Assessing the impact of body condition score dynamics from dry-off to calving on the incidence of early lactation disease in Holstein cows

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Abstract

Automated systems generating body condition scores (BCS) through image technology enable daily assessments of body energy reserves of dairy cows in an efficient non-stressful approach and generate objective information. The availability of high-frequency BCS data allows for the analysis of specific points of interest and could result in quick adjustments of management if necessary. The objective of this study was to evaluate the association between the dynamics of BCS from dry-off to calving and early lactation disease in a population of high-producing Holstein cows. A retrospective observational study was completed using data collected from 12,042 lactations in 7,626 Holstein cows calving between April 2019 and January 2022 in a commercial dairy operation located in Colorado, USA. Scores generated by BCS cameras (DeLaval International AB, Tumba, Sweden), at 0.1 point intervals, at dry-off (BCSdry) and calving (BCScalv) were selected for the analysis and subsequently categorized into quartiles (Q1 = lowest BCS), separately for primiparous and multiparous cows. The change in BCS from dry-ff to calving was calculated as BCScalv – BCSdry and assigned into quartile categories considering Q1 as the 25% of cows with greatest loss. Cows were classified as healthy (HLT; no health event) or affected by at least one health disorder within 60 days postpartum (SCK). Health disorders included reproductive (retained fetal membranes, metritis, and pyometra), metabolic (clinical hypocalcemia, subclinical ketosis, and left displaced abomasum), and other conditions (lameness, clinical mastitis, digestive problem, injury, and pneumonia). Mean (SE) BCSdry for HLT vs. SCK were 3.38 (0.004) vs. 3.42 (0.004) ($P < 0.0001$), while BCScalv for HLT vs. SCK were 3.30 (0.003) vs. 3.33 (0.003) ($P < 0.0001$). Mean BCS differences between dry-off and calving for HLT vs. SCK were -0.088 (0.004) vs. -0.11 (0.005) ($P = 0.0008$). The logistic regression analyses indicated that the odds (95% CI) of disease were smaller in the lower BCSdry categories relative to cows in the highest BCS category (Q4): Q1 = 0.78 (0.65-0.94); Q2 = 0.75 (0.62-0.90); Q3 = 0.79 (0.65-0.96). On the contrary, BCScalv category was not associated with early lactation disease ($P = 0.48$). Reductions in BCS from dry-off to calving were associated with subsequent disease, as cows losing more BCS (Q1 and Q2) had greater odds of disease compared to cows gaining BCS (Q4): Q1 = 1.32 (1.11-1.58) and Q2 = 1.35 (1.14-1.61). Overall, BCS at dry-off and greater loss of BCS between dry-off and calving had a significant impact on occurrence of early lactation disease.

Keywords: body condition, automated, health .

Introduction

Body condition scores (BCS) are an indirect measure of the level of subcutaneous fat in dairy cattle (Ferguson *et al.,* 1994). While BCS at a time point are an indication of energy status, BCS gain or loss, and rate of change are considered as a proxy for the evaluation of energy balance (Roche *et al.,* 2007; 2009). Although BC scoring is an unexpensive tool for monitoring cows' energy dynamics, only one third of the US dairy farms implemented formal BCS into their management practices (Hady *et al.,* 1994; Bewley *et al.,* 2010). A likely explanation for the limited use of this assessment is the time consuming and subjective nature of visual or tactile evaluations (Edmondson *et al.,* 1989; Leroy *et al.,* 2005).

The advent of automated body condition scoring systems has allowed for the use of data originated at multiple and precise time points, with scores that are not affected by inter and intra evaluator variation (Borchers and Bewley, 2015). For example, recent studies using this technology have explored the potential of daily BCS in the prediction of subsequent fertility and health outcomes (Pinedo *et al.,* 2022; 2022a).

