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GLUCOSE HALF-LIFE OF YOUNG POSTPARTUM LACTATING COWS WAS HALF THAT OF NON-LACTATING HERDMATES

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ABSTRACT: Lactation and diet quality have been implicated as regulators of nutrient partitioning by changing tissue sensitivity to insulin. Treatments were arranged as a 2 x 2 factorial to investigate the influence of lactation and season on serum glucose clearance. Glucose tolerance tests (**GTT**) were conducted on lactating (**LACT**, n = 4) and non-lactating (**NLACT**, n = 4) three-year-old crossbred beef cows grazing dormant native range in May (57 d postpartum) and July (135 d postpartum). In January, before calving, NLACT cows were heavier ($P < 0.01$) than LACT cows (468 ± 18 vs 414 ± 9 kg); all cows were body condition score (**BCS**) 4.6 ± 0.2. Calves from NLACT cows did not survive after parturition. NLACT cows gained condition ($P = 0.08$) after calving (May BCS 5.9 ± 0.1; July BCS 6.5 ± 0.3) while LACT cows maintained condition (May BCS 3.9 ± 0.2; July BCS 4.4 ± 0.1). For each GTT, 50% dextrose solution was infused at 0.5 mL/kg BW via jugular catheter and serum was collected at 11 time intervals for 120 min. Serum glucose and insulin areas-under-the-curve (**AUC**) and glucose half-lives were calculated. Glucose and insulin AUC (glucose: 7299 vs 10599 ± 1173 units; insulin: 185 vs 361 ± 17 units) were smaller (glucose: $P = 0.08$; insulin: $P < 0.01$) for LACT cows than for NLACT cows. Glucose half-life was nearly 50% less ($P = 0.03$) for LACT compared to NLACT cows (53 vs 100 ± 12 min) and was longer ($P = 0.08$) in July compared to May (94 vs 58 ± 12 min). Diet quality as affected by season did influence glucose half-life. LACT cows were more responsive to insulin than NLACT cows since they cleared glucose in less time with less insulin, although it would be expected that NLACT cows would clear glucose in less time than LACT cows. Body condition may be as important as lactation in the regulation of glucose clearance.

Key Words: Glucose, Insulin, Lactation, Physiological state

Introduction

Lactation and diet quality have been implicated as regulators of nutrient partitioning by changing tissue sensitivity to insulin (Bines and Hart, 1982; Tovar-Luna et al., 1995). Endecott et al. (2003) found that glucose half-life decreased in young postpartum cows from spring to summer. Unfortunately, the effect of season was confounded with stage of lactation, so it was not possible to determine whether the increased sensitivity to insulin was due to improved diet quality, progression of lactation, or an additive effect of both. Cows were at different stages of lactation in spring and summer, and insulin sensitivity increases as lactation progresses (Bines and Hart, 1982). In order to further explore the influences of physiological state and seasonal diet quality changes on insulin sensitivity, we investigated tissue response to insulin and glucose clearance of lactating and non-lactating cows grazing dormant forage after 57 or 135 d postpartum.

Materials and Methods

The New Mexico State University Institutional Animal Care and Use Committee approved all animal procedures. Glucose tolerance tests (**GTT**) were conducted on lactating (**LACT**, n = 4) and non-lactating (**NLACT**, n = 4) three-year-old crossbred beef cows grazing dormant native range at the Corona Range and Livestock Research Center. The first GTT (May) was in mid-May when cows were approximately 57 d postpartum, and the second GTT (July) took place in late July when cows were approximately 135 d postpartum. Both LACT and NLACT cows were diagnosed pregnant the previous fall and all had calves; however, the NLACT cows' calves died shortly after birth due to complications or unknown causes. Prior to calving, NLACT cows were heavier ($P < 0.01$) than LACT cows (468 ± 18 vs 414 ± 9 kg); all cows were body condition score (**BCS**) 4.6 ± 0.2. NLACT cows gained condition ($P = 0.08$) after calving (May BCS 5.9 ± 0.1; July BCS 6.5 ± 0.3) while LACT cows maintained condition (May BCS 3.9 ± 0.2; July BCS 4.4 ± 0.1). All cows grazed the same pastures for the duration of the experiment. At the time of the May GTT, cows were individually fed a 30% CP supplement twice weekly at a rate of 1135 $g{\bullet}cow^{-1}{\bullet}d^{-1}$; supplementation had ceased at the time of the July GTT. The May GTT was conducted on a day after supplement had been fed.

