



EVALUATION OF POSTPARTUM METABOLIC AND HEALTH RESPONSE IN DAIRY COWS WITH DIFFERENT BODY CONDITION SCORE DURING THE DRY PERIOD

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Summary

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This study aimed to evaluate the effects of different pre-calving body conditions on some metabolic indices, health status and reproductive disorders in dairy cows. The study was conducted on a dairy farm in Eastern Slovakia during the pre-partum period (–1 to –10 DIM) and post-partum period (1 to 14 DIM). Total of 84 cows allotted in 3 groups were submitted to clinical examination and body condition score (BCS) evaluation. At the same intervals blood samples were collected for determination of beta-hydroxybutyrate (BHB), non-esterified fatty acids (NEFA), and calcium levels. During the postpartum period the incidence of reproductive diseases, such as metritis, retained placenta, metabolic disorders, such as milk fever, left displacement of abomasum and orthopaedic disorders were recorded. The strongest lipid mobilisation (NEFA elevation), ketone body production, and blood calcium drop were determined in postpartum dairy cows with the highest prepartum body condition score. In conclusion, the dairy cows with different BCS had a different metabolic response during the postpartum period. The overcondition was connected with stronger lipid mobilisation and calcium drop after calving. Moreover, the higher BCS could contribute to higher incidence of production diseases.

Key words: BCS, dairy cows, diseases, metabolic profile, transition period

INTRODUCTION

Body condition score (BCS) is nowadays considered to be an important part of dairy cow management. The changes of the BCS before parturition affect productivity, reproductive parameters, and health status in the postpartum period. BCS is a subjective, visual or tactile evaluation of

subcutaneous fat in dairy cows (Edmondson *et al.*, 1989). Most of the metabolic disorders are related to the extreme loss of BCS after calving. Overconditioned dairy cows or cows with poor body condition can exhibit calving difficulties and often have postpartum complications due to

immunological deficiency and metabolic disorders (Sordillo & Raphael, 2013). The high-producing dairy cow is always on the verge of abnormal homeostasis as breeding and feeding for high milk yields is frequently associated with the development of metabolic disorders (Ingvarstsen *et al.* 2003). Cows with a high BCS tend to lose more body weight through lipid mobilisation, resulting in enhanced increases in non-esterified fatty acids (NEFA) and beta-hydroxybutyrate (BHB) concentrations during the onset of lactation disorders (Sordillo & Raphael, 2013). Physiologically, high-producing dairy cows lose 0.5 point of BCS in the first 30 days postpartum (Domecq *et al.*, 1997; Duffield *et al.*, 1998). Increased losses over 0.5 points are associated with increased risk of metritis, displaced abomasum, lameness, ketosis, and hypocalcaemia (Kim & Suh, 2003). Therefore, minimising loss of BCS in the postpartum period (≤ 0.5) is essential for good herd fertility (Smith *et al.*, 2014). However, high BCS is not the only cause of metabolic disorders in dairy cows (Vernon, 2005).

The transition period is particularly important for health and the subsequent performance of dairy cows, which are exposed to drastic physiological changes and metabolic stress (Grummer *et al.*, 1993). Excessive energetic demand is typical for these periods to cover needs of foetal growth, lactation, and higher activity of the immune system. Concentrations of blood metabolites including BHB, NEFA, glucose and insulin may provide some indication of postpartum disease risk and can be useful for herd health monitoring (Ospina *et al.*, 2010; LeBlanc, 2010; Fiore *et al.*, 2014). Although a slight increase in serum levels of these metabolites is physiological due to almost unavoidable certain disbalance in energy intake and

output – negative energy balance (NEB) – during early lactation, their excessive increase is indicating an insufficient metabolic adaptation to NEB (Herdt, 2000). Elevated non-esterified fatty acids (NEFA) during the last seven days before calving have been associated with a greater incidence of the following three diseases: ketosis, displaced abomasum (DA) and retained foetal membranes, but not milk fever (LeBlanc *et al.*, 2005). Serum NEFA concentrations reflect the level of fat mobilisation, while BHB concentration indicates complete fat oxidation in the liver (LeBlanc, 2010). Many studies have dealt with the determination of NEFA, BHB and calcium serum thresholds to predict production diseases in transient dairy cows (Ospina, 2010; Roberts *et al.*, 2012;). Increased levels of NEFA, BHB and decreased serum calcium before calving were associated with a higher risk of production diseases (LeBlanc *et al.*, 2005; Seifi *et al.*, 2011), decreased milk yield (Ospina *et al.*, 2010), and insufficient reproduction activity in the postpartal period. A severe decrease in body condition score has been also associated with higher rate of claw horn lesions, possibly due to decreased thickness of the digital cushion (Bicalho *et al.*, 2009; Green *et al.*, 2014).

The aim of the study was to determine the effects of different pre-calving body conditions on some metabolic indices, health status and incidence of reproductive disorders in dairy cows.

