CHANGES AND VARIATION IN BODY CONDITION MEASURES OF A LACTATING COW

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INTRODUCTION

The fundamentals of efficiency for production and metabolic stress in lactating dairy cows involve the interplay of energy expenditure and energy sources during lactation. Both milk yield and dietary intake, their amounts and compositions, can be recorded readily, at least on experimental farms, but body reserves of a living lactating cow cannot be measured. Body reserves is also a function of amount, or weight, and composition, or condition. Weight can be measured, but condition can be only approximated. Body condition score (BCS) is used to approximate the body condition of a dairy cow, with its crudeness unknown because of its subjectivity. It reflects largely adipose tissue stores and not protein reserves, but this is only speculation. Ultrasound measure of muscle (UTM) and backfat (UTBF) may be more objective measures, but indicators of exact what aspects of body reserves remain unknown. We in Denmark are in the process of attempting to profile body energy state of a lactating cow using repeated measures of several body condition related variables such as BCS, UTM and UTBF, and laboratory results of biochemical parameters from liver biopsy and blood samples in a data set from an experimental farm. This paper presents the changes in BCS, UTM and UTBF and their phenotypic and genetic variations during lactation.

MATERIAL AND METHODS

Data. Included in analyses was a total of 3247 BCS records on 241 cows from up to 5 lactations from July of 1997 to December of 2000. Scores taken beyond 411 days postpartum were excluded. The 3rd to 5th lactations were grouped as parity 3+. There were 1074 records on Danish Red cows, 1414 on Holsteins and 759 on Jerseys. A total of 1618 records with 202 recording dates were in parity 1, 847 with 181 in parity 2, and 782 with 123 in parity 3+. The ultrasound measures, from August of 1991 to October of 2000, had a total of 8707 both UTM and UTBF on 158 Danish Red, 190 Holstein and 100 Jersey cows in the three lactation groups.

Models, methods and algorithms. Below analyses were done for BCS, UTM and UTBF individually. Preliminary analyses using SAS were done on a variety of models to test all the fixed effects in the experimental design such as breed, genetic lines, feeding level, parity, days-in-milk (DIM), and scoring date. They were done also to screen fixed interaction effects. Random effects in these fits were cows and cow by parity interactions, the results of which were to provide priors for subsequent analyses. The fixed effects were not of primary interest, and the results are not presented in this paper.

Within each of the three parities by each of the three breeds, data was analyzed by univariate linear mixed random regression models. The fixed effects in the model were two genetic lines, two feeding levels, individual scoring calendar dates, and genetic line by feeding level interaction. In the same model, Legendre polynomials of standardized DIM (LPs) were fitted as both fixed and random covariates. Up to the 5^{th} power LPs were fitted to fixed regressions, and up to 3^{rd} power LPs were fitted to random regressions within each of random additive genetic (*addG*) effects of individual cows, and within each of the random permanent environment (*pe*) effects of cows. Complete pedigree information for the *addG* effects was incorporated.

RESULTS AND DISCUSSION

Changes during a lactation. Shown in Figure 1 on the next page are changes in BCS, UTM and UTBF during lactation 1, 2 and 3+ of Holstein cows. All plots were results of fitting fixed regressions estimated from corresponding models. There were distinct breed differences in BCS changes during lactation, but none are presented in this paper.

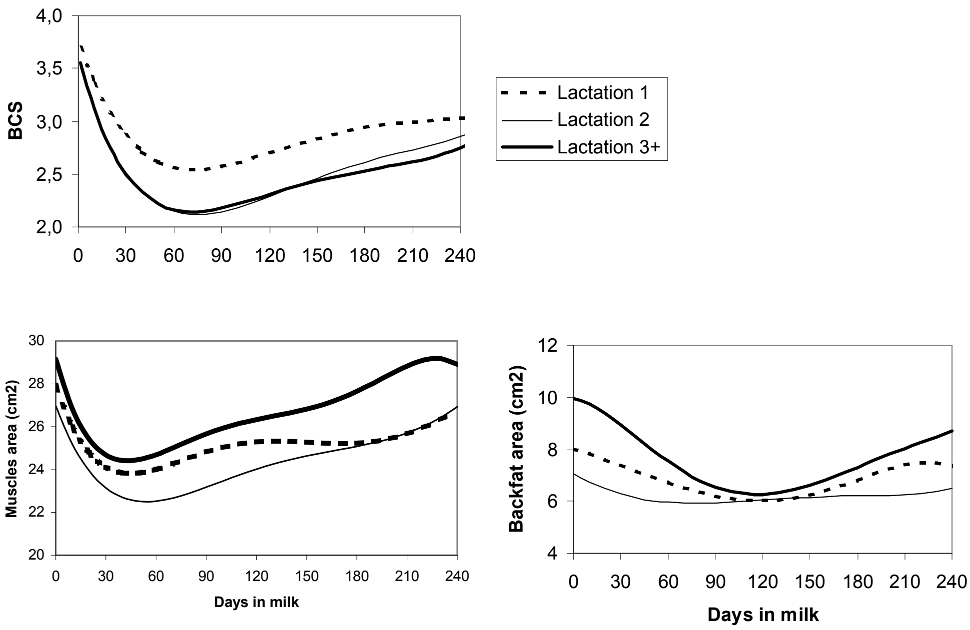

Figure 1. Changes in body condition score (BCS), ultrasound measures of muscle (UTM) and backfat (UTBF) in lactation 1, 2 and 3+ Holstein cows

Appeared to be typical for all parities and breeds, the nadir of BCS occurred at about 60 and 70 days postpartum. After then, it climbed back up towards the end of lactation, but never to the same level as it was at the beginning. The BCSs are higher in the 1^{st} lactation than in later lactations, and with shallower "valleys". These trends were as expected in the context of energy balance. The BCSs were lower and nadirs dropped much deeper especially in lactations 2 and 3+, but all recovered eventually to the similar levels as in lactation 1 at about 300 DIM.

