

Changes in Plasma Insulin and Glucose Concentrations During Early Lactation in Holstein Cows

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Story in Brief

Insulin has been implicated as one possible metabolic mediator of reproduction in lactating dairy cows. This study was designed to evaluate the effect of time after calving on plasma insulin and glucose concentrations. Mature Holstein cows (n=19) were milked twice daily and milk samples were collected twice a week for analysis. Plasma insulin concentration significantly increased progressively between wk 1 and 10 of lactation. Plasma glucose concentration increased between wk 1 and 5 of lactation. After 5 wk of lactation, plasma glucose concentration did not change. We conclude that week of lactation should be considered when interpreting plasma insulin and glucose values.

Key Words: Insulin, Glucose, Dairy Cows, Lactation

Introduction

Many high producing dairy cows are unable to consume enough feed to meet energy demands during early lactation. Therefore, they rely on their ability to mobilize body energy reserves to meet energy requirements, and subsequently enter a state of energy balance deficiency. Energy balance is quantified using measures of milk production, dietary intake, and body weight (Spicer et al., 1990). Lactating dairy cows in positive energy balance have greater reproductive function than cows in negative energy balance (Spicer et al., 1990). Because energy balance is impractical to measure, other factors have been measured to relate nutritional status and reproductive function. One of these factors is plasma insulin (Spicer and Echternkamp, 1995). Insulin stimulates growth and steroid hormone synthesis of bovine ovarian cells in vitro (Spicer and Echternkamp, 1995). However, little work has been conducted to evaluate normal changes in plasma insulin levels during early lactation. The objective of this study was to determine the changes in insulin and glucose concentrations during early lactation in Holstein cows.

Materials and Methods

Mature (i.e., ≥ 2 lactations) Holstein cows (n=19) maintained at the Oklahoma State University Dairy Cattle Center were fed a total mixed ration consisting of concentrates (29%), sorghum silage (24%), alfalfa hay (16%) and cottonseed (6%). Energy concentration of the diet was formulated to support daily milk production of 100 lb. Daily feed intake was recorded and the diet was sampled weekly and composited by month for analyses.

Cows were milked twice daily (0300 and 1500 h) and milk yield was recorded. Milk samples were collected weekly during successive a.m. and p.m. milkings and analyzed for milk fat, protein, lactose, solid non-fat, somatic cell count and urea nitrogen content at the Heart of America DHIA (Manhattan, KS). Blood samples were collected twice weekly for measurement

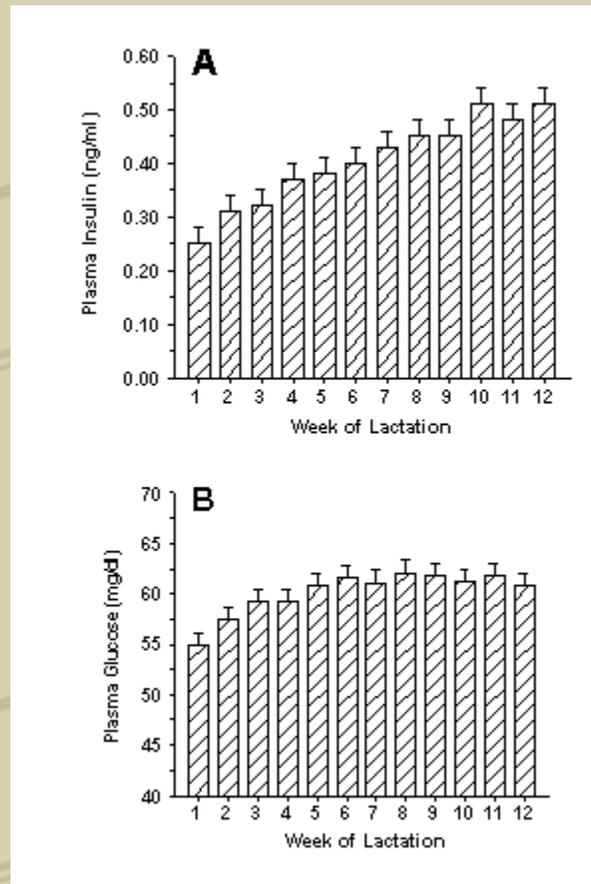
of plasma insulin and glucose concentrations. Body weights were recorded weekly and body condition score (5-point scale, 1=very thin to 5=excessively fat) was evaluated (by one evaluator) for each cow on wk 4 and 10 postpartum.