Related to the application of BCS in management decisions, the level of energy reserves of the cow at dry-off and at calving, as well as the changes occurring the during the dry period, are of special interest in the prediction of the cow performance and health during the subsequent lactation. The magnitude in the change in BCS (ΔBCS) following dry-off has been established as a relevant factor impacting subsequent fertility, health, and survival (Carvalho *et al.,* 2014; Chebel *et al.,* 2018) and the association between overconditioning at dry-off and lesser DMI and time feeding has been recently reported (Daros *et al.,* 2021). Moreover, low BCS at calving has been associated with decreased milk yield and reduced likelihood of pregnancy, whereas overconditioning at calving was associated with greater probability of postpartum metabolic diseases (Roche *et al.,* 2009).

Although the interrelationship between inadequate BCS at dry-off and calving and the occurrence of metabolic imbalances and early lactation diseases has been reported (Roche *et al.,* 2009; Chebel *et al.,* 2018; Stevenson *et al.,* 2020), the lack of consistent BC scoring in large cow populations under similar management has limited the potential for conclusive results when exploring these associations. The availability of daily BCS originated from automated camera systems in a large number of cows under the same productive system provides opportunity for precise assessment of the impact of BCS during the dry period on subsequent cow health.

We hypothesized that the dynamics of BCS during the dry period would have a significant impact on cow health during the early stages of the subsequent lactation. Therefore, the objective of this study was to evaluate the association between the dynamics of BCS from dry-off to calving and early lactation disease in a population of high-producing Holstein cows.

Material and methods

Study design and study population

This retrospective observational study included information collected from 7,626 Holstein cows calving between April 2019 and January 2022 in a commercial dairy operation located in Colorado, USA.

Data collection started at dry-off and continued until 60 days postpartum or culling. Cow demographic, reproductive, and health data were extracted from on-farm software (Dairy Comp 305; Valley Ag Software, Tulare, CA). Daily milk yield and BCS were extracted from DelPro Farm Manager software. The dataset included cow ID, date of calving, lactation number, calving-related and disease events, daily milk yield for the first 60 days in milk (DIM), and daily BCS.

Body condition scoring and BCS categorization

Scores were generated by an automatic BCS system using DeLaval BCS cameras (DeLaval International AB, Tumba, Sweden) previously validated by Mullins *et al.* (2019) that were mounted on the sorting-gate at each exit (n = 2) of the milking parlor. As the cow passed under the mounted camera, a continuous video (30 FPS, 32,000 captured reference points) was taken and a 3D image from the video was automatically created and saved by the BCS camera software (Mullins *et al.,* 2019; Pinedo *et al.,* 2022). In a secondary step, the saved 3D images were processed through an algorithm and analyzed to locate the key physical characteristics (pins, tail head ligaments, sacral ligaments, short ribs, and hooks) of the cow to calculate the automated BCS, viewable in DelPro Farm Manager. The proprietary algorithm used the BCS scoring scale proposed by earlier studies, modified to report BCS in 0.1-point increments (Ferguson *et al.,* 1994).

All automated BCS data were recorded in and downloaded from DelPro Farm Manager and scores generated by BCS cameras at dry-off (BCSdry) and calving (BCScalv) were selected and subsequently categorized into quartiles (Q1 = lowest BCS). The change in BCS from dry-off to calving (ΔBCS) was calculated as BCScalv – BCSdry and assigned into quartile categories considering Q1 as the 25% of cows with greatest loss.

Calving-related events and diseases were obtained from farm records stored in on-farm software. Only health events diagnosed up to 60 days postpartum were considered in the analyses. Cows were classified as healthy (HLT; no health event) or affected by at least one health disorder within 60 days postpartum (SCK). Health disorders included reproductive (retained fetal membranes, metritis, and pyometra), metabolic (clinical hypocalcemia, subclinical ketosis, and left displaced abomasum), and other conditions (lameness, clinical mastitis, digestive problem, injury, and pneumonia). Calvings were grouped by season (spring, summer, fall, or winter). Finally, a milk yield category was added as a covariable in the models using the quartile distribution of the average daily milk yield in the first 60 DIM obtained from DelPro Farm Manager.

Statistical analyses

Descriptive statistics were calculated using the PROC UNIVARIATE in SAS 9.4 (SAS institute Inc., Cary, NC). Initial univariable models using only BCScalv, BCSdry and ΔBCS as explanatory variables were followed by multivariable models that considered calving season, and milk yield up to 60 DIM as covariables. Least square means for BCS by health status category were calculated and compared using ANOVA (PROC GLM).