MATERIALS AND METHODS

The study was conducted on a dairy farm in Eastern Slovakia belonging to the University of Veterinary Medicine and Pharmacy in Kosice from March 2016 to July 2018. The average milk yield per year and

cow was 8,210 kg. The cows were housed in free-stalls with a deep straw bedding and were fed a total mix ration (TMR). A total of 84 Holstein Friesian cows were used in this study. The cows were allotted in three groups depending on their BCS in the prepartum period (1–10 days before calving): G1 (n=4), animals with BCS <3.25, G2 (n=44) with BCS 3.25–3.75 and G3 (n=36) with BCS >3.75. BCS was always recorded by the same observer, using a scale according to Edmondson *et al.* (1989).

Blood samples were collected from the coccygeal vein from 10 to 2 days before the expected date of calving, and from 7 to 14 days postpartum, including post-calving BCS assessment. Serum NEFA and BHB were assayed with kits supplied by Randox Laboratories Ltd. on spectrophotometer Alizé (Lisabio, France). The serum calcium concentrations were determined by flame AAS method (Perkin Elmer AAnalyst 100).

All dairy cows were monitored for 14 days postpartum for occurrence of health disorders, including production diseases, reproduction disorders and lameness.

Statistical analysis of group effects on blood indices and BCS was carried out by a two-factorial analysis of variance (one repeated factor: time, one grouping factor: treatment) with the *post hoc* Bonferroni test (IBM SPSS Statistics 23, 2015). Significance was declared at P<0.05. The difference in the occurrence of health disorders in groups with different BCS was evaluated by the chi-square test (χ^2 test).

RESULTS

Dynamics of blood BCS, BHB, NEFA and calcium in each of the three groups are presented in Table 1. The body condition score decreased from prepartum to postpartum period in each group with the highest difference in group G2 and G3 (P<0.05). The strongest lipid mobilisation (NEFA elevation), ketone bodies production and blood calcium drop were recorded in postpartum dairy cows with the highest body condition (BCS over 3.75, P<0.05). ANOVA did not reveal a difference in postpartum serum concentrations of NEFA, BHB and calcium among the BCS groups.

Table 1. Blood BCS, serum BHB, NEFA, and calcium concentrations in dairy cows of different BCS groups (G1 BCS<3.25; G2 BCS 3.25–3.75; G3 BCS>3.75). Data are presented as mean±SD

Sampling time	Group	BCS scale 1–5	BHB mmol/l	NEFA mmol/l	Ca mmol/l
Before calving	G1 (n=4)	3.00±0.00a	0.32±0.05	0.31±0.03	2.00±0.27a
	G2 (n=44)	3.49±0.18b	0.43±0.13	0.40±0.19	2.39±0.20ab
	G3 (n=36)	4.43±0.22c	0.45±0.18	0.39±0.20	2.74±0.15ac
After calving	G1 (n=4)	3.19±0.43a	1.50±0.76	0.89±0.52	2.75±0.20
	G2 (n=44)	*3.27±0.47ab	0.66±0.45	0.73±0.32	2.16±0.21
	G3 (n=36)	*3.00±0.46ac	*0.80±0.49	*0.72±0.33	*2.18±0.19
Group effect		P<0.05	NS	NS	P<0.05
Time effect		P<0.05	P<0.05	P<0.05	P<0.05

NS – not significant; abc: means with different superscript letters were significantly different (P<0.05) within sampling times; *group means differ between samplings (P<0.05).

Table 2. Incidence of reproductive, production and claw diseases in BCS groups

Variable	Groups						χ^2
	G1 (n=4)		G2 (n=44)		G3 (n=36)		
	N	%	N	%	N	%	
Metritis	1	25	7	15.9	7	19.4	NS
Retained placenta	0		3	6.82	4	11.1	NS
Milk fever	0		3	6.82	4	11.1	NS
LDA	0		0		1	2.78	NS
Claw diseases	1	25	13	29.6	13	36.1	NS
Culled	0		3	6.82	2	5.56	NS

LDA – left abomasal displacement, NS – not significant.

Results of the postpartum health monitoring are given in Table 2. A trend to higher prevalence of health disorders was determined in the group with the highest prepartum BCS. Displacement of the abomasum was detected only in group 3. The most frequent claw diseases were digital dermatitis and toe/sole ulcer. Five dairy cows were sent to the slaughterhouse during the study.

DISCUSSION

The transition from late gestation to early lactation is a metabolic period of change for dairy cows, during which most infectious and metabolic diseases are likely to occur (Mallard *et al.* 1998). Cows unable to adapt to this challenging time are more prone to negative events, and the associations between excessive negative energy balance (NEB) in dairy cows and these detrimental health effects have been reported by several authors (Hammon *et al.* 2006; McArt *et al.*, 2013). The NEB status is characterised by alterations in blood metabolite and hormone profile (Piccione *et al.*, 2012). During the period of NEB, key hormone expression and tissue responsiveness alter to increase

lipolysis and decrease lipogenesis, causing high levels of NEFA and β -hydroxybutyrate concentration which are indicative of lipid mobilisation and fatty acid oxidation (Sakha *et al.*, 2006; Wathes *et al.*, 2009).