Experimental data are presented as least squares means \pm SEM. Data were analyzed as a repeated measures using the MIXED procedure of SAS.

Results

Concentrations of insulin in plasma increased ($P < .001$) with week postpartum such that insulin concentrations at wk 4 were 50% greater ($P < .01$) than wk 1, and wk 10 38% greater ($P < .01$) than wk 4 (Figure 1A). Plasma insulin concentrations increased gradually over the 12-wk period such that plasma insulin concentration at wk 10 was double that of wk 1 ($.25 \pm .03$ ng/ml at wk 1 vs $.51 \pm .03$ ng/ml of wk 10); plasma insulin concentration did not change ($P > .10$) after wk 10 (Figure 1A). Concentrations of glucose in plasma increased ($P < .01$) with week postpartum such that glucose concentration at wk 2 was 4% greater ($P < .01$) than at wk 1, and wk 5 was 7% greater ($P < .01$) than wk 2 (Figure 1B). Plasma glucose levels did not significantly change after wk 5 postpartum (Figure 1B).

Figure 1. Relationship between average weekly plasma insulin (A) and glucose (B) concentrations and week of lactation in Holstein cows



Plasma insulin concentration was positively correlated with dry matter intake ($r=0.37$, $P<.01$) and body weight ($r=0.16$, $P<.05$), but negatively correlated with milk fat ($r= -0.13$, $P<.05$) and protein ($r= -0.26$, $P<.01$) percentage. Plasma glucose concentration was positively correlated with dry matter intake ($r=0.44$, $P<.01$), body weight ($r=0.16$, $P<.05$), and milk lactose percentage ($r=0.21$, $P<.01$), but negatively correlated with milk protein percentage ($r= -.18$, $P<.05$).

Weekly average body weights decreased ($P<.05$) from wk 1 to 3 but did not change between wk 5 and 12 of lactation (data not shown). Average body condition score (BCS) increased ($P<.01$) between wk 4 (BCS=2.5) and 10 (BCS=2.9). Percentage milk fat increased ($P<.05$) between wk 1 and 3 of lactation and gradually decreased between wk 3 and 12 (data not shown). Milk protein and solids non-fat levels decreased ($P<.05$) between wk 1 and 3 postpartum and remained constant between wk 4 and 12 postpartum (data not shown). Percentage milk lactose increased ($P<.001$) between wk 1 and 4, plateaued to week 8 and decreased ($P<.05$) thereafter (data not shown). Milk urea nitrogen concentrations increased ($P<.05$) during early lactation, plateauing after wk 3 (data not shown).

Discussion

In the present study, plasma glucose and insulin concentrations increased with week postpartum. There was a commensurate increase in plasma insulin concentration as the concentration of glucose increased between wk 1 and 5 postpartum, but after wk 5 postpartum insulin concentrations continued to increase while glucose concentrations remained constant. Similar trends were observed by other workers (Koprowski and Tucker, 1973; Smith et al., 1976). Increased insulin concentrations concomitant with unchanged glucose levels implies that cows may have become insulin-resistant after wk 5 of lactation. The lower insulin concentration during the first few weeks of lactation may be reflective of the amount of glucose in blood plasma as well as DMI of cows. In support of this statement, positive relationships between insulin and glucose ($r=.35$) and between DMI and insulin ($r=.37$) or glucose ($r=.44$) were observed in the present study. Further research will be needed to determine the specific cause of increased insulin concentration after wk 5 of lactation.

Literature Cited

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Acknowledgements

The authors thank Heart of America DHIA (Manhattan, KS) for milk component analyses, and C.S. Chamberlain for technical assistance.