Odds ratios (OR) for occurrence of disease were estimated for the explanatory variables of interest using PROC GLIMMIX. For all outcome variables, significant predictors were selected at P-value <0.05; interaction terms and controlling variables remained in the models at P-value ≤ 0.10.

Results and discussion

The recent development of BCS automated systems and their implementation in commercial farms has allowed for daily assessment of large populations of dairy cows. The availability of high frequency data provides detailed information on the dynamics of BCS, which permits a more precise evaluation of potential factors affecting BCS and facilitates the analysis of the effect of BCS on performance variables.

The current analysis included 7,626 multiparous cows. Overall, the distribution of calvings across seasons was spring 23.3%, summer 32.3 %, fall 28.2%, and winter

Table 1. Descriptive statistics for body condition scores during the period of interest. Unless stated, least square means (SE) are presented.

Parameter	Healthy	Sick	P-value
BCS at dry-off	3.38 (0.004)	3.42 (0.004)	<0.0001
BCS at calving	3.30 (0.003)	3.33 (0.003)	<0.0001
BCS change	-0.088 (0.004)	-0.11 (0.005)	0.0008

16.2%. Average (SE) milk yield for the first 60 DIM was 44.9 (0.1) kg. A summary for BCS at dry-off and calving by health status is presented in Table 1.

Overall, BCS values in this study were similar to those presented in a recent report that indicated that BCS at dry-off and calving were 3.43 and 3.40 in cows housed in a large commercial dairy farm in Indiana (Truman *et al.,* 2022). In the same study, multiparous cows lost 0.03 BCS points from dry-off to calving.

The logistic regression analyses identified some significant associations between BCS and health. The analyses indicated that the odds (95% CI) of disease were smaller in the lower BCSdry categories relative to cows in the highest BCS category (Q4): Q1 = 0.78 (0.65-0.94); Q2 = 0.75 (0.62-0.90); Q3 = 0.79 (0.65-0.96). On the contrary, BCScalv category was not associated with early lactation disease (P = 0.48).

When the change of BCS occurring during the dry period was analysed, reductions in BCS from dry-off to calving were associated with subsequent disease, as cows losing more BCS (Q1 and Q2) had greater odds of disease compared to cows gaining BCS (Q4): Q1 = 1.32 (1.11-1.58) and Q2 = 1.35 (1.14-1.61).

The interrelationship between loss in BCS and occurrence of disease is complex and establishing precise cause and effect associations is challenging. Nonetheless, previous studies have reported the associations among BCS variables and health, with partial agreement with our findings (Carvalho *et al.,* 2014). For example, in a recent study by Chebel *et al.* (2018), loss of BCS during the dry period was associated with increased occurrence of health disorders and worsened performance in Holstein cows. In an earlier report, Contreras *et al.* (2004) indicated that cows with BCS $\leq$3 at dry off gained BCS during the dry period and were less likely to have retained fetal membranes compared with cows with greater BCS at dry off.

Interestingly, the results from the current study align with those reported recently by our group in similar analyses focused on BCS changes in lactating cows (Pinedo *et al.,* 2022; 2022a). In these studies, cows with larger loss in BCS from calving to 21, and 56 days postpartum had worsened health and performance than cows maintaining or gaining body condition during these periods.

Conclusions

The strength of our study is the availability of consistent BCS for a for a large number of cows under the same dairy operation. Overall, the associations between BCS dynamics and subsequent health were moderate and more evident at dry-off and for the ΔBCS from dry-off to calving. It is anticipated that changes in BCS during early lactation may be more impactful on cow health.

Automatic BCS is a useful tool to monitor and manage energetic status and energy balance. Individual cow or group BCS profiles should be considered when monitoring herd health. The implications for cow health and welfare deserve further exploration.