In our study, we analysed the main serum parameters which are used in pre and postpartum dairy cows as predictors of NEB and production diseases: NEFA, BHB and calcium (Ospina *et al.*, 2010; Chapinal *et al.*, 2011; Martinez *et al.*, 2014). Their blood concentrations indicate the rate of adaptation to NEB, and the occurrence of postpartum diseases can be predicted. Higher NEFA values during the postpartum period indicated the activation of lipid mobilisation and were accepted as a form of metabolic adaptation to the postpartum period (Piccione *et al.*, 2012). Our study was focused on energetic metabolite values in dairy cows with a different BCS, and their changes during transition period demonstrated no significant effect of the different BCS on their concentrations. Nevertheless, a strong increase in both NEFA and BHB concentrations was determined in the overconditioned group. It is well known that low insulin concentration and reduced insulin sensitivity of the tissues around parturition

increase lipid mobilisation and induces further rises in serum NEFA concentrations (Hayirli, 2006). According to Ospina *et al.* (2010) if the concentration of NEFA before calving is above 0.5 mmol/L, an increased risk of retained placenta, metritis, displaced abomasum, reduced milk production and extension of service period may occur. An elevated BHB concentration (≥ 0.8 mmol/L) in the prepartum period is an indicator of reduced postnatal production, and increased risk of abomasal displacement (Chapinal *et al.*, 2012). Recently, lecithin cholesterol acyltransferase was demonstrated as a useful predictor of postpartum health disorders like retained placenta, ketosis, displaced abomasum, milk fever, mastitis and dystocia (Khalphallah *et al.*, 2018). In our study, the most common health disorders diagnosed in the postpartum period were retained placenta and metritis. It is generally known that dairy cows with BCS >4.00 are more susceptible to metabolic disorders in the postpartum period. In current study the dairy cows of group 3 (BCS >3.75) tended to have the highest rate of the postpartum diseases. Gillund *et al.* (2001) reported a doubling of the risk of ketosis in dairy cows with a calving BCS of >3.5 compared to those with a calving BCS of 3.25. This is consistent with the comprehensive review (Ingvarlsen, 2006) of periparturient morbidity and its relationship to excessive lipid mobilisation in cows with high BCS resulting in elevation of serum concentrations of NEFA and BHB. The massive lipid mobilisation in the overconditioned dairy cows can be also accelerated by a decrease in the feed intake due to hypophagic effects of elevated acetyl-CoA and propionate in the liver (Stocks & Allen, 2012). The lower feed intake can contribute to the lower serum calcium concentrations in affected dairy cows.

However, a dominating cause of milk fever in dairy cows is a short-term excessive calcium intake in the prepartum period, combined with high potassium in the diet (Lean *et al.*, 2006).

The reduction of immune function during the peripartal period has been documented (Hammon *et al.*, 2006; Silvestre *et al.*, 2011), and this is suggested as one of the major reasons for the high incidence of bacterial diseases, such as mastitis and metritis in early-lactation cows (Fiore *et al.*, 2017). The novel findings of this study are the associations between BCS, lipid mobilisation (NEFA), and the imbalance in oxidative status. Results from that study demonstrated an association between metabolic status and the alteration of oxidative status in transition dairy cows. Cows with a higher BCS and greater BCS loss (which had increased concentrations of NEFA and BHB) were particularly sensitive to oxidative stress (Bernabucci *et al.*, 2005). In our study no significant difference in incidence of metritis after calving among the condition groups was registered. Body condition score as a risk factor for lameness has been reported in several studies. Green *et al.* (2014) reported that in a longitudinal study of 1,137 cows, those with BCS ≤ 2 were more likely treated for lameness compared with cows with BCS >2 . Mobilisation of lipid reserves in early lactation resulting in loss of body condition postpartum has been shown to contribute to increased risk of lameness (Hoedemaker *et al.*, 2009). This study indicated that the dairy cows with highest BCS before calving dropped significantly ($P \leq 0.05$) with their condition during the postpartum period and showed a trend to the highest incidence of claw diseases within the first two weeks after calving.

In conclusion, we presume that dairy cows with different BCS have a different metabolic response during the postpartum period. The overcondition is connected with stronger lipid mobilisation and calcium drop after calving. Moreover, the higher BCS could contribute to higher incidence of production diseases. Therefore, a feeding strategy on dairy farms should focus to limit excessive body condition during late lactation and increase energy intake during early postpartum period, reducing the risk of metabolic and inflammatory diseases.

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