Changes in UTM appeared to mirror those in BCS during lactation, except nadir occurred earlier between 30 to 60 DIM. The other difference is in parity differences where UTM is lower in the 2nd lactation than in the 1st until towards the end of lactation, but the greatest throughout in the later lactations. For all parities, nadir for UTBF occurred between 100 to 150 DIM. Cows in 1st lactation appeared to lose thickness in 2nd lactation, but more than gained back in later lactations. Cows in later lactation also had greater changes during lactation. In all lactations, it appeared that backfat continue to be mobilized after muscles had started to recover.

Variations and heritability during lactation. The relative magnitude of variances due to *addG* and *pe* effects, and heritability estimates in BCS, UTM and UTBF are depicted in Figure 2 using 1st lactation Holsteins as example. The sum of the two variance components and a constant (throughout a lactation) residual variance would give phenotypic variance. Heritablity is calculated as a ratio of *addG* variance component over phenotypic variance.

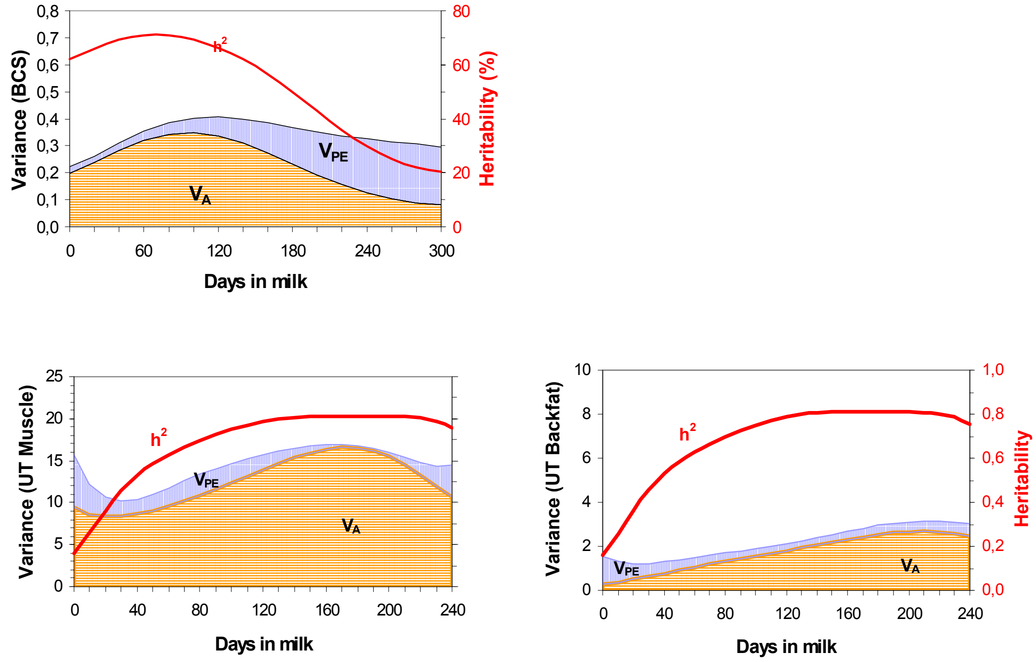

Figure 2. Changes in additive genetic and permanent environmental variances and heritability in body condition score (BCS), ultrasound measures (UT) of muscle and backfat in the 1st lactation Holstein cows

In contrast to the "mean" changes in Figure 1, both variance components of BCS for all breeds and parities humped generally around 120 days postpartum, coinciding when energy expenditure and intake supposedly reach a balance during lactation. After humping at around 100 days, variance due to *pe* grew in general greater, while that due to *addG* effect grew smaller. The magnitude of *pe* variance increased in a fairly dramatic fashion from lactation 1 to subsequent lactations. The phenotypic variances, however, did not alter notably from one lactation to the next. Heritability would either stay reasonably stable during lactation at around 20% level as typically the case in lactation 3+ for all three breeds, or varied wildly between 70% to 10% and humped at some point in lactation. For the 2nd lactation, heritability ended very low to less than 5%.

For UTM, *addG* variance stayed much greater than *pe* variance during lactation and for all parities. Although varied and humped at around 180 DIM, *addG* variance remain fairly stable during a lactation and between lactations, while *pe* variance varied greatly between lactations. There're great similarities between UTM and UTBF in the relative magnitude and lactation trends in variance components and heritability, except *addG* variance became smaller than *pe* variance during later lactations.

CONCLUSIONS

Our results in adjusted means did indicate that BCS appear to provide a good measure of body condition in the context of energy balance in a lactating cow. It was interesting to observe that BCS reflect mostly changes in muscle as indicated by UTM. We also showed that there is ample additive genetic variation in BCS and in UT measures for meaningful genetic selection. Before one address the possibility of using BCS or UT measures in genetic selection, however, how meaningful are they, individually and collectively, as indicators of body reserves must be better understood. Our immediate next task is to establish the phenotypic and genetic covariance structure of these variables in conjunction with biochemical parameters, before attempting to profile body reserves in lactating dairy cows using the same variables.

The cause-consequence relationships between BCS and yield and fertility traits have been studied (e.g. Snijder *et al*., 2000 ; Dechow *et al*., 2001 ; Butler, 2001 ; Gillund *et al*., 2001). We shall examine such relationships involving BCS and ultrasound measures at various stages of lactation.

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