Cows were gathered from the pasture at daylight the morning of each GTT; cows had access to water, but not feed after they had been gathered. For each GTT, 50% dextrose solution was infused at 0.5 mL/kg BW via indwelling jugular catheter. Catheters were inserted the morning of each GTT. A 12-gauge hypodermic needle (Ideal Instruments, Schiller Park, IL) was used to puncture the jugular vein. One-half of a 2.5-m length of sterile Tygon tubing (0.10 cm i.d., 0.18 cm o.d., Cole-Parmer Instrument Company, Vernon Hills, IL) was threaded through the needle and into the jugular vein. The remaining half of the tubing was taped to the neck and back of the cow. Tubing near the puncture site was adhered to the cow's neck in a looped fashion so that it would remain stationary. A blunted 18-gauge needle (Becton-Dickinson, Franklin Lakes, NJ) was inserted in the end of the catheter and a 1-mL syringe (Air-Tite, Virginia Beach, VA) served as the tubing end cap. Serum was collected at –1, 0, 3, 6, 9, 12, 15, 20, 40, 60, 80, 100, and 120 min relative to infusion with the time-zero sample collected immediately after infusion. Catheters were flushed with 10 mL of saline solution immediately before and after each blood sample was collected and after glucose infusion. Blood samples (10 mL) collected at each sampling time were placed in Corvac serum separator tubes and centrifuged at 2000 x *g* at 4° C for 25 min for serum collection. Serum was stored in plastic vials at -20° C for later analysis of glucose and insulin. Serum glucose concentrations were determined with a commercial kit ([Trinder] method, Sigma Diagnostics, St. Louis, MO), with volume modifications for a 96-well plate reader. Serum insulin was analyzed at the New Mexico State University Endocrinology Laboratory by solid-phase radioimmunoassay (DCP kit, Diagnostic Products Corp., Los Angeles, CA) as validated by Reimers et al. (1982). Intra-assay and inter-assay CV were 6.2% and 3.0%, respectively. Serum glucose and insulin areas under the curve (**AUC**) were calculated using trapezoidal summation. Glucose half-life was estimated by determining the time required for a 50% decrease in peak serum glucose concentration.

Data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC) with cow as the experimental unit symmetry covariance structure. The model included effects of physiological state, season, and their interaction.

Results and Discussion

The interaction of physiological state and season was not significant for glucose AUC ($P = 0.21$), insulin AUC ($P = 0.71$), or glucose half-life ($P = 0.11$), suggesting that both physiological states responded to season similarly. Both glucose AUC (7299 vs 10599 ± 1173 units) and insulin AUC (185 vs 361 ± 17 units) were smaller ($P = 0.08$ and $P < 0.01$, respectively) for LACT cows than for NLACT cows. Glucose half-life was nearly 50% shorter ($P = 0.03$) for LACT compared to NLACT cows (53 vs 100 ± 12 min). Both groups of cows exhibited extended glucose half-lives compared to the normal of 35 min (Kaneko, 1989); however it appears that LACT cows were more responsive to the effects of insulin than were NLACT cows. Because NLACT cows did not have the physiological changes occurring due to lactation, it would be expected that they would be more responsive to insulin than LACT cows (Bines and Hart, 1982). The negative effect of lactation on tissue responsiveness to insulin may be caused by growth hormone, which is elevated during this physiological state (Bines and Hart, 1982). Growth hormone apparently blocks the phosphorylation of glucose inside the cell after uptake (Ojeda and McCann, 2000); glucose freely diffuses back out of the cell and thus insulin has a limited effect. Weekes (1991) found that insulin action was impaired in lactating ewes fed a restricted diet compared with non-lactating ewes and with lactating ewes fed ad libitum, which disagrees with the results from the present study. A potential explanation for the fact that LACT cows were more insulin responsive than NLACT cows may be differences in body condition, as the NLACT cows were in higher body condition than LACT cows for both GTT. Insulin AUC above baseline were smaller in lean compared to obese dairy heifers (McCann and Reimers, 1986), and lean dairy heifers were more responsive to insulin than were obese heifers after GTT (McCann and Reimers, 1985). Bergman et al. (1989) produced severe adult-onset obesity in ewes by overfeeding and found that obese sheep had decreased insulin sensitivity compared to lean controls, consistent with decreased insulin receptors in peripheral tissues. Serum glucose concentrations of the NLACT cows did not return to baseline in the 120 min after infusion at the July GTT, which agrees with the hypothesis that increased body condition has a negative effect on insulin sensitivity.

Diet quality, as affected by season, did not significantly influence glucose AUC ($P = 0.14$) or insulin AUC ($P = 0.42$), but did influence ($P = 0.08$) glucose half-life, which was longer in July compared to May (94 vs 58 ± 12 min). Endecott et al. (2003) found that glucose half-life decreased from spring to summer, which appears to directly contradict the results of the present study. However, in the previous study, diet quality improved from spring to summer due to summer precipitation. In the present study, a lack of summer precipitation resulted in lower diet quality in the summer compared to the spring. Therefore, results from both the 2002 experiment (Endecott et al., 2003) and the present study support the hypothesis that diet quality does have an impact on glucose half-life. Additionally, the absence of an interaction between physiological state and seasonal diet quality further supports the interpretation of Endecott et al. (2003) that seasonal influences are independent of physiological state. If these were dependent, cows in different physiological states would have been expected to respond differently to seasonal diet quality changes.

Implications

LACT cows were more responsive to insulin than NLACT cows as they cleared glucose in less time with less insulin, although it would be expected that NLACT cows would clear glucose in less time than LACT cows. Over-conditioned cows may be less efficient at nutrient uptake than thinner cows if they are insensitive to insulin. Body condition may be as important as lactation in the regulation of glucose clearance. Supplementation to improve energy balance of range cows is a common practice, particularly post-calving. Seasonal differences in insulin sensitivity may not allow the nutrients supplied by a supplement to be efficiently utilized for realimentation. Thus, supplementation when only dormant forage is available may not yield expected results if cows are insensitive to insulin at the time of supplementation.

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