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References

Bewley, J. M., M. D.Boehlje, A. W. Gray, H. Hogeveen, S. D. Eicher, M. M. Schutz. 2010. Assessing the potential value for an automated dairy cattle body condition scoring system through stochastic simulation. Agric. Financ. Rev. 70:126-150.

Borchers, M. R. and J. M. Bewley. 2015. An assessment of producer precision dairy farming technology use, prepurchase considerations, and usefulness. J. Dairy Sci. 98:4198-4205.

Carvalho P. D., A. H. Souza, M. C. Amundson, K. S. Hackbart, M. J. Fuenzalida, M. M. Herlihy, H. Ayres, A. R. Dresch, L. M. Vieira, J. N. Guenther, R. R. Grummer, P. M. Fricke, R. D. Shaver, and M. C. Wiltbank. 2014. Relationships between fertility and postpartum changes in body condition and body weight in lactating dairy cows. J. Dairy Sci. 97:3666-3683.

Chebel, R. C., L. G. D. Mendonca, and P. S. Baruselli. 2018. Association between body condition score change during the dry period and postpartum health and performance. J. Dairy Sci. 101:4595-4614.

Contreras, L. L., C. M. Ryan, and T. R. Overton. 2004. Effects of dry cow grouping strategy and prepartum body condition score on performance and health of transition dairy cows. J. Dairy Sci. 87:517–523.

Daros, R. R., C. D. Havekes, and T. J. DeVries. 2021. Body condition loss during the dry period: Insights from feeding behavior studies. J. Dairy Sci. 104: 4682-4691. https://doi.org/10.3168/jds.2020-19481.

Edmondson, A. J., I. J. Lean, L. D. Weaver, T. Farver, and G. Webster. 1989. A body condition scoring chart for Holstein cows. J. Dairy Sci. 72:68-78.

Ferguson, J. D., D. T. Galligan, and N. Thomsen. 1994. Principal descriptors of body condition score in Holstein cows. J. Dairy Sci. 77:2695-2703.

Hady, P. J., J. J. Domecq, and J. B. Kaneene. 1994. Frequency and precision of body condition scoring in dairy cattle. J. Dairy Sci. 77:1543-1547.

Leroy, T., J. M. Aerts, J. Eeman, E. Maltz, G. Stojanovski, and D. Berckmans. 2005. Automatic determination of body condition score of cows based on 2D images. Pages 251–255 in Precision Livestock Farming. S. Cox, ed. Wageningen Press, Wageningen, the Netherlands.

Mullins, I. L., C. M. Truman, M. R. Campler, J. M. Bewley, and J. H. C. Costa. 2019. Validation of a commercial automated body condition scoring system on a commercial dairy farm. Animals. 9(6);287.

Pinedo, P., D. Manríquez, J. Azocar, B. R. Klug, and A. De Vries. 2022. Dynamics of automatically generated body condition scores during early lactation and pregnancy at first artificial insemination of Holstein cows. J. Dairy Sci. 105:4547–4564.

Pinedo, P. J., D. Manríquez, C. Ciarletta, J. Azocar, A. De Vries. 2022a. Association between body condition score fluctuations and pregnancy loss in Holstein cows. J Anim. Sci. 2022 100(10), skac266. doi: 10.1093/jas/skac266.PMID: 35973819.

Roche, J. R., K. A. Macdonald, C. R. Burke, J. M. Lee, and D. P. Berry. 2007. Associations among body condition score, body weight, and reproductive performance in seasonal-calving dairy cattle. J. Dairy Sci. 90:376–391.

Roche, J. R., N. C. Friggens, J. K. Kay, M. W. Fisher, K. J. Stafford and D. P. Berry. 2009. Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. J. Dairy Sci. 92:5769–5801.

Stevenson, J. S., S. Banuelos, and L. G. D. Mendonca. 2020. Transition dairy cow health is associated with first postpartum ovulation risk, metabolic status, milk production, rumination, and physical activity. J. Dairy Sci. 103:9573-9586. doi:10.3168/jds.2020-18636.

Truman, C. M., M. R. Campler, and J. Costa. 2022. Body condition score change throughout lactation utilizing an automated BCS system: A descriptive study. Animals. 12(5), 601.