J.E. McGowan – Condition score at calving did not affect adaptive immune responses in early lactation

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ABSTRACT

The greater the body condition score (BCS) at calving, the more severe the postpartum negative energy balance (NEB). Metabolites reflective of the energy balance status of the cow, such as non-esterified fatty acids and ketone bodies, have been associated with impaired lymphocyte and neutrophil function in vitro. Therefore, we hypothesised that cows that calve at higher BCS may exhibit a greater degree of immune dysfunction than cows that calve at lower BCS. To test this hypothesis, the energy balance of healthy cows was manipulated during mid-lactation to generate groups with differing BCS at calving and antibody-mediated and cell-mediated immune responses were assessed. Calving BCS had no effect on the magnitude of antibody-mediated (P = 0.93) or cell-mediated (P = 0.99) responses. Our results indicate that BCS at calving and the associated degree of postpartum NEB does not influence the cow’s ability to mount an effective adaptive immune response in vivo over the range of BCS tested.

Keywords: Transition; dairy; negative energy balance; Candida albicans; HEWL; HSA; DTH; BCS

INTRODUCTION

Dairy cows exhibit transient immune dysfunction during the period of transition between pregnancy and lactation, which contributes to a higher incidence and severity of infectious disease during the first few weeks of lactation (Mallard et al. 1998). For example, 50% of clinical mastitis occurs in the two weeks after calving (McDougall et al. 2007). In early lactation, voluntary food intake is insufficient to meet the energy and protein requirements of milk production so dairy cows mobilise fat and protein from body tissues, which elevates serum levels of non-esterified fatty acids (NEFA) and ketone bodies (Suriyasathaporn et al. 2000, Roche et al. 2009). These metabolites have been associated with impaired lymphocyte and neutrophil function in vitro (Suriyasathaporn et al. 2000, Ster et al. 2012) and with increased incidence of metritis and mastitis (Ospina et al. 2010). Based on these findings, it is hypothesised that cows that experience a greater negative energy balance (NEB) postpartum may have increased immune dysfunction.

Body condition score (BCS) at calving is positively correlated with postpartum NEB (Roche et al. 2009). Cows with a greater BCS at calving experience more severe NEB in early lactation and may exhibit a greater degree of immune dysfunction than low BCS cows. Reported associations between BCS at calving and incidence of infectious disease in early lactation have been inconsistent (Gearhart et al. 1990, Roche et al. 2009) and much of the research has been epidemiological and unable to distinguish causation or association. The objective of this study was to determine the effect of calving BCS on adaptive immune responses of cows during early lactation.

METHODS

Sixty pasture-fed Friesian and Friesian-Jersey dairy cows between body condition 3.75 and 4.25 (1-10 BCS scale, where 1 is emaciated and 10 is obese; Roche et al. 2009) were allocated randomly to BCS treatment groups. Feeding levels were manipulated so that mean BCS at calving was 3.4, 4.6 and 5.4 for the low, medium and high BCS groups, respectively. For a detailed description of the experimental set up, see (Roche et al. 2013).

Immune responses were measured before allocation to BCS treatment group, coinciding with mid-lactation (baseline), and immediately postpartum (day 0 (d 0) was the day of calving). On both occasions, cows were immunised on d 0 and 14, with Candida albicans and a type-2 antigens (HEWL or HSA), known to induce polarised cell-mediated immune responses (CMIR) and antibody-mediated immune responses (AMIR), respectively (Cartwright et al. 2012). To allow assessment of both primary and secondary AMIR postpartum, a cross-over design was used. Half the animals in each BCS treatment group recieved HSA at baseline testing and HEWL at postpartum testing and the other half, HEWL at baseline testing and HSA at postpartum testing. Blood samples were collected by caudal venepuncture on d 0, 14, and 21 and serum prepared.

As an indicator of AMIR, antigen-specific IgG for HEWL and HSA were measured using previously
described ELISA methods (Cartwright et al. 2012) and expressed as change from d0.

As an indicator of CMIR, delayed-type hypersensitivity (DTH) reactions to C. albicans were assessed on d 21 of baseline testing and on d 8 of post-partum testing using a previously described skin-testing protocol (Hine et al. 2011, McGowan et al. 2014). Responses to DTH testing were expressed as change (DSFT at test site/DSFT at control site) from 0 h.

Specific antibody and DTH responses were examined based on value at each time point and area under the curve (AUC) between time points. Data were log$_{10}$-transformed and responses were analysed using a mixed models approach to repeated measures (Proc Mixed, SAS 9.3) with time, antigen, BCS, and their interactions as fixed effects. Response AUC was analysed using two-way ANOVA for the effects of antigen, BCS, and their interaction, including AUC from baseline as a covariate. Tukey’s test was used for pairwise comparisons. Results are presented as least-squares means and standard errors (SE). Significance is declared if $P<0.05$.

RESULTS AND DISCUSSION

The objectives of this study were to investigate the hypothesis that differences in NEB associated with differing BCS at calving influence adaptive immune function in early lactation cows. To our knowledge, this is the first in vivo investigation of postpartum adaptive immune responses in pasture-fed dairy cows, with imposed differences in calving BCS.

Within the range of BCS investigated, body condition score at calving did not affect the ability of pasture-fed cows to mount adaptive immune responses in-vivo. Differing levels of postpartum NEB were observed as a consequence of differing calving BCS, and the serum NEFA concentrations observed in these cows (Roche et al. 2013) were similar to those reported in periparturient cows with impaired lymphocyte secretion of both IgM and IFN-γ in vitro (Lacetera et al. 2005). Despite this, the effect of BCS on circulating antigen specific IgG antibody production (Figure 1) and DTH responses (Figure 2) was not significant ($P=0.93$ and 0.99, respectively). Our results indicate that, for cows calving within the range of BCS investigated, their ability to mount an effective adaptive immune response in vivo was not influenced by BCS at calving and the associated degree of postpartum NEB, supporting the view that periparturient immune dysfunction is not a direct consequence of the level of postpartum NEB.

Elevated serum NEFA and β-hydroxybutyrate (BHBA) concentrations have been associated with impaired bovine lymphocyte function in vitro (Lacetera et al. 2004, Ster et al. 2012). However, reported associations between measures of NEB and immune dysfunction have been inconsistent. (Nonnecke et al. 1992) reported that high concentrations of ketones and acetate did not affect in vitro IgM secretion when glucose concentration was physiologically relevant. Similarly, dietary-induced NEB in later lactation had an inconsistent effect on immune function (Ingvarsen and Moyes 2013).

Whole-blood assays to measure neutrophil function during the transition period show increased rather than decreased capacity for phagocytosis postpartum, and no clear relationship with serum NEFA and BHBA concentrations (Sander et al. 2009).
2011). These researchers attributed their unexpected results to the presence of opsonising factors in whole blood that are not present in purified preparations. Previous investigations of lymphocyte function have been largely based on in vitro testing using purified cell preparations. In the current study, the effects of BCS at calving on immune function were assessed in vivo, where the influence of other immune cells and proteins contribute to the observed response improving the biological relevance of the findings.

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REFERENCES


