have shown that over conditioning of dairy cattle resulted in the loss of BCS after calving and led to impaired health (Gillund et al., 2001). Others also showed a negative relationship between BCS at calving and changes in BCS during early lactation (Stockdale, 2001). Body condition score at 21 d before calving was more predictive for BCS loss or gain than BCS near calving (Stockdale, 2001). Similarly, more BCS was gained at d -14 than BCS was lost at d-7 in G2 cows. Cows that lost the least BCS or BW during early lactation had greater somatic cell counts (D. P. Berry et al., 2006) but here BW was not significantly correlated with SCC in either G1 or G2 cows during early lactation. BW at d -21 relative to calving was negatively correlated with high BCS in G2 cows at d 7 after calving (P = 0.04, Table 5). Previous study indicated that body weight was positively correlated with SCC (Roche et al., 2007). Similarly, in our study BW numerically positively correlated with SCC in G1 cows at d 7, 14 and 21 after calving but negatively corrected in G2 cows at these periods. Higher milk fat and protein yield were observed in cows that genetically prone to lose more BCS in early lactation (Dechow et al., 2002)

CONCLUSION

Overall, our data suggests that BW at 21 d before calving did not have a significant effect on milk yield, fat, protein, lactose yield or MUN concentrations in early lactation dairy cows. Higher BCS at 21 d before calving had a significant relationship with milk fat, protein and lactose yields at d 7 after calving. BCS at -21 before calving numerically, positively correlated with BHBA in the first week after calving whereas BCS at d 7 after calving highly negatively correlated with BHBA levels at this point. Cows that lost BCS during the transition period from 21 d prior to calving until 21 d after calving had higher circulating BHBA concentrations after calving which is indicative of a potential increase in ketosis incidence. Body weight of cows at d -21 relative to calving significantly positively correlated with milk yield and protein yield, tended to correlate with milk lactose yield at d 21 after calving in G1 cows. BW at -21 before calving tended to negatively correlated with BHBA level at d 7 in G1 cows and positively correlated with BHBA level at d 21 after calving in G2 cows. Further studies are needed to determine the association between pre-calving body weight and body weight changes across the peri-and post-partum periods with milk yield, milk composition, and BHBA levels in early lactation because body weight change (?BW) during these stressful periods may be a better predictor of production performance than simply BW measured at an arbitrary time point.

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